3.13 FISH AND AQUATIC RESOURCES

SYNOPSIS

This section describes conditions and evaluates potential impacts to fish and aquatic resources from the proposed action and alternatives. Each alternative is examined by major project component (Mine Site; Transportation Corridor; and Pipeline) by project phase (Construction, Operations, and Closure). An Essential Fish Habitat (EFH) Assessment is provided in Appendix Q.

EXISTING CONDITION SUMMARY

Fish and aquatic resources are of central importance to the livelihood of residents of the proposed project area. While other chapter sections (Section 3.5, Surface Water Hydrology, Section 3.7, Water Quality, and Section 3.21, Subsistence) discuss topics associated with fish and aquatic resources, this section characterizes aquatic habitat and the diversity, abundance, and distribution of fish in the Kuskokwim River and the drainages affected by the proposed project. The section also describes the regulatory framework associated with the management and protection of area fisheries and aquatic habitats and presents an analysis of expected consequences of the proposed project and alternatives.

Both federal and state laws protect fish and aquatic resources that would be affected by components of the proposed project. Key laws and regulations include: the Clean Water Act (CWA), including Sections 402 and 404, which govern discharges to waters of the U.S.; the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), which governs protection of EFH; and state regulation of mining and water use and discharge permits as well as fish habitat protection requirements.

The Kuskokwim River and many of its tributaries, including tributaries in the Crooked Creek drainage, are designated as EFH for Pacific salmon. In Crooked Creek, populations of Chinook, chum, and coho salmon and limited numbers of sockeye and pink salmon have been recorded. In addition, 12 species of resident fish, including Dolly Varden, rainbow trout, Arctic grayling, burbot, and two species of whitefish, have been documented in Crooked Creek.

The Kuskokwim River aquatic habitat is characterized by sediment-rich, low-gradient, meandering channels of water depth that fluctuates with tides and seasons. Changing flow paths create sandbars and erode riverbanks. Downed trees line many eroding banks and provide refuge for fish. The shallowest stretches of the Transportation Corridor generally lie upstream of Kalskag. At least 27 species of anadromous and resident freshwater fish are found in the Kuskokwim River drainage. Chinook salmon are a special concern in recent years due to low populations, but no endangered or threatened fish species are found in the Kuskokwim River drainage.

The Pipeline crosses the Cook Inlet, Yentna, Skwentna, and Kuskokwim river drainages. Of the streams along the proposed route, those located in the Kuskokwim and Skwentna river drainages support the largest number of fish species (20 and 13 species, respectively). Streams in the Cook Inlet and Yentna drainages are also intersected by the proposed route but provide habitat to fewer fish species (12 and five species, respectively). No endangered or threatened fish species are found in the Cook Inlet, Yentna, or Skwentna river drainages.

The Kuskokwim River subsistence fishery is one of the largest in Alaska. The Kuskokwim drainage contains about 4,600 households within 38 communities. More than 1,500 households engage in subsistence fishing, and the catch is shared with more still. Subsistence salmon fishing on the Kuskokwim has not involved licenses or permits beyond the requisite year of Alaska residency. Although there are generally no limits on individual or household take of subsistence salmon, urgent conservation measures have limited harvest of Chinook salmon in recent years. See Section 3.21, Subsistence, for further details. Commercial harvest of chum is generally greater than subsistence, and commercial use of coho far outweighs subsistence harvest. Sport fisheries also occur in this part of the Kuskokwim, and both commercial and subsistence use of aquatic resources extend into Kuskokwim Bay.

EXPECTED EFFECTS SUMMARY

Alternative 1 - No Action

There would be no new effects on fish and aquatic resources.

Alternative 2 - Donlin Gold's Proposed Action

Effects at the Mine Site component during all three phases include direct habitat removal, wetland removal, streamflow and temperature changes, and sedimentation. These effects would impact migration, spawning, or rearing life stages of Pacific salmon and other anadromous or resident fish species and aquatic habitat. Streams in the Crooked Creek drainage near the mine support Chinook, coho, chum, pink, and sockeye salmon. Just under 8 miles of streambed, (in American and Anaconda creeks and portions of Snow and Lewis gulches) would be eliminated to construct various Mine Site facilities. These, and smaller tributary drainages that would be affected, represent about 8 percent of the Crooked Creek watershed. Most of the segments that would be filled in these tributaries do not support salmon, but in some years, habitat in American Creek supports up to 200 age 0 and age 1 juvenile coho salmon, which would be lost. Streamflow changes would be seasonal, with greatest reductions during winter months, affecting resident fish and overwintering coho salmon. The greatest effects of flow reductions and temperature increase in Crooked Creek would occur upstream of Crevice Creek. Below this, tributary inflows/runoff from unaffected watersheds (e.g., Bell and Getmuna creeks) would overshadow flow reductions resulting from Construction and Operations. Permit-mandated water management practices for the Mine Site component would help avoid and mitigate effects on downstream aquatic resources, including EFH.

Along the Transportation Corridor, depending on water conditions, project-related barge/tug wakes and propeller forces along the Kuskokwim River travel route may accelerate bank erosion and create riverbed scour, particularly in narrow and shallow segments of the river during the Construction and Operations phases. In combination with existing boat traffic, this could degrade habitat and disturb or destroy fish eggs, larvae, or juveniles. Along the proposed access road, six streams used by Chinook, coho, and chum salmon would be crossed with bridges resulting in infrequent degradation of water quality that would be minimized by best management practices (BMPs) employed for construction and operations of roads, bridges, and culverts. Similar measures would be used to control potential water quality effects during the Construction and Operation phases at the proposed port site. During the Closure Phase, areas of habitat alteration could remain and habitat would not be anticipated to return to pre-disturbance character.

Effects at the Pipeline component during the Construction Phase include habitat degradation and releases of turbid runoff at numerous crossings within the proposed construction corridor and along nearby stream corridors. Of the streams in the construction corridor, 77 contain habitat used by five species of Pacific salmon (i.e., Chinook, chum, coho, pink, and sockeye salmon). Effects would be limited and mitigated by horizontal directional drilling (HDD) at five of eight crossings constructed during summer months; timing pipe installation at most crossings in winter when salmon are not typically present, resulting in least disruption to aquatic resources; and employing BMPs during and post construction to minimize potential effects. The North Option would have similar effects to fish and fish habitat; HDD would be applied at three of seven crossings constructed during summer months.

OTHER ALTERNATIVES - This section discusses differences of note between Alternative 2 and the following Alternatives, but does not include a comprehensive discussion of each alternative's impacts if they are the same as Alternative 2 impacts.

Alternative 3A - LNG Powered Trucks

Alternative 3A would decrease the total number of barge trips per season during Operations from 122 to 83. This would result in a proportionate decrease in potential impacts on young-of-year seaward migrating salmon, incubating rainbow smelt eggs, and other life stages of resident and anadromous fishes in certain segments of the Kuskokwim River as a result of barge-generated propeller forces, waves, bank erosion, and riverbed scour.

Alternative 3B - Diesel Pipeline

Alternative 3B would eliminate fuel barging on the Kuskokwim River after the Construction Phase, reducing the total number of barge trips per season during Operations from 122 to 64. This also would result in a proportionate decrease in potential impacts on young-of-year seaward migrating salmon, incubating rainbow smelt eggs, and other life stages of resident and anadromous fishes in certain segments of the Kuskokwim River as a result of barge-generated propeller forces, waves, bank erosion, and riverbed scour. The Port MacKenzie Option would involve similar additional construction infrastructure, but would require crossing of the Susitna River and Little Susitna River. The Collocated Pipeline Option would require a wider pipeline construction footprint.

Alternative 4 - Birch Tree Crossing (BTC) Port

Alternative 4 would eliminate the upriver portion of the river route, replacing it with a longer mine access road and fewer stream crossings than Alternative 2. Under this alternative, fewer impacts associated with a shorter distance of travel along the Kuskokwim River barge route might be offset by greater impacts from roadfills that could affect wetland and riparian communities along a more extended roadway corridor.

3.13.1 REGULATORY FRAMEWORK

Federal and state government agencies regulate developments within aquatic habitats, which include in-water construction (port development and expansion), stream crossings (port to mine road and pipeline), dam construction, water diversions, and discharges for the Mine Site component. Numerous permits and authorizations are required as summarized below.

3.13.1.1 FEDERAL

Under Section 10 of the Rivers and Harbors Act, the Corps regulates navigable waters of the United States, which includes all waters within the Kuskokwim River below the ordinary high water mark. Construction of structures and activities that affect the course, conditions, location, or navigable capacity of the river would require a Section 10 Permit.

Under Section 404 of the Clean Water Act (CWA), the Corps is responsible for maintaining the chemical, physical, and biological integrity of the nation's waters. Any discharge of dredged or fill materials into jurisdictional waters of the U.S. may require a Section 404 Permit. This would include construction of roads, bridges, or pipeline crossings at streams, construction of dams for tailings storage, water storage dams, stream diversion structures, and port development or port facilities on the Kuskokwim River.

The National Marine Fisheries Service (NMFS) of the National Oceanic and Atmospheric Administration (NOAA) is responsible for protecting habitats important to federally managed marine species, which includes anadromous Pacific salmon. Federal agencies must consult with NMFS concerning any action that may adversely affect Essential Fish Habitat (EFH) under the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act). EFH includes habitats necessary to a species for spawning, breeding, feeding, or growth to maturity, which includes marine and riverine migratory corridors, spawning grounds, and rearing areas of the Pacific salmon species.

The U.S. Coast Guard (USCG) is responsible for Vessel Response Plans (VRP) and Facility Response Plans (FRP) which are required under the Oil Pollution Act of 1990, to minimize the impact of oil spills. USCG is also responsible for bridge permits which would be required for any bridges constructed over navigable waters (including any overhead pipeline crossings of navigable waters).

The U.S. Environmental Protection Agency (EPA) has review and oversight authority over Section 404 Permit decisions under the Clean Water Act and the Spill Prevention, Control, and Countermeasure (SPCC) Plan required for oil storage. Facilities with above and underground storage facilities with capacities that would exceed a specific threshold are required to develop and implement a SPCC Plan.

3.13.1.2 STATE

The Alaska Department of Natural Resources (ADNR) coordinates the permitting of large mine projects in the state, including the integration of federal and local government agencies. ADNR develops a large mine project team, an interagency group that works cooperatively with large mine applicants and operators, federal agencies, and the public to ensure that projects are designed, operated, and reclaimed in a manner consistent with the public interest. Specific permits and approvals for work in aquatic habitats include:

- Permit to Appropriate Water. Appropriation of a significant amount of water on other than a temporary basis requires authorization by a Water Rights Permit. A Water Right is a property right for the use of public surface and subsurface waters. Temporary uses of a significant volume of water, for up to 5 years, require a Temporary Water Use Authorization (TWUA).

- Dam Safety Certification. A Certificate of Approval to Construct and a Certificate of Approval to Operate must be obtained for any significant dam in the State, including tailings storage facilities and contact water or fresh water storage reservoirs. These certificates involve a detailed engineering review of the dam's design and operation.
- Upland or Tideland Leases. A project may require a property interest in lands not adjacent to the mine site itself. For use of state-owned tidelands, a tideland lease is issued for marine facilities such as docks or wharfs. Likewise, for use of state-owned uplands, a lease is required for facilities such as transportation and staging facilities or material sites.
- Reclamation Plan and Financial Assurance Approval. This approval authorizes the reclamation plan and financial assurance for non-coal mines in Alaska. It specifies that mine sites must be returned to a stable condition, compatible with post-mining land use. Financial assurance must be in place to ensure that that reclamation and closure of the operation can be completed, even if the operator is unable to complete those obligations.

The Alaska Department of Environmental Conservation (ADEC) administers the following programs involving aquatic habitats:

- Waste Management Permit. If tailings or waste rock from a mine project has the potential for impacting state waters, then a Waste Management Permit must be obtained. This permit usually requires pre-operational, operational, and post closure monitoring. The permit also requires financial assurance both during and after operations to cover short and long-term treatment if necessary, closure costs, monitoring, and maintenance needs.
- Alaska Pollutant Discharge Elimination System Permit. ADEC regulates mine discharges to all waters under the Alaska Pollutant Discharge Elimination System program (APDES). All mines that have a discharge to waters of the U.S. are required to obtain an APDES permit prior to discharging. Under this program, new mine discharges are required to meet applicable New Source Performance Standards and State water quality standards. These include standards for protection of aquatic life in the receiving water. APDES permits require regular monitoring to ensure compliance with discharge limitations and often include other stipulations to protect water quality.
- Domestic and Non-Domestic Wastewater Disposal Permits. ADEC authorizes the discharge of wastewater into or upon all waters and land surfaces of the state. If injection wells are part of the wastewater disposal plan, then the requirements for EPA's Underground Injection Control (UIC) Class V wells must be met in addition to any requirements in a state wastewater permit.
- Certificate of Reasonable Assurance for 404 Permits. Activities involving dredging or discharge of fill material within waters of the U.S. are governed by the terms and conditions of a CWA Section 404 Permit from the Corps. CWA Section 401 also requires the applicant to obtain state certification that any discharge under CWA Section 404 will comply with applicable state water quality standards.

- Storm Water Discharge Pollution Prevention Plan. ADEC administers the APDES Storm Water General Permit for construction activities, and, during the operational phase of facilities, the APDES Multi-sector General Permit for industrial activities. ADEC approves Storm Water Pollution Prevention Plans (SWPPPs) that include storm water best management practices (BMPs). The facility may have separate APDES permits to cover waste water and storm water discharges, or the requirements may be combined into one APDES permit.
- Oil Discharge Prevention and Contingency Plan. Approval of an Oil Discharge Prevention and Contingency Plan (ODPCP) is required prior to commencement of operation of pipelines used to transport oil or petroleum products, non-tank vessels greater than 400 gross tons and oil barges on state waters, or for above ground tank facilities capable of storing 420,000 or more gallons of refined petroleum product or 210,000 or more gallons of crude oil. These contingency plans are reviewed every three years.

The Alaska Department of Fish and Game (ADF&G) has the statutory responsibility for protecting freshwater anadromous fish habitat and ensuring free passage for anadromous and resident fish in fresh water bodies. Any activity or project that has the potential to impede or prohibit fish passage or is conducted below the ordinary high water mark of an anadromous stream requires a Title 16 Fish Habitat Permit. A Fish Habitat Permit is required before any action is taken to construct a hydraulic project; use, divert, obstruct, pollute, or change the natural flow or bed of a specified river, lake, or stream; or use wheeled, tracked, or excavating equipment or log-dragging equipment in the bed of a specified river, lake, or stream. A Fish Habitat Permit also is required for water withdrawals related to construction of ice bridges or roads, water diversion/ dewatering operations, or hydraulic testing of pipelines. A water withdrawal includes any operation in which water is pumped from a stream. Specific screening requirements for the pump intake are specified in the permit to avoid fish entrainment, impingement, or injury.

3.13.1.3 LOCAL

Additional local permits with requirements that would protect fish and aquatic resources also may be required. The mining footprint is in a remote location near the community of Crooked Creek (population of approximately 100). Aniak (population of approximately 600), the regional transportation center of the middle Yukon-Kuskokwim (Y-K) Valley, is located approximately 60 miles downstream of the mine footprint. Bethel (population of approximately 6,000), the administrative and transportation center of the Y-K Delta, is located approximately 180 miles downstream of the Mine Site area. Local permit requirements not related to state and federal authorizations may govern temporary and permanent employment, housing, transportation, access and preservation of subsistence fisheries, and other cultural issues.

3.13.2 AFFECTED ENVIRONMENT

The following is a description of fish and aquatic biota within the Project Area that may be affected by the Donlin Gold Project. This includes freshwater and marine species (e.g., fish, macroinvertebrates, algae) and their associated aquatic habitats. Potential effects would be associated with the three primary components of the project: 1) the Mine Site (Figure 3.13-1 and Figure 2.3-1, Chapter 2, Alternatives); 2) the Transportation Corridor, extending from an existing marine terminal in Dutch Harbor to Kuskokwim Bay, up the Kuskokwim River to a new port site (either Angyaruaq [Jungjuk] or Birch Tree Crossing [BTC]), then inland to the mine along a new road (Figure 3.13-2, and Figures 2.3-11, 2.3-12, 2.3-41, and 2.3-42 in Chapter 2, Alternatives); and 3) the Pipeline, extending from Cook Inlet to the mine (Figure 2.3-14, Chapter 2, Alternatives). Ice roads associated with pipeline construction (or the mine access road under Alternative 4) would affect additional area and streams. The mainstem Kuskokwim River, which is subject to intense flooding, natural bed scours, and ice-out conditions, primarily serves as a migration corridor to anadromous salmon stocks traveling between Kuskokwim Bay and upriver tributaries of the Kuskokwim watershed. These tributaries are important to all salmon life stages by providing habitat more suitable for spawning, overwintering, and rearing. Although primarily serving as a salmon migration corridor, the Kuskokwim mainstem also provides important habitat to life stages of various other anadromous and resident fishes.

3.13.2.1 MINE SITE – CROOKED CREEK DRAINAGE

The Mine Site component encompasses the primary mining operation area including the Waste Rock Facility (WRF), Tailings Storage Facility (TSF), the mine pit itself, and associated facilities (Figure 3.13-1, and Figures 2.3-1 and 2.3-2 in Chapter 2, Alternatives). All activities that would occur at the Mine Site area are situated within the Crooked Creek drainage. Crooked Creek drains an area of 333 square miles (mi^2) (less than 1 percent of the 50,000 mi^2 Kuskokwim River watershed) and enters the Kuskokwim River at the Village of Crooked Creek. An intensive stream habitat survey was conducted in 2009 to document aquatic habitat throughout the Crooked Creek mainstem. Results from the 2009 and subsequent aquatic baseline surveys indicate there is a relatively high amount of natural silt/bed load in this drainage system compared to some of the other similarly sized drainages of the Kuskokwim River (Ottertail 2012b). Additionally, complete freezing during the late winter months has been documented in many of the tributary streams in the Crooked Creek drainage (Ottertail 2012b). The combination of high natural siltation and winter freeze-down limit the amount and quality of aquatic habitat in this drainage system.

3.13.2.1.1 AQUATIC HABITAT

The life stages of salmon and other anadromous and resident fish are dependent on a variety of aquatic habitat types and stream conditions. For the salmon life cycle, suitable habitat and stream conditions are required for adult upstream migration from river estuaries; for tributary spawning and egg incubation in gravel substrates along riffles; for feeding, rearing, and overwintering in tributary pools and off-channel backwater areas; and for seaward migration to complete their life cycle of rearing and growth in estuaries and the open ocean. The nature and extent of aquatic habitat in the Kuskokwim River, Crooked Creek, and other river/stream systems are largely defined by:

- Flow and water quality regimes that reflect seasonally variable depths, velocities, channel configurations, nutrient loads, and stream temperatures;
- The availability and distribution of gravel-sized substrates with a limited amount of fines for fish spawning and aquatic insect production; and

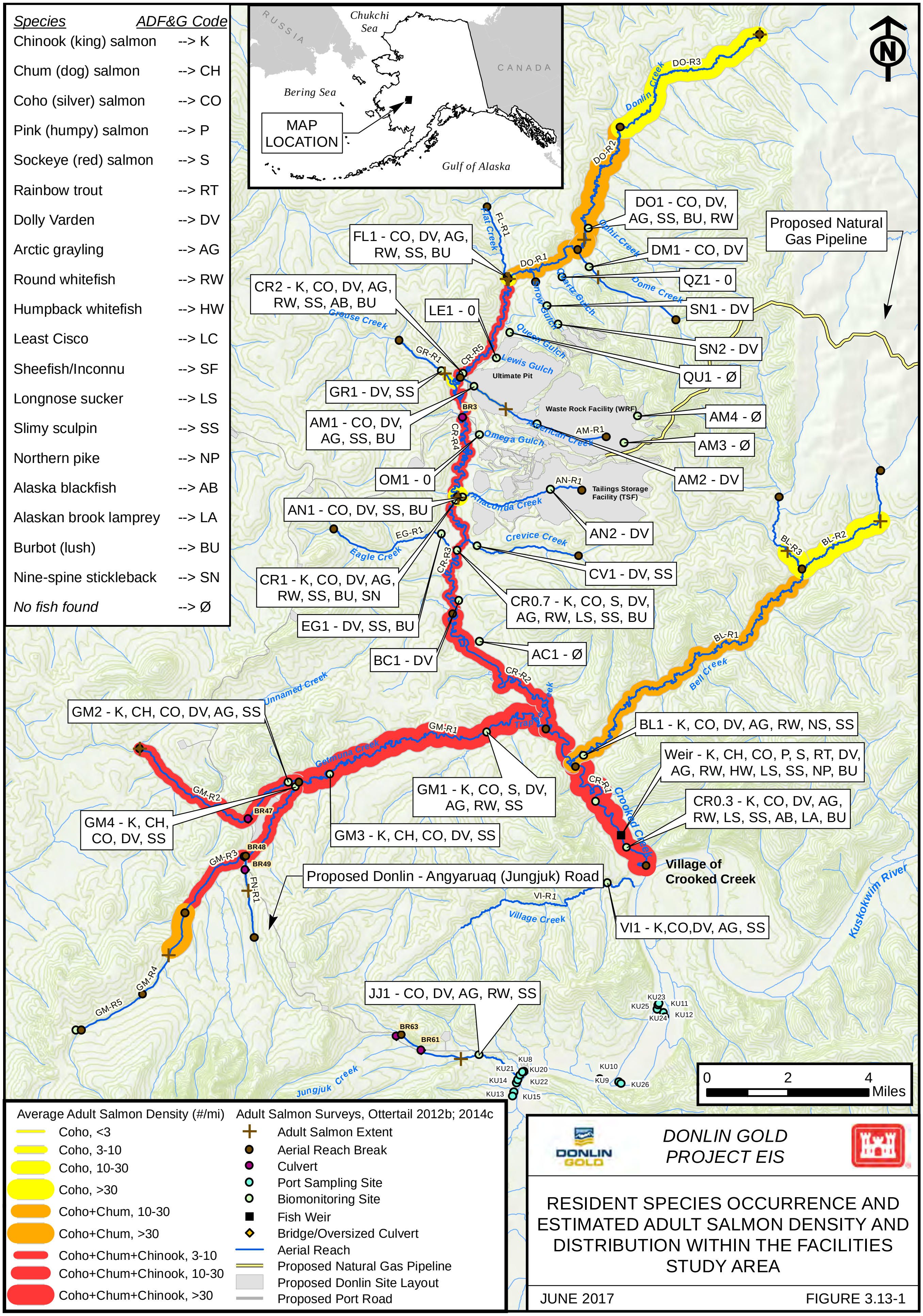
- The availability and distribution of a mixture of instream and streamside rock, woody debris, and vegetative cover that provide suitable conditions for fish migration, refugia, and rearing.

Other related factors that influence the character of aquatic habitat in streams include channel slope and sinuosity; bedload composition and transport mechanisms; the extent of seasonal scouring from flooding, winter freeze and ice break up conditions; and hydraulic forces that affect the type, size, distribution, and quality of key habitat types (e.g., spawning riffles, pools, runs, off-channel rearing areas, and overwintering refuge areas). The combination of these and other factors determine the quality and extent of fish migration, spawning, and rearing essential to the production of salmon smolts, resident fishes, and diverse populations of aquatic prey species.

One of the most fundamental factors affecting aquatic habitat in streams is the flow regime or seasonal pattern of average discharge and the level of variation around that average (Quinn 2005). The flow regime, in combination with other factors as described above, determines the distribution, areal extent, and depth of riffles, pools, and off-channel habitat as well as the distribution of large woody debris all of which are of key importance to salmon production. Pool size and depth, in particular, affect overwinter survival for salmon and other resident fish when other shallower portions of streams completely freeze. The following sections describe the character of aquatic habitat for drainages within the upper, middle, and lower Crooked Creek watershed.

Upper Watershed

Donlin Creek, Flat Creek, and Dome Creek. The upper watershed consists of streams situated upstream of the confluence of Donlin Creek and Flat Creek (Figure 3.13-1). Donlin Creek (DO1) has a moderate gradient and relatively high sinuosity resulting in classic riffle-run-pool habitat types. Donlin Creek and its tributaries drain an area of 30.5 mi^2. Although heavy icing during winter results in some sections of the stream freezing solid, pool depth is generally sufficient to provide fish overwintering habitat. Gravel and cobble are the dominant substrates in riffles throughout much of the Donlin Creek mainstem (Table 3.13-1). Salmon spawning habitat is abundant throughout much of Donlin Creek, however, access to these habitats can be limited in certain years due to beaver activity (Ottertail 2014a).

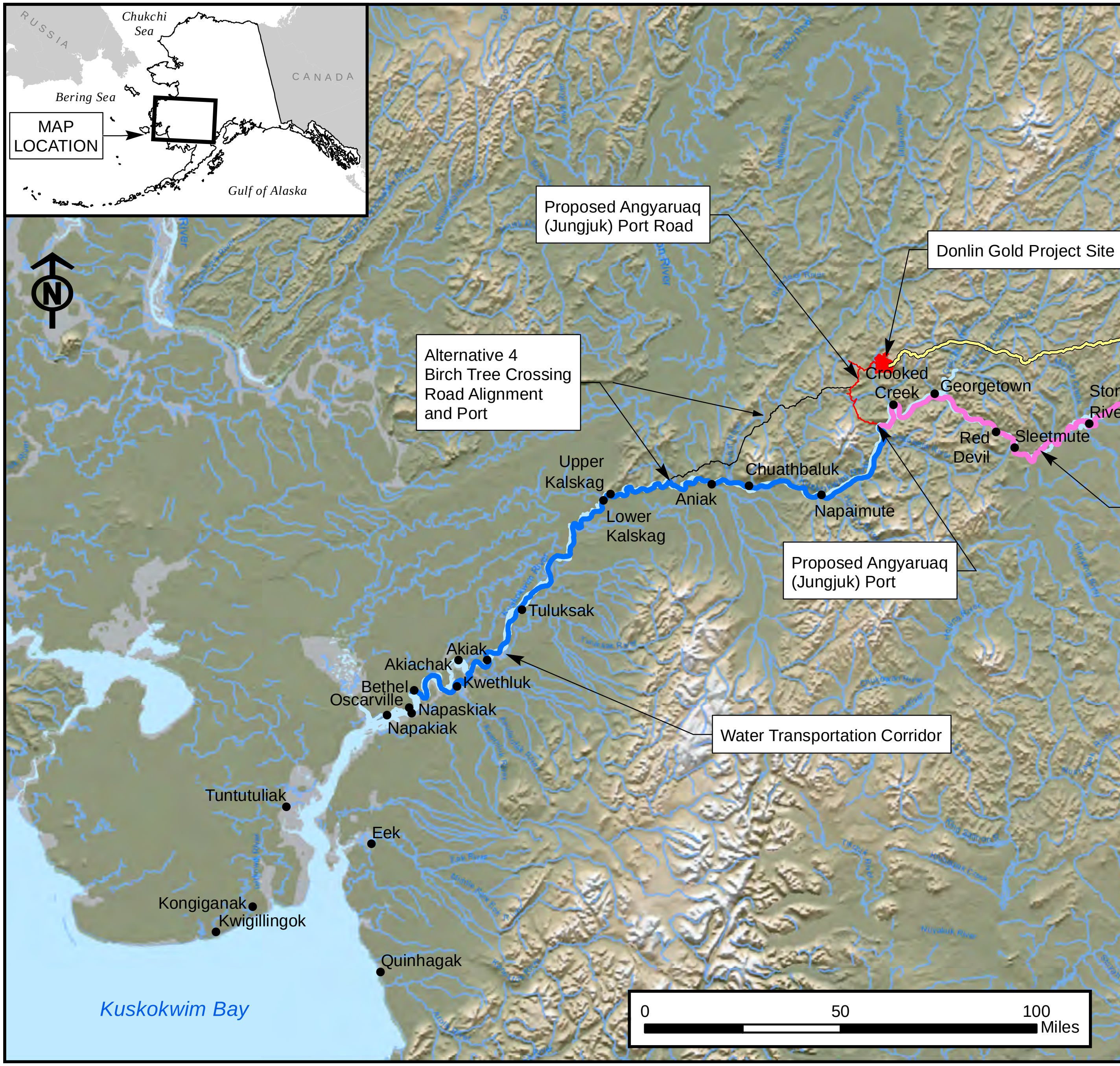


DONLIN GOLD PROJECT EIS

RESIDENT SPECIES OCCURRENCE AND ESTIMATED ADULT SALMON DENSITY AND DISTRIBUTION WITHIN THE FACILITIES STUDY AREA

JUNE 2017

FIGURE 3.13-1



DONLIN GOLD PROJECT EIS

TRANSPORTATION CORRIDOR OVERVIEW

JUNE 2017

FIGURE 3.13-2

Flat Creek (FL1) is smaller than Donlin Creek, draining an area of 19.5 mi^2 (Figure 3.13-1). A moderately high gradient and low sinuosity channel results in a prevalence of riffle-run habitats. The substrate is dominated by cobbles in the lower reaches, transitioning to sand and silt in the upper reaches (Table 3.13-1). Observations during the winter months suggest that Flat Creek has little or no upwelling. Under certain conditions, this may allow bottom freezing in portions of the creek (Ottertail 2011).

Dome Creek (DM1) drains an area of 6.8 mi^2. The Dome Creek monitoring site was established to document aquatic resource conditions within a sub-basin of the Crooked Creek drainage upstream from existing and proposed mining activities. Dome Creek, which flows into Donlin Creek, has a moderate gradient with gravel suitable for salmonid spawning being a dominant substrate in riffle areas (Ottertail 2012b). Only coho and Dolly Varden have been observed in the lower quarter mile of the creek that is passable to fish.

Middle Watershed

Upper Crooked Creek, Quartz Gulch, Snow Gulch, Queen Gulch, Lewis Gulch, American Creek, Omega Gulch, and Anaconda Creek. Upper Crooked Creek, from the confluence of Donlin Creek and Flat Creek downstream to the Crevice Creek confluence (Figure 3.13-1), has a high sinuosity and a repetitive sequence of classic riffle-run-pool habitat types. Gravel and cobble substrates dominate the riffle areas (Table 3.13-1). During winter months, heavy icing may cause variable flows, as some locations may freeze to the stream bottom. The presence of multiple-year classes of slimy sculpin indicate that pool depth and frequency are apparently sufficient for fish overwintering (Ottertail 2012b).

Because the proposed project has the potential to affect the quantity and distribution of surface water flows within the upper Crooked Creek drainage, a habitat mapping study was conducted along 33 miles of Crooked Creek. A key study objective involved the characterization of aquatic habitat by quantifying the distribution and classification of salmonid rearing and spawning areas (Table 3.13-2) at baseflow conditions (Ottertail 2012b). As shown in Table 3.13-3, about 61 percent (568.6 mi^2) of the total wetted surface area at baseflow conditions consisted of run habitat. An analysis of the creek's suitability classification with respect to juvenile salmonid habitat indicated that most of the creek's run habitat (64 percent) was characterized as fair quality; 33 percent was considered good quality; and a very small fraction (less than 1 percent) was considered excellent quality. Riffle habitat made up 12 percent (112.7 mi^2) of the total wetted surface area surveyed. Most of the riffle habitat (71 percent) was classified as being of poor quality juvenile salmonid habitat, 27 percent was classified as fair quality, and less than 2 percent was classified as good quality. It was noted that many juvenile salmon were observed along shallow margins of the stream within low-velocity riffles (Ottertail 2012b). Pool habitat accounted for approximately 8 percent (70.6 mi^2) of the total wetted surface area with 70 percent of the pool habitat characterized as good quality, 25 percent as fair quality, and 5 percent as excellent quality. During higher flow conditions, it is anticipated that most of this pool habitat would likely be classified as run habitat. Glides and fast-run habitat were not very common and were primarily characterized as providing fair salmon rearing habitat (Table 3.13-2 and Table 3.13-3).

Table 3.13-1: Crooked Creek Watershed Stream Characteristics

Stream Name	Percent of Crooked Creek Watershed	Drainage Area (square miles)	Aerial Reach	Site within Reach	Slope[1] Percent	Sinuosity	Rosgen Type[2]	Dominant Substrate in Riffles[3]	AVG Wetted Width[4]	
									feet	meter
Donlin Creek	9.09	30.5	DO-R1	N/A	0.3	1.47	N/A	N/A	N/A	N/A
			DO-R2	DO1	0.4	1.82	B5c	gravel	19.9	6.1
			DO-R3	N/A	0.7	1.48	N/A	N/A	N/A	N/A
Dome Creek	2.03	6.8	DM-R1	DM1	2.6	1.06	G4	gravel/cobble	8.6	2.6
Quartz Gulch	0.35	1.2	N/A	QZ1	3.2	1.03	G3g	gravel/cobble	8.0	2.4
Snow Gulch	1.01	3.4	SN-R1	SN2	1.9	1.04	G6	sand	4.4	1.3
Queen Gulch	0.21	0.7	N/A	QU1	2.6	1.01	G3g	sand/gravel	6.6	2.0
Flat Creek	5.80	19.5	FL-R1	FL1	0.6	1.12	B3c	cobble	12.1	3.7
Lewis Gulch	0.23	0.8	N/A	LE1	4.4	1.01	G3g	gravel/cobble	2.5	0.8
American Creek	2.04	6.9	AM-R1	AM1	2.2	1.04	B5	gravel/cobble	10.5	3.2
			AM-R1	AM2	2.2	1.04	B5	gravel/cobble	13.1	4.0
Grouse Creek	3.56	12.0	GR-R1	GR1	0.9	1.07	B5c	gravel	13.2	4.0
Omega Gulch	0.30	1.0	N/A	OM1	4.5	1.06	G6da	silt/sand	3.3	1.0
Anaconda Creek	2.34	7.9	AN-R1	AN1	1.4	1.15	G6c	silt/sand	7.3	2.2
			AN-R1	AN2	1.4	1.15	G6c	silt/sand	7.4	2.3
Crevice Creek	2.01	6.8	CV-R1	CV1	0.7	1.14	B5c	gravel	5.3	1.6
Eagle Creek	2.53	8.7	EG-R1	EG1	1.0	1.05	G6c	silt/sand	5.0	1.5
Unnamed (BC)	0.10	0.4	N/A	BC1	2.8	1.03	G6da	sand	5.0	1.5
Unnamed (AC)	0.08	0.3	N/A	AC1	2.3	1.04	G6da	sand	3.0	0.9
Bell Creek	21.23	71.3	BL-R1	BL1	0.4	1.68	C4	gravel/cobble	29.5	9.0
			BL-R2	N/A	1.2	1.21	N/A	N/A	N/A	N/A
			BL-R3	N/A	1.0	1.26	N/A	N/A	N/A	N/A

Table 3.13-1: Crooked Creek Watershed Stream Characteristics

Stream Name	Percent of Crooked Creek Watershed	Drainage Area (square miles)	Aerial Reach	Site within Reach	Slope[1] Percent	Sinuosity	Rosgen Type[2]	Dominant Substrate in Riffles[3]	AVG Wetted Width[4]	
									feet	meter
Getmuna Creek	29.39	98.6	GM-R1	GM1	0.4	1.65	C4	gravel/cobble	51.6	15.7
			GM-R2	N/A	0.5	1.39	N/A	N/A	N/A	N/A
			GM-R3	N/A	1.0	1.20	N/A	N/A	N/A	N/A
			GM-R4	N/A	2.3	1.03	N/A	N/A	N/A	N/A
			GM-R5	N/A	2.1	1.01	N/A	N/A	N/A	N/A
Unnamed (FN)	1.67	5.6	FN-R1	N/A	1.1	1.02	N/A	N/A	N/A	N/A
Crooked Creek	100.00	335.5	CR-R1	CR0.3	0.2	1.62	C4	gravel/cobble	23.4*	7.1*
			CR-R2	N/A	0.2	1.97	N/A	N/A	N/A	N/A
			CR-R3	CR1	0.1	2.06	C4	gravel/cobble	54.2	16.5
			CR-R3	CR0.7	0.1	2.06	C4	gravel/cobble	49.3	15.0
			CR-R4	N/A	0.1	2.70	N/A	N/A	N/A	N/A
			CR-R5	CR2	0.3	1.65	C4	gravel/cobble	36.0	11.0

Notes:

1 Gradient and sinuosity were calculated over the reach of stream flown for the aerial salmon counts. For those streams not flown, slope and sinuosity were calculated for the primary mainstem of the drainage.

2 Data on entrenchment, or flood prone width have not been collected for all stream sections; therefore, classifications are only an average estimate based on conditions near sampling reaches.

3 Dominant substrate calculations were not conducted at every site or stream and should be considered an estimate based on various field collection sources.

4 Average wetted width measured at biomonitoring site. *Wetted width at CR0.3 represents only the side channel in which the survey was conducted; Total wetted width for the entire mainstem at this location is approximately 60 feet.

N/A = Not available at this time.

Source: Ottertail 2012b; Rosgen and Silvey 2006

Table 3.13-2: Summary of Habitat Type and Attribute Data for Crooked Creek (2009)

Parameter	Habitat Type[1]								Total
	Riffle	Fast Run	Run	Glide	Pool	Side Arm	Back Water	Abandoned Channel	
General Statistics									
Number of Habitats	206	5	325	16	118	39	83	48	**840**
Total Wetted Surface Area (mi^2)	43.52	1.46	219.55	16.77	27.25	10.57	16.43	21.85	**357.41**
% of Total Wetted Surface Area	12.18	0.41	61.43	4.69	7.63	2.96	4.60	6.11	**100**
Mean Water Velocity (f/s)	2.01	2.64	1.37	1.52	0.96	0.93	0.86	0.87	**1.40**
Dominant Substrate (% Area)[2]									
Silt, loam, clay (<0.063mm)	--	--	0.32	--	7.31	22.49	67.51	76.35	**21.75**
Sand (0.063–2mm)	--	--	11.36	--	39.82	10.71	7.94	0.71	**8.82**
Medium to fine gravel (2mm–2cm)	2.67	--	13.09	16.20	17.19	40.96	0.74	1.29	**11.52**
Coarse gravel (2–6.3cm)	62.76	42.01	53.18	73.82	30.57	22.89	20.69	6.96	**39.11**
Small cobble (6.3–20cm)	34.57	57.99	22.05	9.98	5.11	1.94	2.01	--	**16.71**
Medium cobble (20–40cm)	--	--	--	--	--	--	--	--	**--**
Large cobble (>40cm)	--	--	--	--	--	--	--	--	**--**
Bedrock	--	--	--	--	--	--	--	--	**--**
Organic sludge	--	--	--	--	--	--	0.26	--	**0.03**
Deposits of particulate organic matter	--	--	--	--	--	--	0.40	0.03	**0.05**
Submerged plants	--	--	--	--	--	--	0.45	14.65	**1.89**
Wood	--	--	--	--	--	1.01	--	--	**0.13**
Abundant Habitat Features (% Occurrence)[3]									
Boulders	0.08	--	--	--	--	--	--	1.36	**0.18**
Overhanging Vegetation	0.07	--	0.43	--	2.13	--	0.51	0.67	**0.48**
Submerged Vegetation	0.65	--	0.40	--	1.08	0.49	13.82	81.77	**12.28**
Canopy Shading	2.06	--	12.76	0.47	2.90	38.39	23.83	5.00	**10.68**
Undercut Bank	19.68	--	28.56	80.26	10.17	8.37	2.40	0.93	**18.80**
Woody Debris	1.54	--	11.08	--	22.28	36.43	22.55	7.58	**12.68**
Shallow Margin	30.16	--	17.53	9.51	26.76	50.66	87.14	83.23	**38.12**

Notes:

1 For definitions of habitat types and abundant habitat features, refer to (Ottertail 2011).
2 Dominant Substrate (% Area) Total provides the average for each type of substrate over all habitat types.
3 Abundant Habitat Features (% Occurrence) refers to the percentage of habitat types mapped in which a feature is abundant (>50% area of habitat type). For example, shallow margins were an abundant habitat feature in 30.16% of riffles.

Source: Ottertail 2011

Table 3.13-3: Juvenile Salmon Habitat Suitability for Baseflow Conditions Crooked Creek (2009)

	Area	Suitability Classification[1]				
		Excellent	Good	Fair	Poor	Total
Riffle	mi^2	--	1.74	30.73	80.26	112.73
	%	--	1.54	27.26	71.19	
Fast Run	mi^2	--	--	2.79	1.01	3.79
	%	--	--	73.49	26.51	
Run	mi^2	1.07	189.70	364.90	12.97	568.64
	%	0.19	33.36	64.17	2.28	
Glide	mi^2	--	5.49	37.94	--	43.43
	%	--	12.64	87.36	--	
Pool	mi^2	3.48	49.52	17.58	--	70.59
	%	4.93	70.15	24.91	--	
Side Arm	mi^2	--	9.24	16.67	1.46	27.38
	%	--	33.76	60.90	5.34	
Back Water	mi^2	17.30	24.28	0.97	--	42.55
	%	40.66	57.06	2.28	--	
Abandoned Channel	mi^2	46.65	9.94	--	--	56.59
	%	82.44	17.56	--	--	

Notes:

1 Refer to (Ottertail 2011) for definitions of habitat types and suitability classifications. '%' is the percent area within each habitat type that is classified "excellent," "good," "fair," or "poor." Suitability classification included a ranked scoring for a number of factors including habitat type (riffle, pool, backwater, etc.) and channel attributes (boulders, submerged and overhanging vegetation, undercut banks, woody debris, shallow water margins, etc.).

Source: Ottertail 2011

Higher redd density in the lower drainage may be explained by the closer proximity to the Kuskokwim River, higher summer and winter flows influenced by the Getmuna and Bell creek drainages, and greater availability of suitable spawning habitat.

Backwaters and abandoned channels (relic meander cutoffs) accounted for only 38.3 mi^2 or 5 and 6 percent of the total wetted surface area, respectively (Table 3.13-2). Although a relatively small percentage of total habitat, abandoned channel habitat accounted for the largest amount (82 percent) of juvenile coho salmon habitat classified as excellent quality (approximately 47 mi^2) (Ottertail 2012b).

Quartz Gulch (site QZ1) is a small, high-gradient drainage with an area of 1.2 mi^2. This drainage has been extensively mined in its lower end, and some silt from this area continues to be transported into Donlin Creek. Located just downstream of Quartz Gulch, Snow Gulch (sites SN1 and SN2) drains an area of 3.4 mi^2. The lower end of the Snow Gulch has been extensively mined; sections of the stream have been rerouted, but the stream above the mining area is essentially undisturbed and varies from a deeply incised channel with silt substrates to meandering sections with gravel substrates and beaver activity. Queen Gulch (site QU1) drains an area of 0.7 mi^2. The lower end of Queen Gulch also has been severely disturbed by placer mining. Characteristics for these streams are included in Table 3.13-1 (Ottertail 2012b).

The American Creek drainage (sites AM1 and AM2) is the proposed location of the mine pit and WRF (Figure 3.13-1, and Figure 2.3-1 in Chapter 2, Alternatives). American Creek drains an area of 6.9 mi^2, comprising 2 percent of the entire Crooked Creek drainage. Beaver activity is prevalent throughout the drainage; but in reaches unaffected by beavers the stream is a narrow, incised channel with gravel substrates dominating riffle areas (Table 3.13-1). Flowing water is present year-round in upstream portions of American Creek, while the lower reaches may freeze to the bottom in winter resulting in discontinuous surface flow (Ottertail 2012b).

The small watersheds of Lewis Gulch (0.8 mi^2) and Omega Gulch (1.0 mi^2) have limited aquatic habitat, lack overwintering habitat, and are unlikely to support fish (sites LE1 and OM1, respectively) (Ottertail 2012b).

Anaconda Creek (sites AN1 and AN2) is the proposed location of the TSF (Figure 3.13-1, and Figure 2.3-1 in Chapter 2, Alternatives). Silt and sand are the dominant substrates in this creek, which drains an area of 7.9 mi^2 (Table 3.13-1). Aquatic habitat is classified as poor quality due to the lack of gravel and cobble substrate, a highly incised channel, and highly variable water quality caused by flooding, major stream erosion, turbidity, and silt deposits. A low abundance and diversity of macroinvertebrates and fish were observed in the creek.

Lower Watershed

Lower Crooked Creek, Crevice Creek, Unnamed (AC) Creek, Unnamed (BC) Creek, Getmuna Creek, and Bell Creek. Lower Crooked Creek between sites CR0.7 and CR0.3 (Crevice Creek confluence downstream to the mouth near the Village of Crooked Creek) has a sinuous stream character with a repetitive sequence of classic riffle-run-pool habitat types (Figure 3.13-1). Compared to Donlin Creek in the upper drainage, this reach receives greater flow and has less gradient, which has resulted in greater channel sinuosity. Substrates are dominated by gravel and cobbles in riffle areas and silt/sand in slow-water areas. Surface flows in lower Crooked Creek are likely adequate to support overwintering fish at most locations. The presence of multiple-year classes of slimy sculpin indicate the frequency and depth of pools are likely to provide adequate overwintering conditions for fish (Ottertail 2012b).

Crevice Creek (site CV1) drains an area of 6.8 mi^2 and has little sinuosity. The channel is covered with many overhanging trees and has a narrow, incised, and highly variable character with very little pool habitat. Substrate is dominated by gravel in riffle areas (Table 3.13-1), providing good habitat for macroinvertebrate populations. Sand and silt substrates are common in pool habitats (Ottertail 2012b).

Eagle Creek drains an area of 8.7 mi2 and enters Crooked Creek from the west, just downstream from Crevice Creek (site EG1). The permanent accommodations camp would be located in the upper slopes of this drainage (Figure 3.13-1, and Figure 2.3-12 in Chapter 2, Alternatives). Similar to Anaconda Creek, the channel is highly incised and the substrate is dominated by silt and sand (Table 3.13-1) (Ottertail 2012b).

Two small unnamed drainages, (sites AC1 and BC1), drain areas of approximately 0.3 mi2 and 0.4 mi2, respectively, and enter Crooked Creek from the east, downstream of Crevice Creek (Figure 3.13-1). Both streams have silt- and sand-dominated substrates and limited aquatic habitat. These streams are located near the site of a potential material source of rock and aggregate for proposed construction activities (Ottertail 2012b).

Getmuna Creek drains an area of 98.6 mi^2 and is the largest tributary in the Crooked Creek system. A proposed material borrow site would be located in the upper drainage near the crossing of the proposed mine access road (Figure 3.13-1, and Figure 2.3-12 in Chapter 2, Alternatives). The creek (site GM1) has a repetitive sequence of riffle-run-pool habitat types with less sinuosity than lower Crooked Creek due to its steeper gradient and different geomorphology. The water clarity of Getmuna Creek has been consistently higher than in the mainstem of Crooked Creek due to the geological character of its watershed (Ottertail 2012b). The lower reaches of Getmuna Creek have sand, gravel, and cobble substrate, and good pool habitat. The upper reaches of Getmuna Creek contain numerous riffles with gravel and cobble substrate. Large woody debris and off-channel habitats are abundant throughout the drainage (Ottertail 2012b).

Bell Creek (site BL1) is the second largest drainage in the Crooked Creek watershed covering 71.3 mi^2. This drainage joins Crooked Creek from the east, downstream from the confluence of Getmuna Creek. Stream conditions include gravel and cobble substrates, low-to-moderate gradient, and relatively high sinuosity resulting in classic riffle-run-pool habitat types (Ottertail 2012b). Bell Creek is included here because it is an important component of the Crooked Creek watershed, even though the Bell Creek drainage is not expected to be affected by the Donlin Gold Project.

3.13.2.1.2 FISH

All activities that would occur within the vicinity of the Mine Site are located within the Crooked Creek drainage where fish studies related to the proposed project have been conducted since 1996 (Ottertail 2014c). A formal aquatic biomonitoring program was initiated in 2004 by Ottertail Environmental, Inc. The biomonitoring program included electrofishing, fish trapping, macroinvertebrate collections, fish tissue metals analysis, and aerial adult salmon surveys. In 2008, a resistance-board fish weir was installed on Crooked Creek to estimate adult salmon escapement. Additionally, an intensive stream habitat survey was conducted in 2009 to document aquatic habitat throughout the Crooked Creek mainstem.

Fish population assessments within the Crooked Creek drainage have shown that this system supports viable populations of Chinook, chum, and coho salmon. Since the installation of the fish weir in 2008, limited numbers of sockeye and pink salmon also have been documented. With the exception of Donlin, Bell, and Getmuna tributaries, Chinook or chum salmon have not been documented in other Crooked Creek tributaries. However, limited numbers of coho salmon have been reported in several tributaries. Many other resident fish species typical of the Kuskokwim River drainage also have been found throughout the Mine Site (Table 3.13-4). More detailed descriptions of fish communities in streams surveyed at the Mine Site are provided below.

<u>Upper Watershed</u>

Donlin Creek, Flat Creek, and Dome Creek. Donlin Creek (DO1) provides habitat that supports populations of slimy sculpin, Dolly Varden, burbot, Arctic grayling, and juvenile and adult coho salmon (Table 3.13-4 and Table 3.13-5). Neither juvenile nor adult Chinook salmon have been observed in Donlin Creek during surveys. Coho salmon young-of-the-year have been observed every year, suggesting that the upper reaches of Donlin Creek are likely used by coho salmon for spawning and rearing. Overall, slimy sculpin and coho salmon juveniles appear to be the most abundant species in the upper reaches of this stream while Dolly Varden, Arctic grayling, and burbot were fairly common. The round whitefish was recently documented at this site for the first time (Ottertail 2012b). Intense beaver activity exists in Donlin Creek, often limiting upstream fish migration during dry years (Ottertail 2012b).

Flat Creek (FL1) supports coho salmon, Dolly Varden, Arctic grayling, round whitefish, slimy sculpin, and burbot (Table 3.13-5). Slimy sculpin consistently has been the dominant species in this stream. Coho salmon appear to use Flat Creek for rearing of young in very limited numbers, and some spawning by adults. The only adult coho salmon observed at this site, however, was reported during an aerial survey (Table 3.13-6). Chinook or chum salmon, of any life stage, have not been observed in this creek (Table 3.13-5 and Table 3.13-6).

Species composition at Flat and Donlin creeks is very similar, but substantially more juvenile and adult coho salmon have been observed at Donlin Creek. Young-of-the year coho (total length less than 55 mm) have been observed consistently in both creeks, indicating that spawning and rearing could occur in these drainages.

Surveys of Dome Creek have documented populations of juvenile coho salmon and Dolly Varden (Table 3.13-5). A limited number of adult coho salmon also have been observed in lower reaches of Dome Creek during aerial surveys (Table 3.13-6).

Table 3.13-4: Fish Species Identified within the Crooked Creek Drainage (2004–2013)

Fish Species			Drainage																			
Family	**Scientific Name**	**Common Name**	**Donlin Creek[1]**	**Flat Creek**	**Dome Creek**	**Quartz Gulch**	**Snow Gulch**	**Queen Gulch**	**Crooked Creek[2]**	**Lewis Gulch**	**American Creek**	**Grouse Creek**	**Omega Gulch**	**Anaconda Creek**	**Crevice Creek**	**Eagle Creek**	**Unnamed (BC)**	**Unnamed (AC)**	**Getmuna Creek**	**Unnamed (FN)**	**Bell Creek**	**Grand Total**
Salmonidae	*Oncorhynchus tshawytscha*	Chinook salmon							X										X		X	X
	O. keta	Chum salmon	X						X										X		X	X
	O. kisutch	Coho salmon	X	X	X		X[3]		X		X	X		X[5]					X	X	X	X
	O. gorbuscha	Pink salmon							X[4]													X
	O. nerka	Sockeye salmon							X										X			X
	O. mykiss	Rainbow trout							X[4]													X
	Salvelinus malma	Dolly Varden	X	X	X		X		X		X	X		X	X	X	X		X		X	X
	Thymallus arcticus	Arctic grayling	X	X					X		X			X					X		X	X
	Prosopium cylindraceum	Round whitefish	X	X					X										X		X	X
	Coregonus pidschian	Humpback whitefish							X[4]													X
Catostomidae	*Catostomus catostomus*	Longnose sucker							X													X
Cottidae	*Cottus cognatus*	Slimy sculpin	X	X					X		X	X		X	X	X			X		X	X
Esocidae	*Esox Lucius*	Northern pike							X													X
Umbridae	*Dallia pectoralis*	Alaska blackfish							X													X
Petromyzontidae	*Lethenteron alaskense*	Alaskan brook lamprey							X													X
Gadidae	*Lota lota*	Burbot	X	X					X		X	X		X		X						X
Gasterosteidae	*Pungittius pungittius*	Ninespine stickleback							X												X	X
		Total Species Count	7	6	2	0	2	0	17	0	5	4	0	4	2	3	1	0	8	1	8	17

Notes:

Table includes data from trapping, all electrofishing passes, aerial surveys, and weir counts. Sampling occurred between 21-28 July 2004, 23-28 July 2005, 18-30 July 2006, 21-31 July 2007, 24-28 July 2008, 16-23 July 2009, 20-24 July 2010, 14-21 July 2011, 20-30 July 2012, and 24-25 July 2013.

1 Mouth to endpoint of survey approximately 3 miles (4.8 km) upstream from confluence with Ophir Creek.
2 Mouth to terminus at confluence of Flat and Donlin creeks.
3 Coho salmon adults have only been found in the lower reach of Snow Gulch.
4 Observed at weir site only.
5 A coho salmon juvenile was collected downstream of AN1. One adult coho salmon observed to date. ADF&G also documented coho salmon juveniles downstream of AN1.

Source: ADF&G 2010; Ottertail 2012b; Ottertail 2014c

Table 3.13-5: Summary of Electrofishing Results within the Crooked Creek Drainage (2004–2014)

Stream Name	Site	# Years	# Species	Average # Fish Captured (#/300 feet [91 m])[1]																									
				Coho salmon (juvenile)		Chinook salmon (juvenile)		Sockeye salmon (juvenile)		Dolly Varden		Arctic grayling		Round whitefish		Longnose sucker		Slimy sculpin		Alaska blackfish		Alaskan brook lamprey		Burbot		Ninespine stickleback		Total	
				Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	SD**
Donlin Creek	DO1	9	6	36.3	2 - 182		--		--	3.6	0 - 6.9	2.3	0 - 6.9	0.2	0 - 1		--	99.1	18.7 - 167.1		--		--	1.7	0 - 3		--	**143.2**	**120.1**
Flat Creek	FL1	6	6	1.6	0 - 3.1		--		--	2.1	0 - 10.9	1.0	0 - 3.1	0.3	0 - 1.5		--	129.0	55.8 - 225.4		--		--	2.8	0 - 6.2		--	**136.7**	**65.1**
Dome Creek	DM1	2	2	28.0	0 - 56.1		--		--	26.8	22 - 31.7		--		--		--		--		--		--		--		--	**54.9**	**46.6**
Quartz Gulch	QZ1	1	0		--		--		--		--		--		--		--		--		--		--		--		--	**0.0**	**0.0**
Snow Gulch	SN1	1	1		--		--		--	10.8	N/A		--		--		--		--		--		--		--		--	**10.8**	**N/A**
Snow Gulch	SN2	7	1		--		--		--	3.3	1.2 - 9.4		--		--		--		--		--		--		--		--	**3.3**	**3.7**
Queen Gulch	QU1	1	0		--		--		--		--		--		--		--		--		--		--		--		--	**0.0**	**N/A**
Crooked Creek*	CR2	9	8	18.3	3 - 70.1	2.0	0 - 7.6		--	4.6	1.5 - 11.8	6.1	0 - 27.6	1.3	0 - 7.9		--	165.1	56.4 - 274.3	0.2	0 - 2		--	1.1	0 - 3.9		--	**198.7**	**125.5**
	CR1	9	8	110.0	1.6 - 831.6	2.1	0 - 10.9		--	0.3	0 - 1.6	5.2	0 - 29.5	1.9	0 – 10.7		--	345.1	65.5 – 632.6		--		--	1.2	0 - 4.7	1.4	0 - 3.1	**467.2**	**420.2**
	CR0.7	7	10	35.9	6.4 - 195.7	2.1	0 - 8.5	3.6	0 - 23.4	4.9	0 - 8.5	12.5	0 - 36.2	2.1	0 - 6.4	0.3	0 - 2.1	375.4	142.6 – 704.0	0.3	0 - 2.1		--	4.6	2.1 - 12.8		--	**441.6**	**320.4**
	CR0.3	5	10	11.8	1.5 - 45.5	5.5	0 - 22.7		--	3.0	0 - 12.1	40.3	10.6 - 71.2	5.8	0 - 12.1	7.0	1.5 - 15.2	242.1	121.2 - 319.7	0.3	0 - 1.5	2.7	1.5 - 6.1	4.2	1.5 - 7.6		--	**322.7**	**153.8**
Lewis Gulch	LE1	1	0		--		--		--		--		--		--		--		--		--		--		--		--	**0.0**	**N/A**
American Creek	AM1	7	5	6.0	0 - 18.3		--		--	8.2	2.7 - 15.5	0.4	0 - 1.8		--		--	41.0	3.7 - 99.7		--		--	0.3	0 - 0.9		--	**55.9**	**58.3**
	AM2	1	1		--		--		--	57.0	N/A		--		--		--		--		--		--		--		--	**57.0**	**N/A**
	AM3	1	0		--		--		--				--		--		--		--		--		--		--		--	**0.0**	**N/A**
	AM4	2	0		--		--		--				--		--		--		--		--		--		--		--	**0.0**	**N/A**
Grouse Creek	GR1	1	2		--		--		--	1.4	N/A		--		--		--	36.2	N/A		--		--		--		--	**37.7**	**N/A**
Omega Gulch	OM1	1	0		--		--		--		--		--		--		--		--		--		--		--		--	**0.0**	**N/A**
Anaconda Creek	AN1***	7	5	0.1	0 - 1		--		--	0.8	0 - 3	0.9	0 - 6		--		--	12.4	0.9 - 18		--		--	1.1	0 - 2.7		--	**15.3**	**9.3**
	AN2	4	1		--		--		--	3.4	2 - 3.9		--		--		--		--		--		--		--		--	**3.4**	**1.0**
Crevice Creek	CV1	4	2		--		--		--	0.6	0 - 2.2		--		--		--	42.0	2.2 - 134.3		--		--		--		--	**42.5**	**63.7**
Eagle Creek	EG1	1	3		--		--		--	0.9	N/A		--		--		--	11.8	N/A		--		--	0.9	N/A		--	**13.6**	**N/A**
Unnamed	BC1	1	1		--		--		--	1.0	N/A		--		--		--		--		--		--		--		--	**1.0**	**N/A**
Unnamed	AC1	1	0		--		--		--		--		--		--		--		--		--		--		--		--	**0.0**	**N/A**
Getmuna Creek	GM1	3	7	90.8	15.6 - 231.6	12.0	6 - 21.6	0.8	0 - 2.4	2.4	0 - 7.2	1.2	0 - 2.4	0.4	0 - 1.2		--	410.8	175.2 - 536.4		--		--		--		--	**518.4**	**341.9**
	GM2	1	5	16.0	--					36.0	NA	1.0	NA					59.0	NA									**112.0**	**NA**
	GM3	2	4	35.3	10-65					15.7	6 - 32	0.3	0 - 1					86.0	48 - 154									**137.3**	**NA**
	GM4	1	3	9.0	--					17.0	NA	--	--					31.0	NA									**57.0**	**NA**

Table 3.13-5: Summary of Electrofishing Results within the Crooked Creek Drainage (2004–2014)

Stream Name	Site	# Years	# Species	Average # Fish Captured (#/300 feet [91 m])[1]																									
				Coho salmon (juvenile)		Chinook salmon (juvenile)		Sockeye salmon (juvenile)		Dolly Varden		Arctic grayling		Round whitefish		Longnose sucker		Slimy sculpin		Alaska blackfish		Alaskan brook lamprey		Burbot		Ninespine stickleback		Total	
				Mean	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**SD****
Bell Creek	BL1	2	7	6.0	4.0 - 8.0	0.5	1 - 1		--	1.5	3-3	3.0	N/A	1.5	3 - 3		--	99.0	44 - 154		--		--		--	1.0	2 - 2	**112.5**	**N/A**
Totals			**12***	**405.1**		**24.2**		**4.4**		**205.4**		**74.2**		**13.4**		**73**		**2185.0**		**0.8**		**2.7**		**18.0**		**2.4**		**2942.8**	**1,729.3**

Notes:

See Figure 3.13-1 for site locations.

1 #/300 feet = number of fish per 300 feet (91 m). Fish counts presented in this table represent minimum populations because electrofishing was limited to one pass per reach in 2005 & 2006. To maintain consistent comparisons, only one-pass data were used for all years.

* A total of 17 species have been found in Crooked Creek - Northern pike, chum salmon, pink salmon, humpback whitefish and rainbow trout were documented using other methods including aerial surveys and weir video. Any adult salmon observed in electrofishing reaches were allowed to pass or avoided and are not included in the above counts.

** SD = standard deviation over n (years)

N/A = Standard deviation and ranges not calculated for sites with only 1 year of data; GM2-4 not calculated in Ottertail 2014c.

*** A coho salmon juvenile was collected in 2011 downstream of AN1 in optimum habitat. One adult coho salmon observed to date. ADF&G also documented coho salmon juveniles downstream of AN1.

Source: ADF&G 2010; Ottertail 2014c

Table 3.13-6: Averaged Adult Salmon Aerial Counts for the Crooked Creek Drainage (2004–2014)

Crooked Creek Drainage	REACH	# of Years Surveyed (Summer**, Fall)	Coho			Chinook			Chum			Sockeye			Mean Total Salmon
			Mean[1]	Min	Max	Mean[1]	Min	Max	Mean[1]	Min	Max	Mean[1]	Min	Max	
Reference Streams	DO-R3*	9,10	42.10	0	208	0.0	0	0	0.0	0	0	0.0	0	0	**42.10**
	DO-R2	11,11	43.60	1	190	0.0	0	0	0.50	0	4	0.0	0	0	**44.20**
	DO-R1	11,11	19.5	0	58	0.5	0	5	0.9	0	7	0.0	0	0	**20.9**
	FL-R1	7,8	0.13	0	1	0.0	0	0	0.0	0	0	0.0	0	0	**0.13**
Donlin Creek Tributaries	DM-R1	2,5	1.20	0	5	0.0	0	0	0.0	0	0	0.0	0	0	**1.20**
	SN-R1	4,9	0.33	0	2	0.0	0	0	0.0	0	0	0.0	0	0	**0.33**
Crooked Creek Mainstem	CR-R5	11,11	13.1	0	39	0.60	0	6	1.8	0	8	0.0	0	0	**15.5**
	CR-R4	11,10	11.8	0	38	1.3	0	3	5.4	0	17	0.0	0	0	**18.4**
	CR-R3	11,10	8.2	0	25	1.4	0	4	6.0	1	24	0.0	0	0	**15.6**
	CR-R2	11,10	8.2	0	40	4.2	0	20	133.6	30	178	0.0	0	0	**148.8**
	CR-R1	11,10	4.4	0	14	5.1	0	29	147.2	16	291	0.4	0	3	**157.1**
Crooked Creek Tributaries	AM-R1	6,8	0.38	0	3	0.0	0	0	0.0	0	0	0.0	0	0	**0.38**
	GR-R1	2,2	1.0	0	2	0.0	0	0	0.0	0	0	0.0	0	0	**1.0**
	AN-R1	6,8	0.13	0	1	0.0	0	0	0.0	0	0	0.0	0	0	**0.13**
	CV-R1	6,8	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0	0	**0.0**
	EG-R1	4,3	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0	0	**0.0**
Bell Creek Mainstem	BL-R1	3,3	46.0	134	134	0.0	0	0	3.67	7	7	0.0	0	0	**49.67**
Bell Creek Tributaries	BL-R3	3,3	34.0	97	97	0.0	0	0	0.0	0	0	0.0	0	0	**34.0**
	BL-R2	3,3	42.33	122	122	0.0	0	0	0.0	0	0	0.0	0	0	**42.33**

Table 3.13-6: Averaged Adult Salmon Aerial Counts for the Crooked Creek Drainage (2004–2014)

Crooked Creek Drainage	REACH	# of Years Surveyed (Summer**, Fall)	Coho			Chinook			Chum			Sockeye			Mean Total Salmon
			Mean[1]	Min	Max	Mean[1]	Min	Max	Mean[1]	Min	Max	Mean[1]	Min	Max	
Getmuna Creek Mainstem	GM-R1*	7,8	59.0	3	156	18.00	3	44	259.0	28	701	1.29	0	4	**337.29**
Getmuna Creek Tributaries	GM-R5	3,3	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0	0	**0.0**
	GM-R4	4,5	20.4	12	57	0.0	0	0	0.75	0	3	0.0	0	0	**21.15**
	GM-R3	7,7	36.43	30	60	2.43	0	11	18.71	4	50	0.0	0	0	**57.57**
	GM-R2	7,7	35.57	10	105	0.57	0	4	18.43	0	113	0.0	0	0	**54.57**
	FN-R1	1,2	1.00	2	2	ns	ns	ns	ns	ns	ns	ns	ns	ns	**1.0**
Crooked Creek Drainage Total			**436.01**	**3**	**1,064**	**34.20**	**5**	**62**	**609.36**	**82**	**1,223**	**1.59**	**0**	**7**	**1081.37**
Species RA(%)[2]			**40.32%**			**3.16%**			**56.35%**			**0.15%**			

Notes:
1 Mean = total # fish observed / # years surveyed.
2 Species RA= percent relative abundance of each species. Refer to Figure 3.13-1 for aerial reach locations and adult salmon distributions within the Crooked Creek drainage.
* Only completed fall coho surveys for GM-R1 and DO-R3 in the fall of 2006.
Source: OtterTail 2012b.

Middle Watershed

Upper Crooked Creek, Quartz Gulch, Snow Gulch, Queen Gulch, American Creek, Lewis Gulch, Omega Gulch, and Anaconda Creek. Electrofishing surveys in Crooked Creek indicate this stream provides habitat to juvenile coho and Chinook salmon, Dolly Varden, Arctic grayling, round whitefish, slimy sculpin, burbot, and ninespine stickleback (Table 3.13-5). Of these, slimy sculpin has been consistently the most abundant species, followed by juvenile coho salmon. The presence of juvenile Arctic grayling in Upper Crooked Creek sites suggest nearby spawning of adult Arctic grayling. The presence of juvenile Dolly Varden at these sites is inconclusive, suggesting either that they may overwinter this far upstream in the drainage or simply be seasonally dispersing to utilize these habitats during the open-water months. Aerial surveys along upper reaches of Crooked Creek (reaches CR-R4 and CR-R5) also have documented adult Chinook, chum, and coho salmon in lower numbers than in lower reaches (Table 3.13-6 and Figure 3.13-1). Although aerial surveys and field observations documented limited numbers of chum salmon spawning upstream from this reach in Donlin Creek (reach DO-R1), no juveniles were observed during electrofishing surveys possibly because their fry migrate downstream soon after emergence from spawning gravels.

Quartz Gulch and Queen Gulch are two small streams influenced by historic or current placer mining activity. Electrofishing surveys have not documented fish in either stream (Table 3.13-5).

Electrofishing surveys at Snow Gulch (SN1 and SN2) suggest that Dolly Varden is the only fish species that occurs in this stream (Table 3.13-5). All Dolly Varden collected were over 80 mm in total length. Previous aerial spawning surveys documented coho salmon in the lower Snow Gulch reach (reach SN-R1, Table 3.13-6). Fish habitat in Snow Gulch is limited due to the small size of the drainage. In addition, placer mining activities have filled and blocked the stream channel causing obstructions that could prevent coho salmon and other resident species from entering the main channel of this stream. Survey site SN2 is located well above current placer mining activities (Figure 3.13-1).

The American Creek drainage is the proposed location of the WRF and mine pit (Figure 3.13-1, and Figure 2.3-1 in Chapter 2, Alternatives). Species found during electrofishing surveys (sites AM1 and AM2) include juvenile coho salmon, Dolly Varden, Arctic grayling, slimy sculpin, and a limited number of burbot (Table 3.13-5). The presence of coho salmon juveniles at site AM1 suggests that limited spawning may occur in or near this drainage. Aerial surveys conducted along American Creek also have documented the presence of adult coho salmon in small numbers, while Chinook and chum salmon have not been observed (Table 3.13-6). A winter-use survey determined that surface flow was discontinuous within American Creek during this season, so overwintering fish distribution may be limited to localized unfrozen areas (NES and HDR Alaska, Inc. 1999). Overall, the potential of American Creek to support coho salmon is likely limited by its small size.

Lewis and Omega Gulches are two other streams that would be directly affected by the Mine Site, although no fish have been collected during surveys conducted at these locations (Table 3.13-4) (Ottertail 2012b). In addition, Lewis Gulch has been rerouted by placer mine activities and the lowermost reach has been converted to a man-made canal that diverts water into Crooked Creek just upstream of American Creek at site CR2 (Figure 3.13-1).

Anaconda Creek is the proposed location of the tailings storage facility (TSF) (Figure 3.13-1, and Figure 2.3-1 in Chapter 2, Alternatives). Suitable spawning habitat for salmon species is unlikely to occur in this creek since the dominant substrate type consists of silt. Electrofishing surveys in sites along this creek (AN1 and AN2) have only documented Dolly Varden, slimy sculpin, and burbot in low abundance (Table 3.13-5). Juvenile coho salmon have been observed downstream of site AN1 (ADF&G 2010; Ottertail 2012b). The single adult coho salmon observed during aerial surveys in the lowermost reach of Anaconda Creek, however, was likely to be a stray from a nearby tributary or the Crooked Creek mainstem (Table 3.13-6) (Ottertail 2012b).

Salmon spawning habitat within Crooked Creek is concentrated in the lower sections of the drainage below the Getmuna Creek confluence, although salmon redds (predominately those of coho salmon) also have been observed in the upper Crooked Creek drainage (Ottertail 2012b). Higher redd density in the lower drainage may be explained by the closer proximity to the Kuskokwim River, higher summer and winter flows influenced by the Getmuna and Bell creek drainages, and greater availability of suitable spawning habitat.

Lower Watershed

Lower Crooked Creek, Crevice Creek, Unnamed (AC) Creek, Unnamed (BC) Creek, Getmuna Creek, and Bell Creek. Electrofishing surveys conducted along the lower reaches of Crooked Creek (CR0.7 and CR0.3) have revealed the presence of Arctic grayling, Dolly Varden, round whitefish, longnose sucker, slimy sculpin, Alaska blackfish, Alaskan brook lamprey, as well as juvenile coho, chum, and sockeye salmon (Table 3.13-5). The abundance of juvenile coho salmon observed at these sites was generally lower than at the sites surveyed upstream in Crooked Creek (CR1 and CR2). Conversely, a larger number of adult Chinook, chum, and coho salmon were observed during aerial surveys at the lowermost reaches (CR-R1, CR-R2 and CR-R3) than in reaches located farther upstream (Table 3.13-6). The majority of Chinook salmon and chum salmon spawning was observed to occur in reaches CR-R1 and CR-R2 (Figure 3.13-1). As noted previously, Chinook salmon have been observed as far upstream as the upper Crooked Creek mainstem (reach CR-R5) but have not been observed in Donlin Creek or any of the upper tributaries surveyed (Table 3.13-6). A small number of adult chum salmon have been sporadically observed as far upstream as Donlin Creek (Ottertail 2012b).

In addition to fish population data based on electrofishing and aerial surveys in Crooked Creek, underwater video from the resistance-board weir installed in 2008 at lower Crooked Creek 1.5 river miles upstream from the Kuskokwim River confluence has provided more insight into salmon escapement in this drainage (Table 3.13-7). The weir is located downstream of all major tributaries, allowing for an accurate portrayal of escapement totals for the entire drainage (Figure 3.13-1) (Ottertail 2014c). Coho salmon escapement has ranged from a low of 591 in 2011 to a high of 4,204 in 2008. Half of the run has generally passed through the weir by early September. The Chinook salmon run is small, ranging from 23 to 100 fish between 2008 and 2012, with median passage occurring in mid-July. Chum salmon numbers have ranged from 832 to 1,991 during these same years, with half of the run generally passing by the end of July. Small numbers of pink salmon have been documented at the weir with up to 59 fish documented in 2009. Sockeye salmon, the least abundant salmon in Crooked Creek, have median passage dates that extend from mid-July to early August, similar to pink salmon. Sockeye salmon numbers ranged from 1 to 60 fish between 2009 and 2012. Other fish species documented by weir video in Crooked Creek include humpback whitefish, northern pike, and rainbow trout (Ottertail 2014c).

Table 3.13-7: Crooked Creek Weir Salmon Escapement Summary, 2008 to 2012

Species	2008	2009		2010		2011		2012	
	#	#	%	#	%	#	%	#	%
Chinook Salmon	86	100	2.89	49	1.94	23	0.93	29	1.66
Chum Salmon	1,699	1,991	57.62	1,257	49.72	1,839	74.67	832	47.57
Coho Salmon	4,204	1,295	37.48	1,212	47.94	591	24.0	868	49.63
Pink Salmon	11	59	1.71	5	0.20	4	0.16	19	1.09
Sockeye Salmon	60	10	0.29	5	0.20	6	0.24	1	0.06
Totals	**6,060**	**3,455**		**2,528**		**2,463**		**1,749**	

Notes:

Numbers have been corrected for periods when weir was inoperable. Weir operation period was from 7/26/2008 to 9/29/2008, 6/3/2009 to 9/28/2009, 6/17/2010 to 9/27/2010, 6/27/2011 to 9/27/2011, and 6/27/2012 to 9/28/2012.

Source: Ottertail 2014c

The Crevice Creek drainage may be affected by flow diversions associated with the tailings storage facility (TSF). Electrofishing and aerial surveys conducted along this stream at site CV1 and reach CV-R1 have shown that fish diversity is low with only two species observed (i.e., Dolly Varden and slimy sculpin; Table 3.13-5). No salmon species have been observed in Crevice Creek (Ottertail 2012b).

The small unnamed drainages (AC1 and BC1) have not been found to support any salmon species. A single Dolly Varden was observed at site BC1 in 2010 (Table 3.13-5) (Ottertail 2012b).

The upper reaches of Getmuna Creek (located in the Getmuna Flats between the North and South forks) have been identified as a probable borrow material site for the proposed project (Figure 3.13-1, and Figure 2.3-12 in Chapter 2, Alternatives). The fish community composition in Getmuna Creek is similar to that observed at Lower Crooked Creek sites, but in higher abundance, suggesting it is an important tributary. Juvenile coho, Chinook, and sockeye salmon, as well as Dolly Varden, Arctic grayling, round whitefish, and slimy sculpin have been observed during electrofishing surveys in this creek at sites GM1 and GM3 (Table 3.13-5). Aerial observations also have found relatively high numbers of Chinook, chum, and coho salmon, and low numbers of sockeye salmon in this tributary (Table 3.13-6).

Bell Creek was sampled for the first time in 2011 to help complete the understanding of fish in the Crooked Creek watershed. Electrofishing surveys documented coho salmon, Chinook salmon, round whitefish, Dolly Varden, Arctic grayling, ninespine stickleback, and slimy sculpin. During summer aerial surveys, adult chum salmon were observed in the lower portions of the mainstem in 2011. Fall aerial flights in 2011 documented a substantial adult coho population in Bell Creek (Table 3.13-6).

3.13.2.1.3 ESSENTIAL FISH HABITAT

Under the Magnuson-Stevens Act, EFH is designated for fish species managed by federal Fishery Management Plans. EFH is defined as "those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 U.S.C. 1801-1883). EFH involves any of the habitat types utilized by federally regulated species over their entire life cycle. The Kuskokwim River and certain reaches of many of its tributaries, including those in the Crooked Creek watershed, are classified as EFH for Pacific salmon. This is based on documented uses of these waters and their gravel substrates by various salmon life stages as described in extended inventories by NMFS and ADF&G (NMFS 2005a; Johnson and Daigneault 2013). Salmon species observed in the Crooked Creek watershed, including drainages associated with the Mine Site area, include Chinook, chum, coho, pink, and sockeye. Of these, coho, Chinook, and chum salmon are the species having the greatest presence in the Crooked Creek watershed. Spawning and rearing EFH that supports these species occurs in drainages throughout the system (Johnson and Daigneault 2013).

All freshwater resources that these species rely on in the Crooked Creek and Kuskokwim River watersheds over their life cycles are regulated as EFH. Figure 3.13-1 shows drainages within the Crooked Creek watershed and Mine Site area known to support salmon species associated with EFH.

The NMFS' Habitat Conservation Division works in coordination with industries, stakeholder groups, government agencies, and private citizens to avoid, minimize, or offset the adverse effects of human activities on EFH and living marine resources in Alaska. This work includes conducting and/or reviewing environmental analyses for a large variety of activities ranging from commercial fishing to coastal development to large transportation and energy projects. The Habitat Conservation Division identifies technically and economically feasible alternatives and offers realistic recommendations for the conservation of valuable living marine resources. The Habitat Conservation Division focuses on activities in habitats used by federally managed fish species located offshore, nearshore, in estuaries, and in freshwater areas important to anadromous salmon (NMFS 2015). Appendix Q, the Essential Fish Habitat Assessment, provides more detailed information on EFH in the project area including an assessment of potential effects of Alternative 2 on these resources.

The EFH consultation process is separate and concurrent with the NEPA process. Typically, the timing of EFH consultation is as follows: 1) the Corps provides notification of the action to NMFS, 2) the Corps submits an EFH Assessment to NMFS, 3) NMFS reviews the EFH Assessment, and, if necessary, provides EFH Conservation Recommendations to the Corps within 30-60 days, and 4) the Corps responds to NMFS within 30 days with information on how it will proceed with the action.

3.13.2.1.4 MACROINVERTEBRATES

Macroinvertebrates are an important food base for salmonids and effective indicators of water quality and habitat impairment that could result from elevated concentrations of metals and other contaminants and excessive sedimentation. The varied life histories and contaminant tolerances of indicator species can be used to identify both short- and long-term environmental changes, and to establish a relative index of water quality. Benthic macroinvertebrate production in the Lower Kuskokwim River drainage is relatively low, resulting from high sediment loads and sandy substrates. An early study found that annelids were the most dominant invertebrates, followed by mollusks and insects, which were found infrequently (AGRA 1999).

Specific inventories within the Mine Site area have been conducted for the proposed project to characterize macroinvertebrate communities and to provide baseline data for the assessment of potential impacts from mining (Ottertail 2014c). The Shannon diversity, evenness, and Hilsenhoff biotic indices suggest that natural stressors are present in the system (Table 3.13-8). A plausible explanation for this discrepancy is based on the drastic seasonal changes in habitat conditions often observed in streams in this area. Within the Crooked Creek drainage, several of the smaller tributaries can freeze to the stream bottom during winter (NES and HDR Alaska, Inc. 1999). In addition, the underlying geology of the area causes siltation in the Crooked Creek drainage, which leads to a highly embedded stream bottom. Heavy silt loads fill the interstitial spaces in the gravel, which limits the available habitat for macroinvertebrates (Waters 1995), and exacerbates the effects of winter freezing by limiting the amount of habitat available for colonization.

3.13.2.1.5 FISH TISSUE METALS ANALYSIS

Elevated concentrations of metals in sediments, fish, and other aquatic biota have been documented in the Kuskokwim drainage reflecting the geologic character and historic mining activities of the watershed. The middle Kuskokwim River basin, which includes the Crooked Creek drainage, runs through a highly mineralized region of Alaska's "mercury belt" named for the abundance of mercury mineral deposits and mines in the watershed (Gray et al. 1994, 2000). The potential for mercury, arsenic, antimony, and other trace elements to transfer from mined and unmined sources to the environment, including aquatic habitats, fish, and their prey species, have been extensively studied. Natural sources of mercury include atmospheric transport and deposition from forest fires and volcanoes as well as weathering of mercury-rich mineral deposits (cinnabar and elemental mercury). Human-caused mercury sources include global air pollution (e.g., burning fossil fuels and garbage), historic use of mercury as an amalgam in placer mining, and surface water runoff and groundwater that becomes contaminated when flowing through mine tailings and waste rock (Matz 2012, 2014).

Because of global human health concerns regarding mercury concentrations in fish, contaminant studies in western Alaska have been conducted over the past two decades to assess human health risks from consumption of fish, a primary component of the subsistence diet of Alaska Natives. Such studies have shown measurable concentrations of mercury in predatory fish species in both the Kuskokwim and Yukon river basins (Jewett and Duffy 2007; Matz 2012).

In freshwater aquatic ecosystems, elemental and inorganic mercury complexes can be transformed by anaerobic bacteria to methylmercury (MeHg), the most toxic form of mercury to humans, in sediments associated with standing water such as wetlands, ponds, lakes, backwaters of rivers and streams, and water storage reservoirs (Fenchel and Blackburn 1979; Manahan 1991; Friberg and Vostal 1972; Matz 2014). Shallow sediment catchments and the anoxic bottom waters of stratified lakes are considered important zones of net methylation which are less prevalent in environments with higher flow and low hydraulic retention (St. Louis et al. 1994). In-river methylation is typically a negligible component of the methylmercury budget for creeks whereas wetlands are frequently the most important contributor of methylmercury to downstream aquatic ecosystems (St. Louis et al. 1996, Berndt and Bavin 2012).

Most mercury in edible fish muscle tissue exists as MeHg which has been found to accumulate in high concentrations in fish-eating, long-lived resident fish such as northern pike and burbot (Jewett and Duffy 2007; Matz 2012). While exceptionally low levels of MeHg have been found in muscle tissue of Pacific salmon, the most commonly consumed fish group in the Alaska subsistence diet, there has been an increased reliance in recent years on non-salmonid species (including northern pike and burbot) in the Kuskokwim River subsistence fishery as Chinook salmon runs have diminished.

Since 2010, the BLM, in cooperation with the USFWS and ADF&G, investigated mercury, arsenic, and antimony concentrations in tissue samples of fish collected from the Central Kuskokwim River area. Species sampled included aquatic insects and resident fish (slimy sculpin, juvenile Dolly Varden, and juvenile Arctic grayling) from the mainstem river and tributaries (Red Devil Creek and Cinnabar Creek) associated with abandoned mines whose confluences are located upstream from the Crooked Creek confluence. Other resident fish species, including Arctic grayling, northern pike, sheefish, and burbot, from large tributaries also were collected and sampled. For slimy sculpin, for example, tissue concentrations were higher than levels detected for this species in the Crooked Creek drainage as described below. Section 3.13.2.2.4 provides additional information on metals concentrations in fish in the mainstem Kuskokwim River and its tributaries.

In 2004, an analysis was initiated within the Crooked Creek drainage to assess metals concentrations in the tissue of slimy sculpin, a resident fish species. The two goals of the sampling and analysis plan were to document baseline metals concentrations in the tissue of slimy sculpin of a comparable size (less than 55 mm in length) and to assess the use of sculpin as an indicator species to detect potential future impacts associated with the proposed project (Ottertail 2012b). Additional fish tissue metal analysis was conducted on Getmuna Creek in 2012, 2013, and 2014 (Ottertail 2014c).

A consistent pattern of increasing or decreasing tissue metal concentrations in sculpin across years or sites has not been observed. Metals concentrations, while not significantly different, were generally lower in 2009 than in previous years. In 2010, it was noted that concentrations for certain metals increased to levels observed in years prior to 2009 (Table 3.13-9).

Across all sites surveyed, arsenic, copper, mercury, selenium, and zinc tended to have the smallest coefficients of variation. Therefore, future modifications in the tissue concentration of these metals may be more easily detected than for other metals. A substantial amount of annual variability in concentrations has been observed for all metals except manganese and selenium. Differences in metal concentrations have also been observed across sites. Higher concentrations of both mercury and arsenic have been observed in samples collected at the upper Crooked Creek site (CR2) than in samples from other sites (Table 3.13-9). Three year average mercury and copper concentrations in Getmuna Creek were higher than concentrations for mainstem Crooked Creek (Table 3.13-9).

Section 3.7.2.1.1, Water Quality, presents additional information regarding total mercury levels in surface waters in the vicinity of the mine site relative to EPA acute and chronic water quality criteria for aquatic life: 2,400 nanograms per liter (ng / L) and 12 ng / L, respectively (EPA 2013k). Based on 564 water samples collected in the Crooked Creek drainage between June 2005 and

June 2015, total mercury concentrations ranged from 0.518 to 19,500 ng/L; mean = 7.81 ng/L (SRK 2017b). These data suggest that existing concentrations of total mercury in surface water are sometimes elevated above the applicable chronic criterion for the protection of aquatic life at locations throughout the mine site area, with occasional spikes above the acute criterion, possibly due to precipitation and localized rock weathering conditions. Ongoing and future mining activities in the Crooked Creek drainage would contribute to additional inputs of mercury to surface water from atmospheric and aqueous sources, possibly causing exceedances of the 12 ng/L chronic criterion at sites within the drainage.

Table 3.13-8: Macroinvertebrate Bioassessment Summary Statistics within the Crooked Creek Drainage (2004 to 2014)

Site		DO1	FL1	DM1	QZ1	SN2	QU1	CR2	CR1	CR0.7	CR0.3	AM1	AM2	GR1	OM1	AN1	AN2	CV1	EG1	GM1	GM2	GM3	GM4	BL1
Years Sampled		**9**	**6**	**2**	**1**	**6**	**1**	**9**	**9**	**7**	**5**	**6**	**1**	**1**	**1**	**4**	**4**	**4**	**1**	**3**	**1**	**3**	**1**	**2**
Total # of Replicates		**45**	**28**	**10**	**5**	**30**	**3**	**45**	**45**	**35**	**25**	**30**	**3**	**5**	**5**	**20**	**20**	**20**	**5**	**13**	**5**	**15**	**5**	**10**
		General Metrics[1]																						
Abundance[2] (# / ft)	Mean	244.3	498.8	155.8	259.2	90.2	435.3	212.4	229.9	262.7	377.9	175.5	587.0	66.6	79.8	61.7	34.1	124.8	59.0	460.5	75.8	170.2	179.0	35.3
	SD±	181.3	290.9	116.0	--	34.1	--	190.1	169.6	196.1	272.2	110.1	--	--	--	40.5	31.8	57.5	--	298.2	--	41.7	--	19.1
# Taxa	Mean	20.2	20.0	16.5	15.0	14.3	13.0	19.8	19.4	20.1	19.8	17.7	21.0	12.0	11.0	12.5	12.8	15.5	14.0	22.7	12.0	13.7	13.0	10.5
	SD±	4.1	1.7	2.1	--	4.0	--	4.2	3.6	3.7	2.9	2.7	--	--	--	2.6	4.8	1.3	--	3.1	--	1.5	--	0.7
# EPT Taxa	Mean	11.8	11.5	8.5	6.0	7.7	4.0	11.3	10.7	11.1	11.2	9.2	7.0	6.0	4.0	6.3	5.8	7.8	6.0	13.7	9.0	8.7	8.0	7.0
	SD±	2.0	1.2	2.1	--	1.4	--	1.9	2.9	1.6	2.5	1.6	--	--	--	2.5	3.0	1.0	--	1.2	--	0.6	--	--
% EPT Taxa	Mean	30.7	20.6	57.6	51.7	25.7	59.0	34.8	35.6	28.6	27.2	35.8	14.8	18.9	64.7	51.6	36.0	21.2	68.8	40.9	15.8	29.0	74.2	41.6
	SD±	12.4	7.0	15.2	--	9.1	--	12.9	8.3	8.2	7.4	14.7	--	--	--	18.7	20.7	12.7	--	16.3	--	14.6	--	28.1
% Dominant Taxon	Mean	54.7	56.4	30.7	45.4	57.2	25.1	39.1	41.7	58.0	52.7	43.1	69.0	51.7	41.4	28.3	31.5	50.0	29.8	50.9	79.7	59.7	29.4	49.7
	SD±	19.1	18.0	13.9	--	10.7	--	10.4	12.3	14.7	9.5	16.3	--	--	--	6.2	8.1	11.9	--	16.1	--	17.0	--	28.8
% Chironomidae	Mean	54.7	54.1	14.5	42.3	53.0	14.2	32.3	38.8	58.0	52.7	35.5	8.1	6.0	10.0	17.9	31.0	16.9	18.3	50.3	79.7	59.7	8.4	49.3
	SD±	19.1	21.6	1.7	--	16.2	--	13.9	15.3	14.7	9.5	20.8	--	--	--	8.3	8.8	14.8	--	17.3	--	17.0	--	29.4
EPT/Chironomidae Ratio	Mean	0.7	0.5	3.9	1.2	0.5	4.1	1.7	1.1	0.6	0.5	1.4	1.8	3.2	6.5	3.4	1.3	8.1	3.8	1.0	0.2	0.5	8.9	1.2
	SD±	0.6	0.4	0.6	--	0.2	--	1.7	0.6	0.3	0.2	0.9	--	--	--	2.2	0.9	14.6	--	0.8	--	0.3	--	1.3
		Diversity Indices[1]																						
Shannon (H)	Mean	1.68	1.50	2.02	1.21	1.46	1.75	1.95	1.82	1.56	1.75	1.69	1.30	1.59	1.60	1.90	1.90	1.52	1.92	1.66	0.95	1.43	2.08	1.49
	SD±	0.5	0.4	0.2	--	0.2	--	0.2	0.3	0.4	0.2	0.3	--	--	--	0.1	0.2	0.3	--	0.2	--	0.4	--	0.4
Evenness (e)	Mean	0.57	0.50	0.72	0.45	0.56	0.68	0.66	0.62	0.52	0.59	0.59	0.43	0.64	0.67	0.76	0.78	0.56	0.73	0.53	0.38	0.55	0.81	0.64
	SD±	0.2	0.1	0.0	--	0.1	--	0.1	0.1	0.1	0.1	0.1	--	--	--	0.1	0.1	0.1	--	0.1	--	0.2	--	0.2
		Biotic Index																						
Hilsenhoff Biotic	Mean	4.83	5.03	3.28	3.41	4.20	3.93	4.59	4.73	4.95	4.88	4.28	3.34	3.71	2.38	4.01	4.36	3.84	3.35	4.68	5.27	4.90	3.51	4.04
	SD±	0.4	0.4	0.5	--	1.0	--	0.4	0.3	0.3	0.4	0.6	--	--	--	0.5	0.4	0.5	--	0.3	--	0.4	--	1.6

Notes:

For sample site locations, refer to Figure 3.13-1.

1 Refer to Ottertail (2014c) for definitions of metrics. Shannon (H) and Evenness (e) diversity indices quantify overall biodiversity by measuring the number of species present and how even the number of individuals for each species is distributed in the data set. For example, Shannon (H) is highest when all species present are comprised of an equal number of individuals. The Hilsenhoff Biotic Index is a measure of water quality ranging from 0 to 10 based on the presence of macroinvertebrate families and their tolerance to pollution with 0 being least polluted.

2 Excludes orders composing less than 1.0 percent per site. Chironomidae grouped as 1 taxon for multi-year comparisons.

Abbreviations:

EPT = Ephemeroptera, Plecotera, Trichoptera
Mean = Average of all samples for all years
SD = standard deviation of the mean. SD not calculated for sites with only one year of data.

Source: Ottertail 2014c.

Table 3.13-9: Average Metal Concentrations in Slimy Sculpin <55mm Long within the Crooked Creek Drainage (2004 to 2014)

Site ID	Year	*n*	(mg/kg Wet Weight)											
			Al	**Sb[1]**	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Pb**	**Mn**	**Hg**	**Se**	**Zn**
DO1	2004	6	131	0.0028	0.18	0.019	0.30	0.73	185	0.047	23.58	0.023	1.00	21.8
	2005	6	115	0.0023	0.18	0.019	0.47	0.88	131	0.026	23.15	0.032	0.84	19.3
	2006	9	94	0.0050	0.25	0.023	0.12	0.84	108	0.024	14.90	0.038	0.72	26.9
	2007	15	68	0.0047	0.17	0.018	0.12	0.69	89	0.023	14.90	0.034	0.93	21.1
	2008	15	83	N/A	0.17	0.018	0.20	0.62	104	0.026	14.55	0.038	0.68	20.5
	2009	15	46	N/A	0.12	0.010	0.06	0.49	58	0.012	23.03	0.027	0.62	15.4
	2010	15	86	N/A	0.14	0.014	0.21	0.67	81	0.038	11.79	0.029	0.88	20.9
	2011	15	70	N/A	0.13	0.014	0.16	0.52	85	0.027	12.19	0.025	.72	17.5
	2012	15	34.7	N/A	0.12	0.02	0.97	0.84	62.69	0.04	11.76	0.03	1.22	19.87
	Grand Mean		**80.63**	**0.0037**	**0.16**	**0.02**	**0.29**	**0.70**	**100.32**	**0.03**	**16.65**	**0.03**	**0.85**	**20.37**
	SD		**30.80**	**0.0013**	**0.04**	**0.00**	**0.28**	**0.14**	**38.81**	**0.01**	**5.11**	**0.01**	**0.19**	**3.16**
	CV		**0.38**	**0.3600**	**0.25**	**0.22**	**0.97**	**0.20**	**0.39**	**0.37**	**0.31**	**0.19**	**0.22**	**0.16**
CR2	2004	6	64	0.0055	0.48	0.015	0.24	0.65	82	0.021	10.98	0.032	1.08	20.5
	2005	6	92	0.0080	0.61	0.019	0.35	0.87	120	0.025	19.98	0.045	0.87	18.2
	2006	3	116	0.0063	0.56	0.025	0.10	0.90	127	0.029	12.10	0.045	0.90	27.5
	2007	15	80	0.0061	0.45	0.016	0.21	0.74	102	0.028	10.69	0.042	1.27	21.7
	2008	15	44	N/A	0.45	0.014	0.17	0.63	77	0.014	7.16	0.048	0.95	22.0
	2009	15	36	N/A	0.31	0.013	0.04	0.61	59	0.012	8.80	0.032	1.12	18.0
	2010	15	103	N/A	0.46	0.013	0.58	0.62	128	0.041	11.03	0.040	0.87	17.0
	2011	15	143	N/A	0.66	0.016	0.52	0.65	258	0.048	13.21	0.042	0.65	17.9
	2012	15	39.89	NA	0.34	0.01	0.76	0.98	83.91	0.02	9.77	0.04	1.10	21.27
	Grand Mean		**79.68**	**0.0065**	**0.48**	**0.02**	**0.33**	**0.74**	**115.16**	**0.03**	**11.52**	**0.04**	**0.98**	**20.46**
	SD		**37.20**	**0.0011**	**0.12**	**0.00**	**0.24**	**0.14**	**58.72**	**0.010**	**3.63**	**0.006**	**0.18**	**3.24**
	CV		**0.47**	**0.1600**	**0.24**	**0.23**	**0.74**	**0.19**	**0.51**	**0.47**	**0.32**	**0.13**	**0.19**	**0.16**
CR1	2004	15	54	0.0026	0.29	0.016	0.15	0.62	66	0.019	11.96	0.029	1.05	18.3
	2005	15	82	0.0039	0.31	0.025	0.36	1.16	100	0.025	15.65	0.033	1.10	19.5
	2006	25	104	0.0054	0.45	0.026	0.13	0.83	113	0.027	14.95	0.035	0.84	21.4
	2007	15	86	0.0049	0.31	0.021	0.15	0.65	87	0.026	11.42	0.027	0.86	19.4
	2008	15	50	N/A	0.29	0.018	0.16	0.58	69	0.017	9.78	0.041	0.85	21.6
	2009	15	79	N/A	0.23	0.012	0.09	0.52	76	0.018	10.66	0.026	0.71	15.5
	2010	15	61	N/A	0.23	0.012	0.18	0.53	57	0.022	12.55	0.029	0.62	19.2

Table 3.13-9: Average Metal Concentrations in Slimy Sculpin <55mm Long within the Crooked Creek Drainage (2004 to 2014)

Site ID	Year	*n*	(mg/kg Wet Weight)											
			Al	**Sb[1]**	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Pb**	**Mn**	**Hg**	**Se**	**Zn**
	2011	15	97	N/A	0.23	0.017	0.17	0.54	89	0.034	10.51	0.026	0.65	18.6
	2012	15	55.62	N/A	0.23	0.02	1.13	1.14	72.78	0.15	11.98	0.03	0.86	21.17
	Grand Mean		**74.27**	**0.0065**	**0.29**	**0.02**	**0.28**	**0.73**	**81.04**	**0.04**	**12.16**	**0.03**	**0.84**	**19.40**
	SD		**19.73**	**0.0011**	**0.07**	**0.01**	**0.33**	**0.26**	**17.94**	**0.04**	**1.98**	**0.01**	**0.16**	**1.90**
	CV		**0.27**	**0.1600**	**0.25**	**0.28**	**1.16**	**0.35**	**0.22**	**1.10**	**0.16**	**0.16**	**0.19**	**0.10**
CR0.7	2006	29	109	0.0051	0.43	0.032	0.17	0.98	123	0.028	16.74	0.031	1.01	23.2
	2007	15	94	0.0050	0.30	0.021	0.19	0.70	98	0.027	12.02	0.034	1.03	19.5
	2008	15	42	N/A	0.27	0.016	0.14	0.53	52	0.016	10.25	0.038	0.90	19.9
	2009	15	46	N/A	0.22	0.013	0.05	0.58	47	0.012	9.07	0.022	0.97	15.5
	2010	15	61	N/A	0.21	0.015	0.33	0.56	57	0.028	13.00	0.034	0.67	18.0
	2011	15	70	N/A	0.22	0.017	0.11	0.53	75	0.024	9.88	0.013	0.64	17.0
	2012	15	47.36	N/A	0.23	0.02	0.39	0.93	73.71	0.03	14.22	0.03	1.19	21.14
	Grand Mean		**67.08**	**0.0051**	**0.27**	**0.019**	**0.20**	**0.69**	**75.04**	**0.023**	**12.17**	**0.032**	**0.92**	**19.19**
	SD		**25.83**	**0.0001**	**0.08**	**0.008**	**0.12**	**0.20**	**27.31**	**0.008**	**2.72**	**0.006**	**0.20**	**2.58**
	CV		**0.38**	**0.0200**	**0.30**	**0.33**	**0.62**	**0.28**	**0.36**	**0.28**	**0.22**	**0.16**	**0.22**	**0.13**
GM3.0	2012	14	28.93	N/A	0.22	0.01	0.44	1.30	56.51	0.06	7.77	0.05	1.32	20.64
	2013	16	57.68	N/A	0.24	0.02	0.14	0.57	80.50	0.02	8.89	0.07	1.31	22.52
	2014	15	61.23	N/A	0.47	0.01	0.26	0.63	192.20	0.03	18.57	0.03	1.12	18.93
	Grand Mean		**49.28**	**N/A**	**0.31**	**0.01**	**0.28**	**0.83**	**107.74**	**0.03**	**11.74**	**0.05**	**1.25**	**20.70**
	SD		**20.33**	**N/A**	**0.01**	**0.00**	**0.21**	**0.52**	**16.96**	**0.03**	**0.79**	**0.01**	**0.01**	**1.33**
	CV		**0.33**	**N/A**	**0.03**	**0.21**	**0.82**	**0.82**	**0.09**	**1.21**	**0.04**	**0.34**	**0.00**	**0.07**

Notes:

1 Only a fraction of the samples of antimony were detected above the method detection limit; therefore, data presented here for reference purposes only.
A wet weight to dry weight conversion chart and method detection limits for each analyte can be found in Ottertail 2014c.

Abbreviations:

Al = aluminum
As = arsenic
Cd = cadmium
Cr = chromium
Cu = copper
CV = coefficient of variation (SD/Mean)
Fe = iron
Grand Mean = Average of of all years sampled
Hg = mercury
Mn = manganese
n = the number of composite samples analyzed per given year.
Pb = lead
Sb = antimony
SD = standard deviation of the means per year
Se = selenium
Zn = zinc

Source: Ottertail 2014c

3.13.2.2 TRANSPORTATION CORRIDOR

3.13.2.2.1 AQUATIC HABITAT

Aquatic Habitat within Kuskokwim River Corridor

The Kuskokwim River watershed is a basin encompassing approximately 50,200 mi^2 and is the second largest drainage in Alaska. The Kuskokwim River flows about 900 miles from the headwaters of the Kuskokwim Mountains in the Alaska Interior southwest to the Bering Sea. The proposed Transportation Corridor extends up the Kuskokwim River from Kuskokwim Bay to the proposed port site at either Angyaruaq (Jungjuk) or, alternatively, BTC (Figure 3.13-2, and Figure 2.3-42 in Chapter 2, Alternatives). During the Construction Phase of the pipeline crossing near milepost 240, barge traffic also would travel upriver beyond Stony River to the east and west Kuskokwim River barge landings.

Downriver of Aniak, the river is characterized by low gradient, interconnected meandering channels and sloughs. Tidal influence extends from Kuskokwim Bay upriver to Tuluksak (RM 136). Substantial lateral movement of the channel, which shifts continuously in response to changing levels of flow, has resulted in extensive natural bank erosion, riverbed scour, and high sediment loading. Riverbed substrates primarily consist of a sand/silt/clay composition. Changes in the channel morphology frequently alter riverine habitat through erosion and creation of sand bars (AGRA 1998). Fallen trees, associated with accelerated rates of bank erosion, line most steep banks and provide important refuge and cover for fish. Upstream of Akiak, the river exhibits less lateral movement, although bank erosion is still extensive, and more islands and vegetated sand bars occur than in downstream reaches (AGRA 1998). Near the proposed Angyaruaq (Jungjuk) Port site, the river bed consists primarily of gravel with some cobbles overlain and mixed with silt and sand. Aquatic habitat in the immediate vicinity of the proposed port site is more uniform as the channel is unbraided with no established islands (Figure 2.3-12 in Chapter 2, Alternatives).

Extensive gravel extraction and related barging along the main channel and sloughs of the Kuskokwim River take place from Aniak downriver about 47 miles to the Cenaliulriit Coastal District boundary. This area includes the proposed alternative port site at BTC. Photo interpretive maps indicate there have been well over 100 discrete material sites along this section of river in recent years. BTC, located about 12 river miles downriver of Aniak, is one of the largest material sites along the river in this area. Aggregates from this area are in demand for fill and concrete use associated with transportation, flood control, and building projects in Upper and Lower Kalskag, Bethel, and other communities. Aggregate demands for such projects are particularly high along the Lower Kuskokwim River and Y-K Delta where these materials are in short supply (ADNR 1988).

Aquatic Habitat within Road Corridors

Mine Access Road Corridor

In this section, aquatic habitat at crossings along the proposed 30-mile-long, two-lane, 30-foot-wide, all season gravel mine access road corridor will be described moving in a northerly direction beginning at the Angyaruaq (Jungjuk) Port site (Figure 3.13-1, and Figures 2.3-11 and

2.3-12 in Chapter 2, Alternatives). Along the road corridor, 51 streams or drainages would be crossed involving 6 span bridges, for crossings over waters used by Chinook, coho, and chum salmon, and 45 culverts. Construction materials would be excavated from 13 material borrow sites; the largest of which (about 205 acres) would be located at MP 10.4-11.0 just upstream of the juncture of the north and south forks of Getmuna Creek (Table 2.3-9 in Chapter 2, Alternatives).

Jungjuk Creek joins the Kuskokwim River just downstream of the proposed Angyaruaq (Jungjuk) Port site at the south terminus of the mine access road corridor. As the road corridor extends west and north from the port site, it crosses a small unnamed tributary to the Kuskokwim River and two unnamed Jungjuk Creek tributaries. About 2.6 miles west of the port site, the road corridor crosses Jungjuk Creek (JJ1) and then crosses it again at 3.4 miles. The creek in this area has a moderate gradient, a substrate composition dominated by gravel and cobble, and flows that often run clear. Beaver activity is prevalent in most of the drainage (Ottertail 2012b).

As the road corridor continues north, it crosses the South Fork and North Fork of Getmuna Creek. A proposed material borrow site is located between these forks (Figure 2.3-12 in Chapter 2, Alternatives). Getmuna Creek drains an area of 98.6 mi^2 and is the largest tributary in the Crooked Creek drainage. Getmuna Creek has a repetitive sequence of riffle-run-pool habitat types and is not as sinuous as lower Crooked Creek likely due to its steeper gradient and different geomorphology. Water clarity has been consistently higher at Getmuna Creek than in the mainstem Crooked Creek. This is likely due to the presence of finer textured sediment in the geology of this watershed (Ottertail 2012b). The lower reaches of Getmuna Creek have sand / gravel / cobble substrate and a good frequency and quality of pool habitat. The upper reaches of Getmuna Creek contain numerous riffle areas dominated by a gravel / cobble substrate composition. Large woody debris and off-channel habitats are abundant throughout the drainage (Ottertail 2012b).

An unnamed Creek (FN1) enters the South Fork Getmuna Creek from the south upstream from the North Fork / South Fork confluence. This low- to medium-gradient stream has clean gravel substrate and undercut banks. Another tributary, located north of the North Fork Getmuna Creek, was determined to have limited aquatic habitat, a 1.6-foot-wide channel, and a 10 percent gradient. The remainder of the proposed road corridor (including connections to the proposed airstrip and permanent camp) extends along the divide between the Crooked Creek watershed (to the east) and the Yukon River watershed (to the west) without crossing other tributaries in these drainages until the crossing of Crooked Creek at its northern terminus. Aquatic habitat in the Crooked Creek drainage is described in Section 3.13.2.1.

Birch Tree Crossing Mine Access Road Corridor

Under Alternative 4, the upriver port site would be established at BTC, 124 miles upriver from Bethel, instead of Angyaruaq (Jungjuk) which is located 199 miles upriver from Bethel. This would reduce the barge travel distance from Bethel to the port site for freight and diesel by 75 miles or 38 percent (Figures 2.3-41 and 2.3-42 in Chapter 2, Alternatives). A 76-mile-long, two-lane, 30-foot-wide, all-season, gravel access road would be constructed for mine support traffic between the BTC Port site and the mine. The length of the proposed access road would be 253 percent longer than the 30-mile mine access road constructed under Alternative 2. Preliminary field reconnaissance indicated the route between the BTC Port site and the mine would cross 40 streams or drainages requiring 8 bridges and 32 culverts (compared to 51 stream or drainage crossings involving 6 bridges and 45 culverts under Alternative 2). Of these 40 streams and drainages, only two are known to be used by anadromous fish species: 1) an unnamed tributary to the Kuskokwim River, located between Upper Kalskag and Aniak; and 2) the Owhat River. Documented anadromous fish species found in these streams include coho (both streams), and chum and Chinook salmon (Owhat River only) (Johnson and Litchfield 2016). In addition, 52 borrow sites would be used to provide materials to construct the gravel road between the BTC and the mine. The largest borrow site (about 205 acres) would be located at MP 16 (Table 2.3-37 in Chapter 2, Alternatives). The Owhat River and the lower reaches of several of its tributaries are classified as EFH under the Magnuson-Stevens Act.

3.13.2.2.2 FISH

<u>Anadromous/Resident Fish and Macroinvertebrates within the Transportation Corridor</u>

Anadromous/Resident Fish

The Kuskokwim River serves as a migration corridor for resident and anadromous fish species and provides diverse, year-round habitat for various life stages of some of these species. Due to the diversity and seasonal abundance of these species, the river supports important subsistence, commercial, and sport fisheries for the region. A summary of the general run timing for adult salmon near the Port of Bethel in the lower river is presented in Table 3.13-10 based on 20 years of records (1984 to 2003). The periods encompass the general arrival times of spawning salmon at weirs located in certain tributaries along the middle and upper Kuskokwim River. Based on records from 1996 to 2011, the annual median passage dates of Chinook, chum, and coho salmon at the George River weir (located upstream of the Crooked Creek confluence) was July 7th, July 17th, and August 28th, respectively (Clark and Blain 2012).

Table 3.13-10: Summary of Kuskokwim River Salmon Run Timing Based on Test Fishery at Bethel, AK 1984-2003

Species	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct	
Coho													--	X	X	X	--			
Sockeye											--	X	X	--	--					
Chinook											--	X	X	X	--	--				
Chum												--	X	X	X	--	--			
Pink												--	--	X	X	--	--			

Notes:

Shaded periods indicate peak run times while dashed line depict ascending and descending run times.

Source: Fishery Data Series (FDS) No. 05-14 (ADF&G 2005); pink salmon timing based on Fisheries Management Report (FMR) 08-25 (ADF&G 2008) from Kwethluk River weir in 2004

As shown in Table 3.13-11, at least 27 species of resident freshwater and anadromous fish are supported by the Kuskokwim River drainage (Brown et al. 2011). None of the species identified as being in the area are listed in Alaska as threatened or endangered. While Chinook salmon are now a stock of concern in Alaska, statutory protections are unchanged.

Table 3.13-11: Fish Species Occurring in the Kuskokwim River Drainage

Fish Species		
Family	**Scientific Name**	**Common Name**
Salmonidae	*Oncorhynchus tshawytscha*	Chinook salmon
	O. keta	Chum salmon
	O. kisutch	Coho salmon
	O. nerka	Sockeye salmon
	O. gorbuscha	Pink salmon
	O. mykiss	Rainbow trout
	Salvelinus malma	Dolly Varden
	S. alpinus	Arctic char
	S. namaycush	Lake trout
	Thymallus arcticus	Arctic grayling
	Prosopium cylindraceum	Round whitefish
	Coregonus pidschian	Humpback whitefish
	C. sardinella	Least cisco
	C. nasus	Broad whitefish
	C. laurettae	Bering cisco
	Thymallus arcticus	Sheefish
Catostomidae	*Catostomus catostomus*	Longnose sucker
Cottidae	*Cottus cognatus*	Slimy sculpin
Esocidae	*Esox Lucius*	Northern pike
Umbridae	*Dallia pectoralis*	Alaska blackfish
Petromyzontidae	*Lethenteron alaskense*	Alaskan brook lamprey
	L. camtschaticum	Arctic lamprey
Gadidae	*Lota lota*	Burbot
Gasterosteidae	*Pungittius pungittius*	Ninespine stickleback
Cyprinidae	*Couesius plumbeus*	Lake chub
Osmeridae	*Hypomesus olidus*	Pond smelt
	Osmerus mordax mordax	Rainbow smelt
		Total Species Count: 27

Source: Brown et al. 2011.

The life history for salmon species of importance to subsistence, commercial, and recreational fisheries are briefly summarized below (Groot and Margolis 1991; Mecklenburg et al. 2002; Morrow 1980; NRC 2004; Scott and Crossman 1973; USFWS 1988).

The Kuskokwim River Chinook salmon stock consists of an array of many populations throughout the drainage with a run strength that has been highly variable over the past two decades and historically low returns since 2010 (ADF&G 2013j). Chinook salmon adults typically enter the Kuskokwim River system in June and July and primarily spawn in the main channel of tributaries from mid- to late summer. Fry emerge from redds the following spring and typically spend one year in tributaries and backwater rearing areas before their seaward migration. Smolts migrate to the ocean in late spring, following ice breakup.

Chum salmon tend to be the most abundant salmon in the Kuskokwim River basin. Adults typically enter the Kuskokwim River in late June and July and spawn primarily in tributaries from July to August, depending on location. Chum salmon eggs typically hatch and emerge from redds in May. While still at a relatively small size, fry migrate downstream soon after emergence entering the Kuskokwim Bay estuary in May and June.

Coho salmon adults typically enter the Kuskokwim River in late July and spawn primarily in tributaries in September to early October. Fry emerge in May or June and typically spend 1 or 2 years in freshwater tributaries before migrating to the ocean in late spring or early summer. Numerous clear-water tributaries of the Kuskokwim River provide important rearing and overwintering habitat for juvenile coho salmon.

Sockeye salmon adults typically enter the Kuskokwim River in June and July and spawn primarily in tributaries in August and early September. Young emerge from redds the following April to June and typically spend 1 or 2 years in fresh water lakes before migrating to the ocean in late spring / early summer.

Pink salmon are the least abundant salmon in the Kuskokwim River system. Adults enter the river in early to mid-summer and spawn primarily in tributaries in mid- to late summer. Fry emerge in May and immediately begin their seaward migration.

In recent years, a trend of low productivity and abundance of Kuskokwim River Chinook salmon stocks indicates the run has become insufficient to meet the escapement levels necessary to sustain the run while also providing the levels of harvest needed by the subsistence community as established by the Alaska Board of Fisheries. To address such concerns and provide a basis for future decisions affecting Chinook salmon stocks and subsistence fisheries, a panel of experts has outlined a series of proposed studies described in the Arctic-Yukon-Kuskokwim Chinook Salmon Research Action Plan (Schindler et al. 2013). Objectives of the plan involve the evaluation of several key factors that could be contributing to the sharp decline in Chinook salmon abundance and productivity. These include:

- Density dependent feedbacks in population dynamics that may cause changes in fish abundance that could persist for 10-year or more periods of time;
- Changes in the suitability or productivity of freshwater habitats used for spawning, rearing, and migration;
- Changing physical and biological ocean conditions in the Bering Sea that cause an increase in mortality of Chinook salmon during their early marine life cycle;
- Human-caused changes in oceans that reduce growth and survival of Chinook salmon;
- Mortality of Chinook salmon from incidental capture during non-salmon marine fisheries;
- Effects of selective fishing and natural mortality on the genetic character of stocks resulting in alteration of fish size, sex ratio, and composition of life history types, declines in egg deposition, and stock recruitment; and

- Effects of pathogens that have increased mortality rates of Chinook salmon during upstream migration.

In 2011, surveys were conducted by Ottertail Environmental, Inc. in the Kuskokwim River to document fish populations near the proposed Angyaruaq (Jungjuk) Port site. The selected sampling sites were located at the port site (KU8) and in areas upstream (KU9, 10, 11, 12) and just downstream (KU13, 14, 15) to provide representative sampling in the proposed port site vicinity (Figure 3.13-1). Each sampling site contained slightly different habitat types which required different sampling methods. Most of the fish were captured with seines during these surveys, but fyke net sets and electrofishing also were conducted. Across all sites, the most common species collected were longnose sucker, Arctic grayling, humpback whitefish, and round whitefish. Juveniles of all five Pacific salmon were collected in the vicinity of the proposed port site. Other species collected included least cisco, sheefish, ninespine stickleback, burbot, northern pike, Dolly Varden, and lamprey species. These and other non-salmon species, some of which are described below, are important to the subsistence fisheries and as forage for upper level predators along the river.

In 2014, the abundance and distribution of juvenile Pacific salmon and resident fishes were evaluated using seines along shorelines at five select reaches of the Kuskokwim River where relatively narrow channels exist (Owl Ridge 2014a). This included a site near the BTC port site alternative. The surveys, which involved over 250 seine hauls conducted from July 16-25 and August 27-September 6, yielded only a few juvenile salmon (one Chinook, six coho, and 28 sockeye). In contrast, surveys conducted during the August 27-September 6 sampling period in two Kuskokwim River tributaries, the Holokuk and Aniak rivers, resulted in the collection of 164 Chinook, 267 coho, and 46 sockeye salmon juveniles. During the July sampling period in the Kuskokwim River, a total catch of over 14,000 fish consisted of nearly 92 percent longnose sucker, with slimy sculpin (4.5 percent) and arctic grayling (1.9 percent) comprising the next most abundant species. During the late August sampling period, 9,290 fish were collected comprised of over 78 percent longnose sucker, 6.9 percent arctic grayling, and 6.3 percent slimy sculpin. Results of the study suggest that few juvenile salmon rear within the mainstem Kuskokwim River. The study further suggests that juvenile salmon not out-migrating to the estuary in May and June likely remain within local tributaries to rear and overwinter until the following spring. This also is consistent with field studies conducted in the Kuskokwim River during 2015 (May 15 to June 4 and June 19 to 25) where 80 percent of the fish collected in nearshore seine hauls were out-migrating juvenile salmon (Owl Ridge 2015b).

Other species of importance to subsistence fisheries in the Kuskokwim River drainage include broad whitefish, humpback whitefish, and round whitefish, least cisco, sheefish Arctic grayling, rainbow smelt, northern pike, burbot, and Alaska blackfish. The following paragraphs summarize life history and background information for some of these species.

Whitefish

Broad whitefish, humpback whitefish, sheefish (inconnu), and least cisco in the Kuskokwim River system generally exhibit similar life history traits. A variety of studies have documented information regarding distribution and migration patterns, population size, size and age structure, natural mortality, rearing/breeding habitats, and harvest numbers. Whitefish are known to overwinter in large rivers and typically enter freshwater tundra ponds and lakes during April or May. They remain in these waters to feed over the summer until oxygen levels decrease causing them to return to the mainstem of the Kuskokwim River to begin migrating to fall spawning locations (Alt 1979; Reist 1997; Harper et al. 2007, 2008, 2009, 2012). Although some species of whitefish may remain in freshwater their entire lives, others overwinter in brackish waters in the lower Kuskokwim River migrating upstream in early June through late September where peak spawning occurs in late September to November (Harper et al. 2009, 2012). While less is known about spawning preferences and timing for broad whitefish and least cisco, humpback whitefish spawning has been documented to occur in late September and early October in areas with relatively swift currents and gravel substrates (Alt 1979; Chang-Kue and Jessop 1997; Fleming 1996; Brown 2006). Whitefish are broadcast spawners releasing their eggs and milt into the current where fertilized eggs then settle to the bottom to lodge in gravel while maturing over the winter. In the spring, river currents carry fry to the lower river and estuary areas where the fish rear.

Radio telemetry studies conducted from 2004 to 2009 have documented the timing and seasonal distribution of broad whitefish, humpback whitefish, and least cisco from Whitefish Lake (south of Aniak) and the Kuskokwim River (Harper et al. 2008, 2009, 2012). The whitefish tracked during these studies were found to consist of mixed stocks that follow complex migration patterns over long distances with migrations occurring at different times of the year. Some migrate up the Kuskokwim River from early June through late September while others migrate from mid-September through early October. Broad whitefish migrated out of Whitefish Lake in early July, September, and October with some overwintering in Ophir Creek, a tributary to Whitefish Lake. Broad whitefish were tracked to possible main channel fall spawning areas near the confluence of the Swift River and to an area between the villages of McGrath and Medfra. Humpback whitefish radio-tagged from Whitefish Lake were found to migrate to suspected spawning areas in the Holitna, Swift, and Big rivers in the upper Kuskokwim system. Tracking results indicated that Whitefish Lake was used by multiple stocks of whitefish before traveling to several different upriver spawning areas and that multiple year classes of these fish used the lake as a year to year feeding area. Spawning habitat documented during the fish tracking studies was characterized as consisting of swift current with gravel substrates. The documented migration patterns indicate that whitefish travel long distances and return to similar spawning areas each year. Stocks in Whitefish Lake and along the Kuskokwim River are vulnerable to harvest by subsistence fisheries in the Kuskokwim River drainage.

Bering cisco are also found in the main stem and South Fork Kuskokwim River drainage, (Alt 1973; RJ Brown et al. 2012). Sampling in the South Fork Kuskokwim drainage by Alt (1973) also observed an occasional Bering cisco near the mouths of tributaries downstream from the South Fork. Pre-spawning Bering cisco were sampled in the South Fork Kuskokwim River, up to 47 miles from the mouth (M. Thalhauser, unpublished data as cited in RJ Brown et al. 2012).

Sheefish

Sheefish, or inconnu, is the largest species of whitefish in the Kuskokwim River system reaching lengths of 30 inches by age 8, with the record sport-caught sheefish in northwestern Alaska weighing 53 pounds. Sheefish migrate over long-distances; some over 1,000 miles within a single summer. Sheefish in major Alaskan river drainages such as the Kuskokwim, Yukon, Selawik, and Kobuk rivers typically overwinter in the brackish waters of the bays. During spring break up, many sheefish travel upriver to feed. Some will migrate upriver later in the summer to spawn. Some sheefish, called “residents” do not migrate to the bays at all; instead, remaining in freshwater their entire lives. Sheefish may take up to 2 months to reach spawning and overwintering locations. Spawning sheefish return to their natal spawning grounds and release eggs that are broadcast in shallow waters over gravel of varying size. Eggs typically hatch in early spring before ice out; juveniles subsequently drift downriver to eddies, off-channel lakes, and estuary areas near the river mouth seeking refuge and food that includes insects and other small prey. Adults feed almost entirely on herring, smelt, juvenile northern pike, sticklebacks, lamprey ammocoetes, and other small out-migrating juvenile fish. Kuskokwim River sheefish tend to travel to and feed in the same areas each spring and summer (ADF&G 2014a). Radiotelemetry and aerial surveys conducted from 2007–2011 by Stuby (2012), have documented seasonal distributions, spawning locations, and movements of sheefish throughout the Kuskokwim River mainstem and its tributaries. The investigations revealed that, during summer, sheefish traveled to and between the mouths of major Kuskokwim River tributaries to feed and annually returned to these same areas. Upstream migrations to spawning areas in Highpower Creek and Big River occurred from late July to mid-September with spawning taking place from late September through early October. Tributaries used for feeding included the Johnson River and Kongeruk River in the lower river, and the Holitna River near Sleetmute in the middle river. Post-spawning out-migrations of sheefish were found to occur during a 1 to 1.5-week period in mid-October with most fish returning to overwinter in the lower river while a smaller number of fish overwintered in the Middle Kuskokwim River and Holitna River.

Arctic Grayling

Arctic grayling are a common resident species within the Kuskokwim basin, noted for its broad sail-like dorsal fin. The species is long-lived in Alaska living up to 32 years. Arctic grayling are spring spawners, spawning for the first time between the ages of 4 and 7 years and at a length of about 10 to 12 inches. They broadcast spawn from 1,500 to 30,000 eggs with eggs lodging in between pebbles and gravel. Eggs hatch after about three weeks with fry immediately moving to edge habitats along stream banks where they grow quickly; reaching a length of 2 to 4 inches by the end of summer (ADF&G 2015j). Based on studies conducted in the spring and early summer of 2015 on the mainstem Kuskokwim River, juvenile grayling were found to be relatively common, comprising the third most abundant fish in the nearshore catch (Owl Ridge 2015b). Adult grayling were not found in the mainstem Kuskokwim River, but were observed in tributary streams such as the Holokuk and Aniak rivers (Starkes 2015). During summer, Arctic grayling feed on a variety of invertebrates but primarily on drifting aquatic insects, including black flies, mayflies, stone flies, and caddis flies. They also feed on salmon eggs during spawning runs, smaller fish, or terrestrial insects. During winter, Arctic grayling feed minimally, conserving energy by occupying lakes and pools in streams. Grayling tolerate low dissolved oxygen levels, a common condition beneath the ice, and have evolved different migratory strategies depending upon the environmental conditions in the stream basins they inhabit. While some Arctic grayling may use different stream basins for overwintering, summer feeding, and spawning, others may complete their entire life in only a short section of a single stream or lake. Shortly after ice-out, adult grayling begin to migrate upstream to spawning grounds. Immediately after spawning, they migrate to summer feeding areas traveling distances that can vary from less than a mile to over 100 miles. In the early fall, grayling begin to slowly migrate back to deeper pools that do not freeze completely during winter (ADF&G 2015j).

Rainbow Smelt

Rainbow smelt are a principal prey species important to pike, sheefish, and other species and are harvested by the subsistence communities. Rainbow smelt are an anadromous smelt species with poorly documented populations in the Kuskokwim River and elsewhere in southwest Alaska. In other river systems, these fish are preyed upon by various commercially and recreationally valuable coastal marine species (Buckley 1989). During spring ice out, or soon thereafter, rainbow smelt have been observed to begin their spawning migration from Kuskokwim Bay and the tidally influenced reaches of the lower Kuskokwim River near Tuluksak. Spawning generally occurs during a brief one- to two-day period in the vicinity of Lower and Upper Kalskag, where eggs and milt are broadcast into the current along the riverbed. Fertilized eggs adhere to river substrates and hatch in less than a month. Until recently, specific spawning habitat in the river was only informally delineated based on general observations (Cannon 2013). In other river systems, rainbow smelt spawning is reported to be associated with specific substrate types (sand, gravel, small boulders, and aquatic vegetation) located upriver from tidally influenced waters since salinities of 12-14 parts per thousand have been documented to be fatal to eggs (Buckley 1989). Water velocity, substrate type, and egg density are all reported to be important factors to egg survival (Sutter 1980), although Clayton (1976) indicates that spawning site selection by rainbow smelt in the Parker River of Massachusetts was influenced largely by water velocity rather than depth or substrate.

In certain Alaska rivers, potential threats to rainbow smelt populations may result from overharvest and habitat alteration caused by resource extraction practices that affect instream flows, cause blockages or delays to fish passage, degrade water quality, or cause sedimentation (ADF&G 2006c). In the Kuskokwim River, spawning habitat disruption and sedimentation can result from natural flooding, ice break up, bank erosion, and riverbed scour (from both natural causes and marine traffic). Depending on water temperature, eggs spawned in mid to late May typically will incubate for about 21 days. During this time, the eggs are susceptible to disruption until incubation is completed and flows carry the larvae downstream to the estuary.

In 2014, 2015, and 2016 surveys were conducted to determine the timing, distribution, and habitat associations of rainbow smelt spawning in the Kuskokwim River. The 2014 survey revealed that spawning, which ultimately took place upstream of Upper Kalskag over a two-day period from May 21-22, occurred along a distance of about 4 miles of gravel and sand substrates at depths of 5 to nearly 14 feet on the sides of the mainstem channel (Owl Ridge 2014a). During 2015, rainbow smelt also spawned in late May but at two locations downriver from lower Kalskag, in narrower river segments with coarse gravels and at a deeper mean depth of 14.5 feet (range 8.7 to 23.4 feet) near the thalweg where barge traffic would travel (Owl Ridge 2015a). One of the spawning locations in 2015 was in a side channel behind an island remote from the main channel what would not be affected by barge traffic; average depths were below the depth expected to experience significant prop wash induced sediment displacement (Owl Ridge 2015a). In the spring of 2016, locations of smelt occurrence were reported to Owl Ridge by local scientists and fishers. The 2016 rainbow smelt spawning migration began on May 10 with spawning completed by May 17. This was the earliest spawning migration observed between 2014 and 2016. The 2016 spawning occurred in the same reaches as observed in 2014, at Kalskag and just upstream (Owl Ridge 2016).

Northern Pike

Northern pike are a large resident freshwater species ranging from Alaska's Interior to the Arctic coast, from the Canadian border to the Seward Peninsula, and southwest to Bristol Bay drainages. During recent years, illegally stocked northern pike have established themselves in many Alaskan streams, however, those in the Kuskokwim basin are native (Cannon 2014b). Northern pike spawn in the spring of the year soon after ice out. A 25-pound female may contain up to 500,000 eggs deposited in the grassy margins of slow moving streams, or off-channel backwaters, with incubation requiring about 30 days. Most northern pike overwinter in the deep, slow waters of large rivers. In spring, northern pike migrate from overwintering areas to spawning grounds and then return to summer feeding areas generally a short distance away. During summer, migration patterns are localized involving warm, shallow feeding areas (ADF&G 2015k). In 2014, several subadult to adult northern pike were captured in the shore zone of the mainstem Kuskokwim River during summer months (Owl Ridge 2014f). These fish often were observed within or along the edge of off-channel backwaters, but also were found in the nearshore mainstem and side channels (Starkes 2015). Within interior Alaska, northern pike are slow growing where 12-inch fish are 2 to 3 years old and 15-pound fish are 10 to 17 years old. While young northern pike feed on small crustaceans and insects, adults feed on a variety of fish species and sizes including whitefishes, suckers, burbot, smaller pike, and juvenile salmon. Large adults also have been documented to feed on voles, shrews, red squirrels, and small waterfowl (ADF&G 2015k).

Burbot

Burbot occupy most large clear and glacial-fed rivers and many lakes throughout most of Alaska. The species is relatively long lived and slow growing, reaching ages in excess of 20 years. Burbot typically require 5 to 7 years to reach sexual maturity at a length of about 18 inches (ADF&G 2015l). During fish surveys conducted in the spring of 2015, burbot were uncommonly captured along nearshore waters in the mainstem Kuskokwim but were occasionally captured in cobble shoal and run habitats (Owl Ridge 2015a). Within the Kuskokwim River basin, burbot populations are considered robust. In late winter, burbot spawn under the ice where they have been observed in dense concentrations. Spawning burbot can produce over a million eggs, broadcast spawning into the water column where the eggs and milt settle and fall to the bottom. In rivers, burbot spawn in low velocity areas in main channels and side-channels behind sand or gravel bars. They tend to prefer river substrates consisting of fine gravel, sand, and fine silt. The spawning season is relatively short lasting approximately 2 to 3 weeks during low water temperatures. Incubation rates are long, ranging from 41 to 128 days, depending upon water temperatures (McPhail and Paragamian 2000). Young burbot feed mainly on insects and other invertebrates but by the age of 5 or 6 they begin feeding almost exclusively on fish. While whitefishes, sculpins, lampreys, and other burbot are common food items, mice or shrews are occasionally consumed (ADF&G 2015l).

Alaska Blackfish

The Alaska blackfish is a small freshwater resident species (seldom larger than 8 inches) that typically occupies lowland swamps, ponds, rivers, and lakes in areas of dense aquatic vegetation (ADF&G 1994). Blackfish primarily feed on aquatic invertebrates and insect larvae (Chlupach 1975). Spawning occurs from May to August, with the possibility of individual fish spawning several times a year. Eggs adhere to vegetation for a relatively short period (about 9 days at 54 degrees Fahrenheit [°F]) before hatching. Reproductive maturity has been documented to occur when the fish reach a length of approximately 3 inches. The species is unique because it possesses a modified esophagus that is capable of gas absorption. This allows the fish to breathe atmospheric oxygen and live in small stagnant tundra or muskeg pools that are almost devoid of oxygen during the summer, and to survive in moist tundra mosses during extended dry periods (ADF&G 1994). Alaska blackfish have been documented within the Kuskokwim drainage (Scott and Crossman 1973) and are locally harvested for subsistence use, though now at much lower than historical levels (LaVine et al. 2007). The species has been documented to occur at low densities, generally two fish per 300 linear feet or less within mainstem Crooked Creek within the project area (ADF&G 2010; Ottertail 2012b; Table 3.13-5).

Fish Species of the Kuskokwim Management Area

The Kuskokwim Management Area includes the Kuskokwim River drainage and all waters that flow into the Bering Sea between Cape Newenham and the Naskonat Peninsula, and Nunivak and St. Matthew Islands. The Kuskokwim Management Area is divided into four commercial fishing districts with Districts 1 and 4 being most relevant to this discussion. District 1 includes the Lower Kuskokwim River and District 4 extends from the mouth of Weelung Creek to the Arolik River (approximately 7 miles north of Quinhagak to approximately 4 miles south of Quinhagak) and expands 3 miles from the coast into Kuskokwim Bay. Districts 1 and 4 support important subsistence, commercial, and sport fisheries.

As presented in Table 3.13-12, at least 32 species of marine and anadromous fish are supported by the Kuskokwim Management Area within the Transportation Corridor (Brazil et al. 2013). Some of these species also utilize other segments of the Kuskokwim River, as previously shown in Table 3.13-11. None of these species are listed in Alaska as threatened or endangered.

Table 3.13-12: Marine, Anadromous, and Resident Fish Species Occurring in the Kuskokwim Management Area

Fish Species			
Family	**Subfamily**	**Scientific Name**	**Common Name**
Salmonidae	Salmoninae	*Oncorhynchus tshawytscha*	Chinook salmon
		O. keta	Chum salmon
		O. kisutch	Coho salmon
		O. gorbuscha	Pink salmon
		O. nerka	Sockeye salmon
		Salvelinus malma	Dolly Varden
		S. alpinus	Arctic char
		S. namaycush	Lake trout
	Thymallinae	*Thymallus arcticus*	Arctic grayling
	Coregoninae	*Coregonus pidschian*	Humpback whitefish
		C. sardinella	Least cisco
		C. nasus	Broad whitefish
		C. autumnalis	Arctic cisco
		Stenodus leucichthys	Sheefish

Table 3.13-12: Marine, Anadromous, and Resident Fish Species Occurring in the Kuskokwim Management Area

Fish Species			
Family	**Subfamily**	**Scientific Name**	**Common Name**
Cottidae	-	*Oligocottus maculosus*	Tidepool sculpin
		Megalocottus platycephalus	Belligerent sculpin
		Myoxocephalus quadricornis	Fourhorn sculpin
Umbridae	-	*Dallia pectoralis*	Alaska blackfish
Petromyzontidae	Lampetrinae	*Entosphenus tridentatus*	Pacific lamprey
		Lethenteron camtschaticum	Arctic lamprey
Gadidae	-	*Gadus macrocephalus*	Pacific cod
		Eleginus gracilis	Saffron cod
Gasterosteidae	-	*Pungittius pungittius*	Ninespine stickleback
		Gasterosteus aculeatus	Threespine stickleback
Osmeridae	-	*Mallotus villosus*	Capelin
Pleuronectidae	Pleuronectinae	*Platichthys stellatus*	Starry flounder
		Pleuronectes glacialis	Arctic flounder
		Limanda aspera	Yellowfin sole
		Parophrys vetulus	English sole
		Hippoglossus stenolepis	Pacific halibut
Hexagrammidae	Hexagramminae	*Hexagrammos stelleri*	Whitespotted greenling
Clupeidae	Clupeinae	*Clupea pallasii*	Pacific herring
		Total Species Count: 32	

Salmon, herring, halibut, sheefish, whitefish, rainbow smelt, char, Arctic grayling, Arctic lamprey, and saffron cod are among the important species for commercial, subsistence, or recreational fisheries in marine and freshwaters of the Kuskokwim Management Area. In Kuskokwim Bay, commercial salmon fisheries open in late June, beginning with Chinook salmon and are followed by sockeye, chum, and coho salmon.

The Kuskokwim Management Area also includes a large subsistence herring fishery. The herring stocks utilized by the subsistence fishery are the same stocks targeted by the commercial fishery, although no commercial herring harvest has occurred in the Kuskokwim Area since 2006 when 390 tons were collected. Herring harvest peaked in the mid-1990s when market value was high, but then declined as market value decreased in the following decade. Although only a few surveys of herring subsistence harvests have been conducted and no data after 1996 exist, data suggest that approximately 110 tons of herring have been harvested annually by the Kuskokwim Delta villages (ADF&G 2013h).

The Bering Sea halibut fishery is also important commercially and as a subsistence fishery. The most recent data available for Pacific halibut fisheries in this area are from the 2010 sport harvest and the 2011 subsistence harvest. Sport harvest records for Pacific halibut show that 184 halibut were caught in the Arctic-Yukon-Kuskokwim area in 2010, however, none were caught in the Kuskokwim River and Bay drainages (Jennings et al. 2011). Subsistence harvest records indicate that approximately 6,168 pounds of halibut were harvested in the Bering Sea Coast area, with the majority harvested from the Y-K Delta area, with a smaller component of the harvest from Norton Sound (Fall and Koster 2013). According to the International Pacific Halibut Commission's 2011 Annual Report, the commercial catch for the entire Bering Sea was approximately 3.4 million pounds, however, data are unavailable for the Kuskokwim Bay area.

Kuskokwim River Subsistence and Commercial Fisheries

Subsistence fishing has occurred on the Kuskokwim River for thousands of years. The commercial fishery dates back to the late 1800s, when harvested fish were primarily sold locally to dog mushers (Oswalt 1990). The first recorded commercial harvest for export occurred in 1913 (Pennoyer et al. 1965). Management was under federal control from the early 1900s through 1959 with fluctuating harvest limits and commercial closures. Beginning in the 1960s, the State of Alaska assumed management responsibility for the fisheries, and ADF&G began regulating commercial and subsistence harvest by imposing restrictions on gear, fishing areas, and fishing time, but did not restrict the allowable harvest for subsistence. The largest annual commercial harvest of Chinook salmon occurred in the early and late 1970s, early and late 1980s, and early 1990s. With the growth of the subsistence fishery, the directed commercial fishery for Chinook salmon was eliminated in 1987 (Ward et al. 2003, Brazil et al. 2013; Lipka et al. 2016).

The Kuskokwim River subsistence fishery has been one of the largest in Alaska (Carroll and Patton 2010; Merritt 2001). In some communities, fish have contributed as much as 85 percent and salmon 53 percent of the total pounds of the annual fish and wildlife harvested (Brazil et al. 2013). As reported by ADF&G, the Kuskokwim drainage contains 38 communities and approximately 4,600 households within the river's lower, central, and upper regions. Of these, more than 1,500 households currently subsistence fish with additional households involved in fish processing. The river's lower region includes the community of Bethel, the river's regional hub, and extends from Kuskokwim Bay upriver to the Tuluksak River. The central region extends from the Tuluksak River to the Village of Chuathbaluk. The upper region extends past the community of Crooked Creek to the major headwater tributaries near the communities of Takotna, McGrath, Medfra, and Nikolai (ADF&G 2014b).

The Kuskokwim River subsistence salmon fishery has not required licenses or permits, although participants in this and other Alaska subsistence fisheries must be state residents for the prior twelve months to be eligible to harvest salmon for subsistence uses. Subsistence harvest methods include the use of set and drift nets, fish wheels, rod and reel, and occasionally beach seines. There are generally no limits on the number of salmon that can be taken by individuals or households for subsistence purposes in the Kuskokwim area but limits and restrictions are established for rod and reel harvests, net length and mesh size. In addition, rolling subsistence closures are implemented at certain times and locations (ADF&G 2014b).

Information on the customary uses of subsistence fisheries harvests, including salmon and non-salmon subsistence harvest surveys, are developed at the community level by the ADF&G Division of Subsistence and the Division of Commercial Fisheries with cooperation and approval from local Village Councils. In addition, local and traditional ecological knowledge (TEK) research is periodically conducted and published in Division of Subsistence Technical Papers in order to document and share knowledge and observations of the local people across multiple generations (ADF&G 2014b).

Based on an analysis of the subsistence fishery for the Kuskokwim Management Area, the 2004-2013 10-year running average subsistence salmon harvest was determined to include 65,092 Chinook, 62,671 chum, 42,812 sockeye, and 34,800 coho salmon (Lipka et al. 2016; Tables 3.13-13 to 3.13-16). In 2010, Chinook salmon stocks in the Kuskokwim River began a sharp decline that has continued since then. The reduced run size and escapement in recent years represent some of the lowest recorded in 25 years. The reduced run size has affected harvest success and the subsistence lifestyle along the river. The 2014 estimated subsistence harvest of Chinook in the Kuskokwim Management Areas was 11,234, well below the 73,648 10-year running average previously mentioned (Lipka et al. 2016; Shelden et al. 2016).

In 2014, estimates of the total commercial harvest were dominated by coho salmon (117,588), followed by chum (19,080), and sockeye (2,720), with the Chinook salmon catch limited to only 35 fish taken incidental to other catches (Lipka et al. 2016; Tables 3.13-13 to 3.13-16). Based on the 2014 Kuskokwim Area Management Report, final estimates of the 2014 subsistence harvest show that chum salmon were the most abundant species harvested (68,398), followed by coho (49,736), sockeye (48,372), and Chinook (11,234) salmon. The 2004-2013 total utilization average, which includes the combined Kuskokwim River harvests from the commercial, subsistence, sport, and Bethel test fisheries, included 78,255 Chinook, 123,880 chum, 56,684 sockeye, and 187,336 coho salmon (Lipka et al. 2016; Tables 3.13-13 to 3.13-16).

Table 3.13-13: Chinook Salmon Utilization, Kuskokwim River, Kuskokwim Area, 1990-2014

Year	Estimated Total Run	Estimated Escapement	Subsistence Harvest	Commercial Harvest[a]	Sport Harvest	Bethel Test Fish Harvest	Harvest Total
1990[b]	264,802	100,614	109,778	53,504	394	512	164,188
1991	218,705	105,589	74,820	37,778	401	149	113,148
1992[c]	284,846	153,573	82,654	46,872	367	1,380	131,273
1993[c]	269,305	169,816	87,674	8,735	587	2,515	99,511
1994[c]	365,246	242,616	103,343	16,211	1,139	1,937	122,630
1995[c]	360,513	225,595	102,110	30,846	541	1,421	134,918
1996	302,603	197,092	96,413	7,419	1,432	247	105,511
1997	303,189	211,247	79,381	10,441	1,227	332	91,381
1998	213,873	113,627	81,213	17,359	1,434	210	100,216
1999	189,939	112,082	72,775	4,705	252	98	77,830
2000	136,618	65,180	70,825	444	105	64	71,438
2001	223,707	145,232	78,009	90	290	86	78,475
2002	246,296	164,635	80,982	72	319	288	81,661
2003	248,789	180,687	67,134	158	401	409	68,102
2004	388,136	287,178	97,110	2,305	857	691	100,963
2005	366,601	275,598	85,090	4,784	572	557	91,003
2006	307,662	214,004	90,085	2,777	444	352	93,658
2007	273,060	174,943	96,155	179	1,478	305	98,117
2008	237,074	128,978	98,103	8,865	708	420	108,096
2009	204,747	118,478	78,231	6,664	904	470	86,269
2010	118,507	49,073	66,056	2,732	354	292	69,434
2011	133,059	72,097	62,368	747	579	337	64,031
2012	99,807	76,074	22,544	627	—	321	23,492
2013	94,166	47,315	47,113	174	—	201	47,488
2014	135,749	123,987	11,234	35	—	497	11,766
10-year average (2004-2013)	222,282	144,374	74,286	2,985	737	395	78,255

Notes:

Dashes indicate no data available.

a Commercial harvest data do not include fish retained for personal use.
b Bethel test fish harvest data includes Eek test fishery.
c Bethel test fish harvest data includes Eek and Aniak test fisheries.
Source: Appendix B5 and B9 from Lipka et al. (2016), 2014 Kuskokwim Area Management Report

Table 3.13-14: Chum Salmon Utilization, Kuskokwim River, Kuskokwim Area, 1990-2014

Year	Commercial Harvest[a]	Subsistence Harvest	Bethel Test Fish Harvest	Sport Fish Harvest	Harvest Total
1990[b]	459,974[d]	153,825	2,107	533	616,439
1991	431,802[d]	87,237	1,014	378	520,431
1992[c]	344,603[d]	116,391	15,330	608	476,932
1993[c]	43,337[d]	59,797	8,451	359	111,944
1994[c]	271,115[d]	76,937	11,998	1,280	361,330
1995[c]	605,918[d]	70,977	17,473	226	694,594
1996	207,877[d]	100,913	2,864	280	311,934
1997	17,026[d]	37,366	790	86	55,268
1998	207,809[d]	61,732	1,140	291	270,972
1999	23,006	44,242	562	180	67,990
2000	11,570	56,499	1,038	26	69,133
2001	1,272	56,005	1,743	112	59,132
2002	1,900	86,381	2,666	53	91,000
2003	2,764	41,167	1,713	53	45,697
2004	20,150[d]	64,140	1,810	84	86,184
2005	69,139[d]	58,555	4,459	500	132,653
2006	44,152[d]	89,674	3,547	13	137,386
2007	10,783[d]	73,560	3,237	391	87,971
2008	30,798[d]	63,789	2,472	121	97,180
2009	76,956[d]	44,324	2,746	285	124,311
2010	93,917[d]	45,089	2,872	85	141,963
2011	118,316[d]	54,316	2,289	83	175,004
2012	65,195[d]	79,631	2,730	80	147,636
2013	52,236[d]	53,627	2,615	31	108,509
2014	19,080[d]	68,398	2,549	–	90,027
10-year average (2004-2013)	58,164	62,671	2,878	167	123,880

Notes:

Dashes indicate no data available.

a Commercial harvest data do not include fish retained for personal use.
b Bethel test fish harvest data includes Eek test fishery.
c Bethel test fish harvest data includes Eek and Aniak test fisheries.
d Districts 1 and 2.
Source: Appendix B8 and B9 from Lipka et al. (2016), 2014 Kuskokwim Area Management Report

Table 3.13-15: Sockeye Salmon Utilization, Kuskokwim River, Kuskokwim Area, 1990-2014

Year	Commercial Harvest[a]	Subsistence Harvest	Bethel Test Fish Harvest	Sport Fish Harvest	Harvest Total
1990[b]	84,414[d]	45,897	–	61	130,372
1991	108,946[d]	47,370	–	38	156,354
1992[c]	92,218[d]	43,514	–	131	135,863
1993[c]	27,008[d]	51,616	–	348	78,972
1994[c]	49,365[d]	42,362	–	359	92,086
1995[c]	92,500[d]	30,905	–	95	123,500
1996	33,878[d]	40,591	–	315	74,784
1997	21,989[d]	38,744	–	423	61,156
1998	60,906	36,103	–	178	97,187
1999	16,976	47,360	–	54	64,390
2000	4,130	45,942	–	46	50,118
2001	84	53,245	510	231	54,070
2002	84	32,296	228	42	32,650
2003	282	32,241	646	140	33,309
2004	8,532[d]	39,127	742	400	48,801
2005	27,645[d]	41,885	1,062	636	71,228
2006	12,618[d]	43,577	519	231	56,945
2007	703[d]	46,817	488	322	48,330
2008	15,601[d]	52,213	584	273	68,671
2009	25,673[d]	35,747	515	162	62,097
2010	22,428[d]	38,735	495	419	62,077
2011	13,482[d]	43,245	380	98	57,205
2012	2,857[d]	47,396	399	132	50,784
2013	768[d]	39,382	462	85	40,697
2014	2,720[d]	48,372	3,221	–	54,313
10-year average (2004-2013)	13,031	42,812	565	276	56,684

Notes:

Dashes indicate no data available.

a Commercial harvest data do not include fish retained for personal use.
b Bethel test fish harvest data Includes Eek test fishery.
c Bethel test fish harvest data includes Eek and Aniak test fisheries.
d Districts 1 and 2.
Source: Appendix B6 and B9 from Lipka et al. (2016), 2014 Kuskokwim Area Management Report

Table 3.13-16: Coho Salmon Utilization, Kuskokwim River, Kuskokwim Area, 1990-2014

Year	Commercial Harvest[a]	Subsistence Harvest	Bethel Test Fish Harvest	Sport Fish Harvest	Harvest Total
1990[b]	409,053[d]	57,560	–	581	467,194
1991	500,935[d]	39,252	–	1,003	541,190
1992[c]	666,170[d]	52,299	–	1,692	720,161
1993[c]	610,739[d]	28,485	–	980	640,204
1994[c]	724,689[d]	36,609	–	1,925	763,223
1995[c]	471,461[d]	36,823	–	1,497	509,781
1996	937,299[d]	43,173	–	3,423	983,895
1997	130,803[d]	29,816	–	2,408	163,027
1998	210,481[d]	24,667	–	2,419	237,567
1999	23,593	27,409	343	1,998	53,343
2000	261,379[d]	42,341	2,828	1,689	308,237
2001	192,998	31,089	1,723	1,204	227,014
2002	83,463	42,602	2,484	2,030	130,579
2003	284,064	33,259	2,377	3,244	322,944
2004	435,407[d]	45,450	2,259	4,996	488,112
2005	142,319[d]	32,755	1,499	3,539	180,112
2006	185,598[d]	41,175	1,186	1,474	229,433
2007	141,049[d]	33,766	1,557	2,355	178,727
2008	142,862[d]	44,724	2,954	3,755	194,295
2009	104,546[d]	29,767	2,394	3,257	139,964
2010	58,031[d]	33,580	1,020	1,482	94,113
2011	74,108[d]	32,172	1,207	896	108,383
2012	86,389[d]	28,200	1,255	974	116,818
2013	114,069[d]	26,409	1,767	1,147	143,392
2014	117,588[d]	49,736	2,880	–	170,204
10-year average (2004-2013)	148,438	34,800	1,710	2,388	187,336

Notes:

Dashes indicate no data available.

a Commercial harvest data do not include fish retained for personal use.
b Bethel test fish harvest data Includes Eek test fishery.
c Bethel test fish harvest data includes Eek and Aniak test fisheries.
d Districts 1 and 2.
Source: Appendix B7 and B9 from Lipka et al. (2016), 2014 Kuskokwim Area Management Report

Residents along the lower Kuskokwim River, where 76 percent of the area's households reside, have been responsible for 80 percent of the Chinook harvest in past years. The Chinook salmon subsistence harvest was below the most recent 10-year (2004–2013) average. The sockeye, coho, and chum salmon harvests were above their respective 10-year averages. Throughout the Kuskokwim Management Area in 2014, Chinook, sockeye, and chum salmon escapements were below average. Coho salmon escapements were above average and it was estimated to be a strong return. Sockeye, chum, and coho salmon escapements goals were achieved or exceeded in all systems with established goals (Lipka et al. 2016). Table 3.13-17 shows escapement counts from weirs in the Kuskokwim River area. Recent years of low run abundance for Chinook salmon has caused the subsistence fishery to redirect a greater proportion of harvest efforts to other salmon and non-salmon species. As a result, non-salmon species are becoming an increasingly important component of the subsistence fishery. Annual harvest records for non-salmon species are limited making it difficult to determine the historic abundance or relative proportion these fish contribute to the subsistence fishery.

Table 3.13-17: Escapement Counts for Salmon from Kuskokwim River Area Weirs in 2014

Weir Location	Escapement Counts			
	Chinook	Sockeye	Coho	Chum
Kuskokwim River				
Kwethluk River	3,187	3,776	43,945	17,941
Tuluksak River	320	514	13,672	8,724
Aniak River	-	-	-	[b]
George River	2,993	156	35,771	17,148
Kogrukluk River	3,732		52,975	30,763
Tatlawiksuk River	1,904	9	19,814	12,455
Takotna River	[a]	[a]	[a]	[b]
Telaquana River	-	24,293	-	-
Kuskokwim Bay				
Salmon River	1,757	894	8,254	2,890

Notes:

Dashes indicate no data available.

a Counts are incomplete or weir did not operate
b Historical run timing indicates that more than 40% of the run was missed; annual escapement was not determined.

Source: Lipka et al. 2016

Several species of whitefish (*Coregonus* spp.) comprise an abundant and increasingly important segment of the Kuskokwim River subsistence fishery while having lesser importance to the sport and commercial fisheries of the area. The harvest of humpback whitefish comprises a large portion of the subsistence harvest in the Kuskokwim region where these fish make up about 10 percent of the total harvested weight equal to sockeye, chum, and northern pike in the village of Kwethluk and 9 percent in Akiak (Brown et al. 2013). The harvest of whitefish was largely unregulated until the 1970s when the abundance and size of these fish declined and as commercial harvests in Whitefish Lake and Johnson River were eliminated (Harper et al. 2009). Regulations on the whitefish subsistence fishery in Whitefish Lake were enacted in 1992 due to concerns of smaller fish size and abundance. Historically, this subsistence fishery relied on abundant populations of broad and humpback whitefish and few harvest restrictions. In some years, whitefish have comprised 24 percent of the non-salmon subsistence harvest caught. Whitefish are actively pursued by 87 percent of households while only 70 percent actively harvested salmon (Harper et al. 2009). Rainbow smelt also are an abundant and increasingly important component of the subsistence fishery which extends from the Bethel vicinity to above

Upper Kalskag. In 2014, peak harvests of rainbow smelt were reported at Bethel (65,781), Akiachak (19,968), and Kwethluk (16,860) (Shelden et al. 2016). Coffing et al. (2001) report that 84 percent of the households in Akiachak use smelt as a subsistence resource.

Freshwater commercial fisheries also harvest whitefish and burbot for local markets, but this has only occurred sporadically and there has been little to no harvest in recent years. A saltwater commercial fishery exists for saffron, but harvest numbers are unknown. Other species fished commercially and for subsistence include sheefish, char, Arctic grayling, northern pike, Arctic lamprey, rainbow smelt, blackfish, rainbow trout, lake trout, threespine and ninespine stickleback, and longnose sucker (ADF&G 2013h).

Kuskokwim Bay Fisheries

A study by LaVine et al. (2007) has documented local and TEK from 1916 to 2004 associated with the life histories, migration, spawning, distribution, past and present subsistence activities, and long-term trends related to anadromous and freshwater resident subsistence fish populations of the lower Kuskokwim Bay area. Based on the research, the most important fish species for local subsistence harvest over the past decades, and still widely consumed today, involved Chinook, sockeye, chum, and coho salmon, Dolly Varden, and rainbow smelt. Chinook salmon were reported to be harvested in greater quantities in more recent decades, compared to years ago, due to more efficient harvest technologies (e.g., stronger nets and better boats). Rainbow smelt were reported to be consistently widespread in the area, abundant, and accessible in large quantities from fall to late spring. Other species of importance harvested intermittently or for special purposes included spawned out sockeye salmon, Arctic grayling, round whitefish, rainbow trout, and Bering cisco. Alaska blackfish was once a very important species for subsistence use but its use has declined in recent years due to other preferred species. Over the years, Arctic char, lake trout, burbot, and northern pike were reported to be seldom available due to their distance from the Kuskokwim Bay area or were taken incidental to harvests of other preferred species.

Kuskokwim River Sport Fishery

The ADF&G is responsible for sport fisheries management on the Kuskokwim River. Tributaries important to sport fishing include the Aniak, Tuluksak, Kisaralik, Kasigluk, Kwethluk, Holitna, and George rivers, and many smaller streams. Additionally, the Eek, Goodnews and Kanektok rivers with confluences in Kuskokwim Bay also have important sport fisheries. From 2003 to 2007, the annual sport fishing effort in the Kuskokwim River Basin was 22,563 angler days. Important sportfish species include salmon, rainbow trout, Dolly Varden, Arctic char, Arctic grayling, northern pike, and sheefish (Chythlook 2009).

<u>Anadromous/Resident Fish and Macroinvertebrates within the Mine Access Road Corridor</u>

Starting in 2007, fish surveys were intermittently conducted during the spring and summer in streams that would be crossed by the proposed mine access road corridor via bridges or culverts (Figure 3.13-1, and Figure 2.3-12 and Table 2.3-10 in Chapter 2, Alternatives). Many of the same species and relative abundances observed in the Crooked Creek drainage also were observed in the drainages crossed by the mine access road corridor.

Fish species observed at sampling site JJ1, located just upstream from the mouth of Jungjuk Creek, include coho salmon, Dolly Varden, Arctic grayling, round whitefish, longnose sucker, and slimy sculpin. Dolly Varden also were documented at two proposed road crossings farther upstream (crossings 61 and 63). An annual average of 4.8 adult coho salmon were observed in the mainstem Jungjuk Creek (reach JJR1) during fall aerial flights in 2007, 2008, 2010, and 2011. No fish were observed at the time of the instream surveys conducted at proposed locations for crossings 60 and 59. Crossing 60 would be situated on an unnamed tributary just upstream from its confluence with Jungjuk Creek and monitoring site JJ1. Crossing 59 would be located about a half-mile down the road corridor on an unnamed tributary about a mile upstream from its confluence with the Kuskokwim River (Ottertail 2012b).

The proposed mine access road would cross the upper reaches of Getmuna Creek near the junction of the north and south forks in the vicinity of a proposed material borrow site. As noted previously, aerial survey data suggests that Getmuna Creek is an important tributary to Crooked Creek in terms of salmon production. On average, 24 Chinook, 331 chum, and 200 coho salmon have been observed during annual aerial surveys of spawning salmon conducted along Getmuna Creek reaches from 2007 to 2011 (Ottertail 2012b). Additionally, an unnamed tributary would be crossed (#49) by the proposed mine access road near the South Fork of Getmuna Creek where coho salmon, Dolly Varden, Arctic grayling, and slimy sculpin were collected. No fish were collected or observed at crossing 43, located at an unnamed tributary north of the North Fork of Getmuna Creek.

Macroinvertebrate inventories were conducted within the drainages influenced by the proposed mine access road corridor to characterize species presence and community structure as a basis for assessing potential impacts of the proposed project. The macroinvertebrate communities observed from the sites sampled are similar to those found in the Crooked Creek drainage and other systems throughout Alaska (Ottertail 2012b). In general, the observed macroinvertebrate taxa are indicative of good water quality. However, as observed in Crooked Creek sites, metrics such as the Shannon Diversity Index (H) and evenness (e) suggested that natural stressors occur in the system. Freezing, flooding, and high natural siltation rates are likely the most important factors affecting stream community structure in Kuskokwim River tributaries. Siltation limits macroinvertebrate colonization by filling the interstitial spaces in the gravel-cobble stream bottom, reducing the amount of area in the stream bottom available for colonization. Furthermore, these interstitial spaces are used by macroinvertebrates as refugia from freezing during winter. Reductions in the availability of such interstitial spaces would, therefore, tend to prevent macroinvertebrates from successfully overwintering and maintaining a sustainable community structure.

As shown in Figure 2.3-42 (Chapter 2, Alternatives), the proposed 76-mile long road that would connect the BTC Port site to the mine would be about 46 miles (1.5 times) longer than the 30-mile long road that would connect the Angyaruaq (Jungjuk) Port site with the mine under Alternative 2. The proposed road from the BTC Port site would cross 40 streams, 11 fewer than the number crossed for Alternative 2 (Table 2.3-38, Chapter 2, Alternatives). Of the streams crossed, 8 would involve bridges while 32 would involve culverts (Alternative 2 would require 5 bridges and 45 culverts). Bridge crossings would occur at Ones Creek, Kaina Creek, Owhat River, Jubil Creek, Tyrel Creek, Cobalt Creek, Iditarod River, and Crooked Creek. Many of these waters, including the lower reaches of their tributaries, are used by anadromous and resident fishes for spawning and rearing life stages and are classified as EFH under the Magnuson-

Stevens Act. Anadromous species occurring in the waters crossed by the roadway include Chinook, coho, and chum salmon.

3.13.2.2.3 ESSENTIAL FISH HABITAT

Similar to the Mine Site component, the Transportation Corridor component includes river and stream segments that are designated as EFH for the Alaska stocks of Pacific salmon. Aquatic habitats these fish rely on in these waters constitute EFH and are protected under the Magnuson-Stevens Act. Designated EFH waters along the mine access road corridor within the Crooked Creek watershed include Crooked, Jungjuk, and Getmuna creeks and their respective tributaries. Designated EFH also exists from Kuskokwim Bay upriver beyond the proposed Angyaruaq (Jungjuk) Port site and mouth of Crooked Creek. The Kuskokwim River, which would serve as the key waterway for barge traffic delivering fuel and freight for the proposed project, supports all five Pacific salmon species (i.e., Chinook, chum, coho, pink, and sockeye salmon). These species utilize the Kuskokwim River primarily as a migration corridor between Kuskokwim Bay and tributaries located at various distances upriver and downriver of the proposed Angyaruaq (Jungjuk) Port site. While spawning and juvenile rearing habitats for these salmon species have been documented within Kuskokwim River tributaries, substantial spawning or juvenile rearing has not been documented by ADF&G within the mainstem of the Kuskokwim River from Kuskokwim Bay to the proposed Angyaruaq (Jungjuk) Port site (Johnson and Daigneault 2013). Under Alternative 4, many of the drainages crossed by the mine access road originating from the BTC Port site are used by anadromous and resident fishes for rearing and spawning and are classified as EFH under the Magnuson-Stevens Act. Appendix Q contains the EFH Assessment (Owl Ridge 2017c), which includes an assessment of potential effects on these resources.

3.13.2.2.4 FISH TISSUE METALS ANALYSIS

From 2010 to 2011, the BLM, in cooperation with USFWS and ADF&G, investigated mercury, arsenic, and antimony concentrations in tissue samples collected from fish and aquatic insects in the Central Kuskokwim River area from McGrath to Aniak (which includes river segments that would be traveled by barge traffic for the proposed project). Sites sampled during the 2010-2011 study, and during 2005-2007 studies that targeted northern pike, involved the mainstem Kuskokwim and several large and small tributaries upstream and downstream from Crooked Creek (Matz 2012, 2014). In the 2010-2011 study, resident fish species (slimy sculpin, juvenile Dolly Varden, and juvenile Arctic grayling) were sampled from small tributaries associated with abandoned mines (Red Devil Creek and Cinnabar Creek) located upstream from the Crooked Creek confluence. Other resident fish species, including Arctic grayling, northern pike, sheefish, and burbot, also were collected and sampled from large tributaries and the mainstem river up and downriver from Crooked Creek. As described below, results from these studies illustrate that many natural mercury deposits and historic mine sites have contributed to mercury levels in the Kuskokwim watershed, including the lower Kuskokwim mainstem and certain tributaries, with variable levels of mercury and MeHg being documented in certain species of resident fish and aquatic biota (Matz 2012).

Mercury

Results of BLM's 2010-2011 investigation showed differences among species with respect to mercury concentrations. Burbot and northern pike had the highest average total mercury concentrations in muscle tissue (0.45 and 0.42 micrograms per gram [μg/g], respectively). Sheefish, adult Arctic grayling, slimy sculpin, and juvenile Dolly Varden had lower concentrations (0.20-0.22 μg/g). Adult Dolly Varden, juvenile Arctic grayling, and long-nosed sucker had the lowest concentrations (0.05, 0.04, and 0.02 μg/g, respectively). Seasonal data from burbot show substantially higher mercury concentrations in the summer/fall (0.45 μg/g) than in the winter (0.16 μg/g). This is likely a result of sampling from populations with different life histories.

Ratios of methylmercury to total mercury were approximately 1:1 in tissues of northern pike, burbot, sheefish, and Arctic grayling. This suggests that these fish are experiencing chronic, long-term exposure to mercury through their diet rather than from direct acute exposure. Slimy sculpin and juvenile Dolly Varden exhibited lower ratios, suggesting exposure through gill or digestive tissue.

With regard to fish length and age, total mercury in whole body slimy sculpin was found to be significantly and positively correlated with length but not for juvenile Dolly Varden or Arctic grayling. Muscle concentrations of total mercury in northern pike were significantly and positively correlated with age and length; however, this was not observed for burbot, sheefish, or Arctic grayling.

Spatial variations accounted for some key differences in mercury concentrations with slimy sculpin, Dolly Varden, and aquatic insects sampled from Red Devil Creek and Cinnabar Creek having had significantly higher concentrations of total mercury than their counterparts collected from other sampled tributaries. This suggests that historic mine activities along those creeks have influenced mercury concentrations in fish and aquatic insect populations. These results agree with findings from Gray et al. (2000), who observed similar patterns. Northern pike, burbot, and Arctic grayling in the George River had significantly higher mercury concentrations than in other large tributaries, however, sheefish showed no significant differences in mercury concentrations among the sampled rivers. Based on the study findings relative to mercury concentrations in fish, it was recommended that the State of Alaska issue consumption guidance for northern pike and burbot from the Central Kuskokwim River area since these species are harvested for subsistence use.

Arsenic and Antimony

Arsenic concentrations were determined to be highest in aquatic insects (mean concentrations of 12 mg/kg) as compared to other biota. Among fish sampled, sheefish, burbot, juvenile Dolly Varden, and slimy sculpin had the highest arsenic concentrations (1.3–3.1 mg/kg). Adult Dolly Varden, northern pike, long-nosed sucker, and juvenile Arctic grayling had considerably lower concentrations (0.12–0.38 mg/kg) with adult Arctic grayling showing the lowest concentrations (0.03 mg/kg). With regard to spatial variation, arsenic concentrations were highest in biota from Red Devil Creek. Arsenic concentrations in burbot were found to decline in fish collected in upstream portions of drainages compared to downstream reaches. Differences in arsenic concentrations relative to spatial variation were not observed for sheefish or northern pike.

Antimony was not detected in many sampled fish, but it was detected in 100 percent of the aquatic insects sampled. The mean concentration of antimony was two orders of magnitude higher in Red Devil Creek insects than in insects collected from other tributaries.

Preliminary data from ongoing ADF&G radio-telemetry research conducted in 2012 and 2013 have revealed information that should provide future insights concerning relationships between tissue metal concentrations and the distributions of resident fish in the Kuskokwim River and its tributaries (Albert 2013). Based on preliminary study results, most of the Arctic grayling radio-tagged in the George River were found to remain within this drainage throughout the study period. Arctic grayling tagged near Sleetmute, however, moved to the Stony River to overwinter where they spawned during the following summer. These fish later migrated downstream to the Oskawalik, George, and Holokuk rivers. During this same study, most northern pike radio-tagged in the George River remained within the drainage, as did most of the northern pike tagged in the Holitna River. Northern pike tagged between the George and Holitna rivers migrated into the Holitna during the winter. Subsequently, these fish returned to the same areas where they were tagged along the mainstem Kuskokwim River. This suggests that elevated mercury concentrations in tissues from fish known to remain in the George River drainage may be associated with mercury exposure from processes occurring in this drainage. Movement patterns of radio-tagged burbot showed these fish migrated upstream between mid-September and December (most likely for spawning) and returned downstream between February and May. They remained in the middle and lower sections of the mainstem Kuskokwim River between Crooked Creek and Bethel. Their residency in these waters suggests these fish would be susceptible to long-term exposure of metal concentrations in the river as may be verified from future tissue analysis results.

3.13.2.3 PIPELINE

The following information is specific to the Pipeline component that would extend 316 miles north and west from the west end of the Beluga Gas Field near Cook Inlet to the Mine Site component (Figure 2.3-14, Chapter 2, Alternatives). The pipeline would connect with the existing Beluga Natural Gas Pipeline about 8.5 miles west of Beluga (Figure 2.3-14). Natural gas from the pipeline would be used to provide fuel for the power plant for generating electricity, providing heat, and processing ore from the proposed mine (Figure 2.3-1, Chapter 2, Alternatives). As described in greater detail in Section 3.5, Surface Water Hydrology, 452 streams involving several major drainages would be crossed along the 100-foot-wide temporary construction corridor that would extend west from Cook Inlet, across the Alaska Range near MP 118, to the Alaska Interior Region (Table 3, Appendix G). Of these streams, 163 have been identified as fish bearing with nearly half (72) supporting one or more species of salmon. Included in the Pipeline component are temporary shoofly and pipeline access roads that would be constructed within the pipeline corridor. Near water body crossings, temporary roads would be installed close to the pipeline to provide construction access.

3.13.2.3.1 AQUATIC HABITAT

The pipeline route begins near the settlement of Beluga on the north end of Cook Inlet and extends northwest towards the headwaters of the Skwentna River. The route then enters the Alaska Range and crosses the divide near MP 118. Once in the Kuskokwim River drainage, the route continues northwest following the South Fork of the Kuskokwim River. After exiting the

Alaska Range near MP 150, the route turns to the west/southwest and proceeds another 163 miles ending at Donlin Creek at MP 316. The route passes through varied topography with elevations ranging from just above sea level to approximately 3,350 feet near the summit of Rainy Pass.

The pipeline route crosses drainages ranging in size from small headwater streams to large glacially fed rivers. Stream crossings occur in four major drainages: Cook Inlet, and the Yentna, Skwentna, and Kuskokwim rivers. In 2010, data associated with stream channel characteristics, water quality, and stream substrates were collected at 233 sampling sites within these drainages as summarized below (Table 3.13-8).

Cook Inlet Drainages

The average wetted width for the 131 crossings within the Cook Inlet drainage was 6.8 feet (range: 0 to 95 feet). In general, surveyed streams had sand/silt/clay as a dominant substrate and gravel as the sub-dominant substrate type. The average pH for the drainage was 6.9 (range: 5.5 to 7.9) and the average water temperature over the period sampled was 46.3°F (range: 36.5 to 58.4°F). The average conductivity was 45.2 micro Siemens per centimeter (µS/cm) with a range of 16 to 105 µS/cm.

Skwentna River Drainage

The average wetted width for the 105 crossings within the Skwentna River drainage was 40.8 feet (range: 0 to 1,850 feet). In general, silt/sand/clay was the dominant substrate and gravel was the sub-dominant substrate type. The average pH for the drainage was 7.1 (range: 5.6 to 9.6) and the average water temperature for the period sampled was 49.8°F (range: 37.9 to 61.8°F). The average conductivity was 109.6 µS/cm with a range of 12 to 385 µS/cm.

Yentna River Drainage

The average wetted width for the six crossings within the Yentna River drainage was 2.5 feet (range: 2 to 3 feet). In general, these streams had sand/silt/clay as a dominant substrate and gravel as the sub-dominant substrate type. The observed substrate conditions may not be representative of the overall drainage given the small sample size. The average pH at these sites was 7.0 and the average water temperature for the period sampled was 51.4°F (range: 47.1 to 58°F). The average conductivity was 53.3 µS/cm with a range of 28 to 77 µS/cm.

Kuskokwim River Drainage

Stream characteristics and water quality data were collected at 210 crossings within the Kuskokwim River drainage. The relatively large geographical size of this drainage resulted in the most variation in stream characteristics. The average wetted width for sampling sites was 66.6 feet (range: 0 to 2,000 feet). In general, streams sampled within the Kuskokwim River drainage had sand/silt/clay as a dominant substrate and gravel as the subdominant substrate type. The average pH at these sites was 7.4 (range: 2 to 9.2) and average water temperature for the period sampled was 43.0°F (range: 34.1 to 59°F). The average conductivity was 221.0 µS/cm (range: 9.1 to 942 µS/cm). The broad range of conductivity may have resulted from the varied geological conditions in the drainage.

Table 3.13-18: Stream Characteristics and Water Quality Data by Drainage for the Pipeline Route (2010)

Drainage Area	Mainstem	Tributary	# Sites	Wetted Width (ft)		Substrate		pH		Conductivity (µS/cm)		Water Temp (°F)		Water Temp (°C)	
				AVG	Range	Average (%) Dominant Type	Average (%) Sub-Dominant Type	AVG	Range	AVG	Range	AVG	Range	AVG	Range
Cook Inlet	Beluga R.		1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Theodore R.	Mainstem	1	10.0	N/A	N/A	N/A	6.7	N/A	74.0	N/A	51.0	N/A	10.6	N/A
		Tributaries	2	8.5	(5-12)	(60) Sand/Silt/Clay	(40) Org. Other	6.5	(6.2-6.8)	46.2	(36.4-56)	53.1	(50.1-56.1)	11.7	(10.1-13.4)
	Lewis R.	Tributaries	42	9.8	(1-95)	(21) Sand/Silt/Clay	(10) Gravel	6.9	(6.1-7.5)	35.2	(22.1-68)	44.8	(36.5-51.8)	7.1	(2.5-11)
	Alexander Cr.	Lower Sucker Cr.	48	5.7	(0-16)	(16) Sand/Silt/Clay	(14) Gravel	7.1	(6.1-7.9)	39.3	(16.5-66.8)	45.0	(39.4-51.1)	7.2	(4.1-10.6)
		Bear Cr.	17	6.4	(0-20)	(22) Gravel	(17) Sand/Silt/Clay	6.9	(5.5-7.6)	49.0	(30.2-87.7)	47.1	(42.4-50.9)	8.4	(5.8-10.5)
		Clear Cr.	18	4.7	(1-13)	(28) Gravel	(24) Sand/Silt/Clay	6.8	(5.9-7.6)	56.7	(33-93)	47.4	(41.9-57.2)	8.5	(5.5-14)
		Deep Cr.	2	7.0	(5-9)	(45) Cobble	(34) Gravel	6.7	(6.7-6.8)	92.9	(81-104.8)	53.8	(49.1-58.4)	12.1	(9.5-14.7)
		Cook Inlet Total:	**131**	**6.8**	**(0-95)**	**(19) Sand/Silt/Clay**	**(16) Gravel**	**6.9**	**(5.5-7.9)**	**45.2**	**(16.5-104.8)**	**46.3**	**(36.5-58.4)**	**7.9**	**(2.5-14.7)**
Skwentna	Skwentna R.	Mainstem	3	1025.0	(200-1850)	(45) Sand/Silt/Clay	(43) Gravel	6.8	(6.8-6.8)	158.0	(158-158)	50.8	(50.8-50.8)	10.4	(10.4-10.4)
	Eightmile Cr.	Mainstem	2	12.0	(12-12)	(48) Sand/Silt/Clay	(5) Org. Other	7.3	(7.3-7.3)	78.7	(78.7-78.7)	61.8	(61.8-61.8)	16.6	(16.6-16.6)
		Tributaries	5	4.7	(2-7)	(25) Cobble	(11) Gravel	7.2	(7.2-7.2)	72.0	(67.7-76.4)	48.0	(47.5-48.4)	8.9	(8.6-9.1)
	Shell Cr.	Mainstem	1	25.0	N/A	(70) Gravel	(20) Sand/Silt/Clay	6.3	N/A	40.0	N/A	56.4	N/A	13.6	N/A
		Tributaries	5	4.0	(4-4)	(16) Boulder/Bedrock	(10) Sand/Silt/Clay	6.2	(6.2-6.2)	30.0	(30-30)	56.7	(56.7-56.7)	13.7	(13.7-13.7)
	Happy R.	Mainstem	2	157.5	(150-165)	(58) Cobble	(33) Gravel	8.1	(6.6-9.6)	286.5	(248-325)	44.1	(44-44.2)	6.7	(6.7-6.8)
		Canyon Cr.	10	6.0	(0-35)	(50) Sand/Silt/Clay	(7) Cobble	6.7	(6.6-6.9)	206.3	(138-240)	41.2	(38.3-45.8)	5.1	(3.5-7.7)
		Squaw Cr.	3	12.5	(5-20)	(25) Gravel	(25) Gravel	7.0	(6.7-7.3)	175.5	(168-183)	44.6	(42.5-46.8)	7.0	(5.8-8.2)
		Indian Cr.	3	22.0	(18-26)	(25) Gravel	(20) Cobble	7.4	(6.9-7.8)	258.5	(243-274)	42.0	(41.2-42.8)	5.6	(5.1-6)
		Pass Cr.	4	30.7	(20-47)	(39) Cobble	(34) Gravel	7.6	(6.9-8.3)	315.0	(242-385)	39.9	(37.9-42)	4.4	(3.3-5.6)
		Tributaries	10	9.8	(0-28)	(62) Sand/Silt/Clay	(14) Gravel	7.1	(6.1-8.7)	158.8	(12-315)	46.7	(40.6-51.1)	8.1	(4.8-10.6)
	Tributaries		57	5.7	(0-19)	(28) Sand/Silt/Clay	(18) Gravel	7.1	(5.6-8.4)	42.2	(18.1-170)	53.7	(45.4-61.7)	12.0	(7.4-16.5)
		Skwentna Total:	**105**	**40.8**	**(0-1850)**	**(30) Sand/Silt/Clay**	**(18) Gravel**	**7.1**	**(5.6-9.6)**	**109.6**	**(12-385)**	**49.8**	**(37.9-61.8)**	**9.9**	**(3.3-16.6)**
Yentna	Yentna R.	Johnson Cr.	6	2.5	(2-3)	(38) Sand/Silt/Clay	(5) Gravel	7.0	(6.7-7.6)	53.3	(28-77)	51.4	(47.1-58)	10.8	(8.4-14.4)
		Yentna Total:	**6**	**2.5**	**(2-3)**	**(38) Sand/Silt/Clay**	**(5) Gravel**	**7.0**	**(6.7-7.6)**	**53.3**	**(28-77)**	**51.4**	**(47.1-58)**	**10.8**	**(8.4-14.4)**
Kuskokwim	S.F. Kuskokwim R.	Mainstem	1	2000.0	N/A	(60) Cobble	(20) Gravel	8.6	N/A	435.0	N/A	42.8	N/A	6.0	N/A
		Tatina R.	20	83.8	(3-850)	(37) Cobble	(26) Gravel	8.6	(7.3-9)	326.3	(192-407)	43.2	(39-52)	6.2	(3.9-11.1)
		Post R.	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		High Lakes	1	2.0	N/A	(70) Org. Macro	(30) Sand/Silt/Clay	7.0	N/A	269.0	N/A	44.1	N/A	6.7	N/A
		Tin Cr.	4	10.0	(10-10)	(20) Gravel	(15) Cobble	7.2	(7.2-7.2)	524.0	(524-524)	42.3	(42.3-42.3)	5.7	(5.7-5.7)
		Sheep Cr.	15	14.0	(4-35)	(25) Sand/Silt/Clay	(15) Gravel	7.8	(7.4-8.9)	800.7	(702-864)	46.0	(44.1-47.9)	7.8	(6.7-8.8)
		Tributaries	17	11.3	(2-50)	(21) Sand/Silt/Clay	(15) Gravel	8.0	(6.7-8.9)	653.7	(497-766)	45.9	(40.1-59)	7.7	(4.5-15)
	Windy F. Kuskokwim R.	Mainstem	1	1000.0	N/A	(40) Sand/Silt/Clay	(35) Cobble	7.2	N/A	443.0	N/A	49.2	N/A	9.6	N/A
		Pitka F.	2	2.0	(2-2)	N/A	N/A	9.0	(9-9)	N/A	N/A	42.5	N/A	5.8	(5.8-5.8)

Table 3.13-18: Stream Characteristics and Water Quality Data by Drainage for the Pipeline Route (2010)

Drainage Area	Mainstem	Tributary	# Sites	Wetted Width (ft)		Substrate		pH		Conductivity (µS/cm)		Water Temp (°F)		Water Temp (°C)	
				AVG	Range	Average (%) Dominant Type	Average (%) Sub-Dominant Type	AVG	Range	AVG	Range	AVG	Range	AVG	Range
Kuskokwim (cont'd)		Khuchaynik Cr.	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Tributaries	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	M.F. Kuskokwim R.	Mainstem	1	120.0	N/A	(60) Cobble	(20) Gravel	8.7	N/A	501.0	N/A	52.6	N/A	11.4	N/A
		Tributaries	21	11.6	(0-45)	(38) Sand/Silt/Clay	(21) Gravel	8.6	(6.9-9.1)	427.5	(32-942)	46.0	(38.6-54.4)	7.8	(3.7-12.4)
	Big R.	Mainstem	1	180.0	N/A	(70) Cobble	(20) Sand/Silt/Clay	7.2	N/A	393.0	N/A	46.4	N/A	8.0	N/A
		Sidearm	4	25.5	(16-35)	(44) Sand/Silt/Clay	(18) Gravel	6.9	(6.7-7.2)	385.5	(382-389)	45.4	(43.6-47.2)	7.4	(6.4-8.4)
		Tributaries	17	1.7	(0-4)	(42) Sand/Silt/Clay	(14) Org. Other	7.4	(5.7-8.8)	187.2	(29-270)	48.3	(38.2-57.6)	9.1	(3.4-14.2)
	Tatlawiksuk R.	Mainstem	1	192.0	N/A	(60) Gravel	(20) Cobble	8.4	N/A	127.0	N/A	43.6	N/A	6.4	N/A
		Sidearm	2	16.0	(16-16)	(70) Sand/Silt/Clay	(18) Gravel	7.9	(7.9-7.9)	142.0	(142-142)	40.3	(40.3-40.3)	4.6	(4.6-4.6)
		Tributaries	42	9.1	(2-67)	(48) Sand/Silt/Clay	(13) Gravel	7.1	(4.4-9.2)	57.4	(9.1-242)	41.6	(36.6-55.5)	5.3	(2.6-13.1)
	Kuskokwim R.	Mainstem	1	1500.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Sidearm	1	900.0	N/A	(80) Sand/Silt/Clay	(20) Gravel	N/A	N/A	365.0	N/A	49.1	N/A	9.5	N/A
	Nunsatuk R.	Tributaries	3	2.5	(2-3)	(72) Sand/Silt/Clay	(10) Cobble	7.3	(6.1-8.5)	145.5	(130-161)	39.0	(38.9-39)	3.9	(3.8-3.9)
	Moose Cr.	Mainstem	1	6.0	N/A	(50) Sand/Silt/Clay	(20) Cobble	6.2	N/A	105.0	N/A	39.6	N/A	4.2	N/A
		Tributaries	1	2.0	N/A	(80) Sand/Silt/Clay	(10) Gravel	3.6	N/A	137.0	N/A	35.3	N/A	1.8	N/A
	George R.	Mainstem	2	100.0	(100-100)	(30) Cobble	(10) Gravel	6.8	(6.8-6.8)	172.0	(172-172)	N/A	(0-0)	N/A	N/A
		E.F. George R.	13	18.8	(1-120)	(47) Sand/Silt/Clay	(23) Gravel	6.9	(2-8.5)	154.0	(97-205)	38.5	(36.5-40.2)	3.6	(2.5-4.6)
		N.F. George R.	3	34.0	(3-65)	(32) Gravel	(25) Cobble	7.9	(7-8.9)	215.0	(197-233)	37.5	(34.1-41)	3.1	(1.2-5)
		Tributaries	3	2.5	(2-3)	(80) Sand/Silt/Clay	(23) Org. Other	6.7	(6.5-6.8)	138.0	(138-138)	38.8	(38.2-39.4)	3.8	(3.4-4.1)
	Tributaries		23	17.5	(2-150)	(49) Sand/Silt/Clay	(13) Org. Other	7.1	(6.4-8.6)	101.2	(50-248)	40.8	(36.5-48.8)	4.9	(2.5-9.3)
		Kuskokwim Total:	**210**	**66.6**	**(0-2000)**	**(36) Sand/Silt/Clay**	**(15) Gravel**	**7.4**	**(2-9.2)**	**221.0**	**(9.1-942)**	**43.0**	**(34.1-59)**	**6.1**	**(1.2-15)**
		Grand Total:	**452**	**43.0**	**(0-2000)**	**(30) Sand/Silt/Clay**	**(16) Gravel**	**7.2**	**(2-9.6)**	**140.3**	**(9.1-942)**	**45.7**	**(34.1-61.8)**	**7.6**	**(1.2-16.6)**

Notes:

Table represents averaged stream data along the pipeline route collected during summer, 2010. Substrate displayed as (percentage) of substrate type within survey reach.
N/A = not applicable

Source: Ottertail 2012e

3.13.2.3.2 FISH

Lakes, rivers, and perennial and intermittent streams along the pipeline route provide seasonal or year-round fish habitats supporting spawning, foraging, rearing, refuge, and / or migratory use. Some streams intersected by the pipeline route are likely to provide habitat for resident and / or anadromous fishes, including fish of conservation concern as identified in Alaska's Comprehensive Wildlife Conservation Strategy (e.g., ninespine stickleback, Pacific lamprey, and others) (ADF&G 2006c). Many of the fish species found in streams that intersect the Pipeline also occur along the Transportation Corridor. See Section 3.13.2.2.2 for full species descriptions of salmon, whitefish, Arctic grayling, rainbow smelt, northern pike, burbot, and Alaska blackfish.

Anadromous fish present in the proposed project area include all five species of Pacific salmon: Chinook, chum, coho, pink, and sockeye (Ottertail 2014d). Anadromous Bering cisco is also present in the mainstem of the Kuskokwim River and the South Fork (RJ Brown et al. 2012). Streams along the pipeline route also provide habitat to native fish (e.g., Dolly Varden, rainbow trout, northern pike, round whitefish, burbot, slimy sculpin, longnose sucker, and stickleback [spp.]). These species play a crucial role in the aquatic ecosystem as they provide prey for terrestrial animals and other freshwater and anadromous fishes (ADF&G 2006c; Groot and Margolis 1991). A summary of stream crossings along the five drainages traversed by the pipeline route is provided in Table 3.13-19. A summary of fish species known to occur in drainages along the pipeline route is presented in Tables 3.13-20 and 3.13-21.

Of the streams along the proposed route, those located in the Kuskokwim and Skwentna river drainages support the largest number of fish species (20 and 13 species, respectively). The mainstem of the Kuskokwim River and the East Fork of the George River are the most diverse of these drainages. Streams in the Cook Inlet and Yentna drainages are also intersected by the proposed route but provide habitat to fewer fish species (12 and 5 species, respectively). The two most common species found across all drainages were slimy sculpin and Dolly Varden (Table 3.13-20 and Table 3.13-21). A total of 1,031 sampling site visits between 2010 and 2014 were conducted by Ottertail (2014d). A total of 577 crossings were identified by the end of the 2014 field season. These crossings included those designated as anadromous waters under the ADF&G's Anadromous Waters Catalog (AWC), crossings assessed from the air, crossings surveyed on the ground, crossings assessed on the ground but not sampled, Shoofly Road crossings, access road crossings, and small undefined drainage crossings (grouped with Pipeline crossings). Crossings are defined as the exact location the route crosses a stream. Sampling sites were ideally located immediately downstream of the pipeline crossing. In cases where this was infeasible (e.g., canyon wall or access issues), the closest location that fit project objectives was selected. Overall, 151, 121, 4, and 300 crossings were identified within the Cook Inlet, Skwentna River, Yentna River, and Kuskokwim River drainage areas, respectively. Additionally, 96 optimum habitat sites were sampled; 19 of these sampling sites occurring in the Cook Inlet drainage area, 9 in the Skwentna drainage area, one in the Yentna drainage area, and 67 in the Kuskokwim drainage area. These optimum habitat sites added refined species composition information to many of the drainages crossed by the Pipeline.

Fish presence was documented at 178 of the 574 crossings assessed (Table 3.13-19). Of these, 42 occurred within reaches previously documented as anadromous under the AWC and were not sampled. Additionally, Ottertail (2014d) documented salmon at 36 crossings not previously documented as anadromous waters. Stream channel characteristics and water quality data were collected at 305 crossings and 88 optimum habitat (OH) sampling sites.

Cook Inlet Drainage

A total of 2,762 fish were collected at 57 fish bearing stream crossings within the Cook Inlet drainage. Salmon were documented at two crossings by electrofishing or by documentation of salmon at an upstream sampling site. Fish species collected in the Cook Inlet drainages included coho salmon, Dolly Varden, rainbow trout, ninespine stickleback, three-spine stickleback, slimy sculpin, and Alaskan brook lamprey. Additionally, ADF&G has previously documented the presence of Chinook salmon, humpback whitefish, and coastrange sculpin in drainages that would be crossed by the pipeline (Table 3.13-19 through Table 3.13-21).

Skwentna River Drainage

A total of 34 fish bearings stream crossings were surveyed within the Skwentna River drainage resulting in the collection of 1,297 fish. Fish species collected in the Skwentna drainage area included coho salmon, Chinook salmon, sockeye salmon, Arctic grayling, Dolly Varden, rainbow trout, Alaskan brook lamprey, burbot, ninespine stickleback, three-spine stickleback, and slimy sculpin. ADF&G also previously documented pink salmon within drainages that would be crossed by the pipeline (Table 3.13-19 through Table 3.13-21).

Yentna River Drainage

A total of 408 fish were collected within the four fish sampling sites in the Yentna River drainage. Coho salmon were documented at a single sampling site by electrofishing. The fish species collected in the Yentna drainage included coho salmon, rainbow trout, longnose sucker, three-spine stickleback, and slimy sculpin (Table 3.13-19 through Table 3.13-21).

Kuskokwim River Drainage

A total of 86 fish bearing stream crossings were surveyed within the Kuskokwim River drainage resulting in a total of 6,138 fish. The fish species collected in the Kuskokwim drainage included coho salmon, Chinook salmon, Arctic grayling, Dolly Varden, round whitefish, Alaska blackfish, longnose sucker, northern pike, and slimy sculpin. ADF&G has previously documented chum salmon, sockeye salmon, rainbow trout, broad whitefish, sheefish, lake chub, Alaskan brook lamprey, burbot, and ninespine stickleback, within drainages that would be crossed by the pipeline (Table 3.13-19 through Table 3.13-21).

The greatest number of fish captured occurred in the Kuskokwim River drainage. The catch per unit of effort (CPUE; total fish captured / seconds of electrofishing) varied across the drainages and included 0.0208 CPUE for the Kuskokwim River drainage, 0.0249 CPU for the Skwentna River drainage, 0.0281 CPUE for the Cook Inlet drainage, and 0.1056 CPUE for the Yentna River drainage (Ottertail 2014d).

In addition to electrofishing, aerial surveys were conducted to assess the distribution and relative abundance of adult salmon populations (Ottertail 2014d). Aerial surveys were conducted on 82 reaches. Of these, 11 were in the Cook Inlet drainage, 27 were in the Skwentna River drainage, one was in the Yentna River drainage, and 43 were in the Kuskokwim River drainage. A total of 101 Chinook, 41 chum, 46 coho, and 801 sockeye salmon adults were observed during the surveys. These values do not represent the total spawning escapement in these drainages since survey flights generally focused on identifying spawning habitat locations and the presence / absence of adult salmon rather than determining population estimates.

3.13.2.3.3 ESSENTIAL FISH HABITAT

Rivers and tributaries with variable substrate character would be crossed by the pipeline, temporary access roads, and shoofly roads within the Kuskokwim, Skwentna, Yentna, and Cook Inlet drainages (Table 3.13-19). Table 3.13-20 lists the rivers and tributaries documented as supporting EFH-protected species that the pipeline route would cross (Ottertail 2012a, 2014b). Pacific salmon EFH has been designated within 23 mainstem and tributary streams in all 4 of the main drainages, where substantial levels of spawning and rearing have been documented (Johnson and Daigneault 2013). Drainages crossed by the proposed pipeline route have salmon spawning runs that extend from May, when Chinook salmon start their upstream migrations, through September when coho salmon spawn throughout area streams. These include Lewis River and Wolverine and Sucker creeks that are of particular importance to salmon. The Lewis River has historic stocks of Chinook and coho salmon with Chinook now recognized as a species of concern by the ADF&G Board of Fish. Below the confluence of Wolverine Creek, Wolverine and Sucker creeks provide over 90 percent of the spawning habitat for Chinook salmon in the Alexander Creek drainage. EFH for all five salmon species has been designated in Cook Inlet, with most species present in the Beluga and Theodore rivers and within the Skwentna River drainage's mainstem and Shell Creek. EFH for Chinook, coho, chum, and pink salmon has been designated in the upper Kuskokwim drainages, while only coho EFH is present in the Yentna River. Appendix Q contains the EFH Assessment with further details (Owl Ridge 2017c).

3.13.2.3.4 MACROINVERTEBRATES

Macroinvertebrate samples were collected at survey sites where riffle habitat was present. Collected samples were sorted and preserved with isopropyl alcohol for future analysis.

3.13.2.4 CLIMATE CHANGE

Climate change is affecting resources in the EIS Analysis Area and trends associated with climate change are projected to continue into the future. Section 3.26.3, Climate Change, discusses climate change trends and impacts to key resources in the physical and biological environments including atmosphere, water resources, permafrost, and vegetation. Current and future effects on fish and aquatic resources are tied to changes in water resources (discussed in Section 3.26.4).

Table 3.13-19: Summary of Pipeline Route Stream Crossings (2010–2014)

Crossing Type	Status	Drainage				Total
		Cook Inlet	Skwentna	Yentna	Kuskokwim	
Pipeline Crossings	Anadromous (ADF&G)	2	12	0	18	32
	Anadromous (OT)	0	11	0	18	29
	Fish Captured	50	6	1	34	91
	No Fish Caught	26	28	2	67	123
	Not Sampled	63	47	1	117	228
	Total	**141**	**104**	**4**	**254**	**503**
Access Road Crossings	Anadromous (ADF&G)	0	0	0	0	0
	Anadromous (OT)	0	0	0	2	2
	Fish Captured	0	0	0	1	1
	No Fish Caught	0	0	0	0	0
	Not Sampled	0	1	0	3	4
	Total	**0**	**1**	**0**	**6**	**7**
Shoofly Road Crossings	Anadromous (ADF&G)	1	3	0	6	10
	Anadromous (OT)	0	1	0	3	4
	Fish Captured	4	1	0	4	9
	No Fish Caught	1	1	0	9	11
	Not Sampled	5	10	0	18	33
	Total	**11**	**16**	**0**	**40**	**67**
All Crossings Combined	Anadromous (ADF&G)	3	15	0	24	42
	Anadromous (OT)	0	12	0	23	35
	Fish Captured	54	7	1	39	101
	Total Fish Bearing	**57**	**34**	**1**	**86**	**178**
	No Fish Caught	27	29	2	76	134
	Not Sampled	68	58	1	138	265
	Total Non-Fish Bearing	95	87	3	214	399
	Total	**152152**	**152**	**121**	**4**	**300**

Notes:

The designation of non-fish bearing is based on sampling effort and may not be definitive as fish may use these waters at different times of year, or under different hydrologic conditions. Statuses listed as "not sampled" are already documented by ADF&G, or the stream is intermittent, meaning there is no chance of fish in those streams.

Source: Ottertail 2014d

Table 3.13-20: Summary of Fish Species Composition per Drainage for the Pipeline Route (2010 to 2013)

Drainage	Mainstem	Tributary	Salmon								Non-Salmon																		Total Species
			Coho salmon	Chinook salmon	Chum salmon	Sockeye salmon	Pink Salmon	Arctic grayling	Dolly Varden	Rainbow trout	Round whitefish	Humpback whitefish	Broad whitefish	Whitefish Sp. 4	Sheefish	Least cisco	Bering Cisco	Alaska blackfish	Alaskan brook lamprey	Arctic Lamprey	Lamprey Sp.	Burbot	Longnose sucker	Ninespine stickleback	Threespine stickleback	Northern pike	Coastrange sculpin	Slimy sculpin	
Cook Inlet	Beluga River	Mainstem	X1	X1		X1	X1					X1													X1		X1		7
	Theodore River	Mainstem	X1	X1	X1		X1			X1										X1					X1				7
		Tributaries	X	X																				X					3
	Lewis R.	Tributaries	X						X	X																		X	4
	Alexander Cr.	Lower Sucker Cr.							X																			X	2
		Bear Cr.		X1					X																			X	3
		Clear Cr.							X												X			X				X	4
		Deep Cr.							X																X			X	3
		Cook Inlet Total	**X**	**X**	**X**	**X**	**X**		**X**	**X**		**X**								**X**	**X**			**X**	**X**		**X**	**X**	**15**
Skwentna	Skwentna R.	Mainstem	X1	X1	X1	X1	X1		X1	X1																		X1	8
	Eightmile Cr.	Mainstem[3]	X						X	X																			3
		Tributaries	X						X	X																			3
	Shell Cr.	Mainstem	X1		X	X1	X1																						4
		Tributaries	X							X									X									X	4
	Happy R.	Mainstem		X2		X2			X1																			X1	4
		Canyon Cr.		X1																									1
		Squaw Cr.		X2		X2																						X1	3
		Indian Cr.		X2					X																				2
		Threemile Cr.				X1			X2																				2
		Pass Cr.		X					X																			X	3
		Sheep Cr.		X					X																				2
		Tributaries	X2	X2	X	X		X	X	X												X		X	X			X	11
	Tributaries		X2	X2	X	X		X	X	X												X		X	X			X	11
		Skwentna Total	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**									**X**			**X**		**X**	**X**			**X**	**13**
Yentna	Yentna R.	Johnson Cr.	X							X													X		X			X	5
		Yentna Total	**X**							**X**													**X**		**X**			**X**	**5**
Kuskokwim	S.F. Kuskokwim R.	Mainstem	X1	X1	X1				X1		X1			X1	X1		X5											X1	8
		Sidearm	X1						X1		X1																	X1	4
		Tatina R.	X						X2		X			X														X	5
		Post R.	X	X				X1	X2		X																	X2	6
		High Lakes																											0
		Tin Cr.							X																				1

Table 3.13-20: Summary of Fish Species Composition per Drainage for the Pipeline Route (2010 to 2013)

Drainage	Mainstem	Tributary	Salmon								Non-Salmon																		Total Species
			Coho salmon	Chinook salmon	Chum salmon	Sockeye salmon	Pink Salmon	Arctic grayling	Dolly Varden	Rainbow trout	Round whitefish	Humpback whitefish	Broad whitefish	Whitefish Sp. 4	Sheefish	Least cisco	Bering Cisco	Alaska blackfish	Alaskan brook lamprey	Arctic Lamprey	Lamprey Sp.	Burbot	Longnose sucker	Ninespine stickleback	Threespine stickleback	Northern pike	Coastrange sculpin	Slimy sculpin	
Kuskokwim (cont'd)	S.F. Kuskokwim R. (cont'd)	Jones R.	X1						X2																			X	3
		Sheep Cr.							X																				1
		Tributaries		X					X																			X	3
	Windy F. Kuskokwim R.	Mainstem	X						X						X1								X					X	4
		Khuchaynik Cr.																											0
		Tributaries							X																				1
	M.F. Kuskokwim R.	Mainstem	X						X2						X1													X2	3
		Tributaries							X2																			X2	2
	Big R.	Mainstem	X1	X1	X1				X1			X5		X1														X1	6
		Sidearm	X1	X1	X1				X1					X1														X1	6
		Tributaries							X																				1
	Tatlawiksuk R.	Mainstem	X2	X1	X1						X1																		3
		Sidearm	X2	X1	X1																								3
		Tributaries	X2	X2				X2	X2									X				X						X2	7
	Kuskokwim R.	Mainstem	X1	X1	X1	X1		X1			X1	X1	X1	X1	X1	X1	X5	X1	X1		X1	X1	X1			X1		X1	18
	Nunsatuk R.	Tributaries							X																			X	2
	Moose Cr.	Mainstem	X						X																			X	3
		Tributaries	X						X																				2
	George R.	Mainstem	X2	X1	X1			X1	X1					X1														X1	7
		E. F. George R.	X2	X1	X1			X1	X2		X1			X1							X1	X1		X1				X2	11
		N. F. George R.	X1	X1	X2				X1					X1														X1	6
		Tributaries		X1																									1
	Tributaries		X					X	X2									X								X		X2	6
		Kuskokwim Total	**X**	**X**	**X**	**X**		**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**		**X**	**X**		**X**	**X**	**X**	**X**		**X**		**X**	**20**
		Grand Total	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**26**

Notes:

Refer to Ottertail 2012b; 2014d for complete fish sampling data collected by Ottertail Environmental, Inc. An "X" does not indicate that the species occurs in all streams sampled, but rather was found in at least one stream within the drainage.

1 ADF&G data from Anadromous Waters Catalog and Alaska Freshwater Fish Inventory databases.
2 Found by Ottertail Environmental, Inc. and ADF&G data from Anadromous Waters Catalog or Alaska Freshwater Fish Inventory databases.
3 Mainstem Eightmile Creek was not sampled. Fish species assemblage collected from tributary sEIT2 that feeds the Eightmile Creek mainstem.
4 Some whitefish species will not be found unless the survey is conducted during the latter part of September when mature fish move from feeding grounds in the lower Kuskokwim River to spawning areas located in the headwaters.5 From RJ Brown et al. (2012) and Harper et al. (2012)
Source: ADF&G 2010; Ottertail 2012a; 2014d; Johnson and Litchfield 2016

Table 3.13-21: Summary of Fish Species Composition along the Pipeline Route (2010 to 2013)

Species Code	Drainage Area				Total # Crossings[1]
	Cook Inlet	Skwentna	Yenta	Kuskokwim	
Ø	25	28	2	69	126
DV	37	3		23	63
DV,SS	7	1		9	17
CO,SS		3		5	8
CO,DV,SS				4	4
CO,DV		1		3	4
CO		1		3	4
SS	1	1		2	4
CO,RT		2			2
NS	1				1
AB				1	1
AG,SS,BU				1	1
CH,CO,RT,SS,NS		1			1
CO,AG,BU		1			1
CO,AG,SS				1	1
CO,AG,SS,AB				1	1
CO,AG,SS,NP,AB				1	1
CO,DV,SS,AB				1	1
CO,RT,SS		1			1
CO,RT,SS,LA		1			1
DV,AB				1	1

Species Codes		
Code	Common Name	Scientific Name
Ø	No fish caught	
LS	longnose sucker	*Catostomus catostomus*
SS	slimy sculpin	*Cottus cognatus*
AB	Alaska blackfish	*Dallia pectoralis*
NP	northern pike	*Esox lucius*
TS	threespine stickleback	*Gasterosteus aculeatus*
LA	Alaskan brook lamprey	*Lampetra alaskensis*
BU	burbot	*Lota lota*
P	pink salmon	*Oncorhynchus gorbuscha*
CH	chum salmon	*Oncorhynchus keta*
CO	coho salmon	*Oncorhynchus kisutch*
RT	Rainbow trout	*Oncorhynchus mykiss*
S	sockeye salmon	*Oncorhynchus nerka*
K	Chinook salmon	*Oncorhynchus tshawytscha*
RW	round whitefish	*Prosopium cylindraceum*
NS	ninespine stickleback	*Pungittius pungittius*
DV	Dolly Varden	*Salvelinus malma*
AG	Arctic grayling	*Thymallus arcticus*

Table 3.13-21: Summary of Fish Species Composition along the Pipeline Route (2010 to 2013)

Species Code	Drainage Area				Total # Crossings[1]		Species Codes		
	Cook Inlet	Skwentna	Yenta	Kuskokwim			Code	Common Name	Scientific Name
K,CO,DV,SS,BU				1	1				
K,DV,SS		1			1				
RT		1			1				
SS,TS	1				1				
TS			1		1				
Total # Crossings[1]	75	46	3	126	250				

Notes:

Table represents data collected from 2010 to 2013 along the Pipeline by Ottertail Environmental, Inc.

1 Ottertail 2014d. A crossing is defined as the point where the proposed pipeline route or support road crosses a stream. This table represents data collected within 1000 ft upstream or downstream of a crossing (1000 ft (304.8 m) Buffer). Crossings previously documented as anadromous by ADF&G in the Anadromous Waters Catalog (AWC) were not included in this table. Note that the crossing totals displayed here differ from those presented in Table 3.13-20. This table only includes species composition for sites sampled. In Table 3.13-20, some crossings were close enough to another crossing to use the same dataset for both.

Source: Ottertail 2014d

3.13.3 ENVIRONMENTAL CONSEQUENCES

This section analyzes potential effects of the proposed project and alternatives on fish and aquatic resources from Construction, Operations, and Closure Phase activities associated with the Mine Site, Transportation Corridor, and Pipeline components. Supplementing this analysis is an assessment of project-related impacts associated with Alternative 2 on EFH (see Appendix Q, EFH Assessment, Owl Ridge 2017c). The area of potential effect evaluated includes watersheds and downgradient aquatic habitats in the vicinity of these project components from headwater streams to marine waters. The intensity, duration, geographical extent, and context of potential impacts are considered in this analysis for each alternative and phase of the project.

Aquatic resources described in Section 3.13.2, Affected Environment, have been evaluated on the basis of certain pathways and mechanisms of potential impacts for various project components. For example, the key pathway of potential impacts to fish, other aquatic species, and their associated habitats affected by mining involves water. Mechanisms of potential mining impacts on aquatic resources include changes to water quality or quantity, in-stream or riparian habitat, and fish health, behavior, and migration access. These and other potential impacts have been evaluated for various project components and related activities over the project's life cycle (Construction, Operations, Closure) by considering direct and indirect effects to fish and aquatic resources as a result of:

- Mine pits, fresh and contact water dams and water storage reservoirs;
- Overburden stockpiles and waste rock facilities;
- Tailings storage dam and impoundment;
- Temporary and permanent access roads and runways;
- Bulkheads / fills, and other overwater structures related to port terminals and barging;
- Bridges, culverts, and pipeline / roadway stream crossings;
- Equipment / materials storage / laydown areas;
- Rock and aggregate materials sites;
- Dewatering wells and related drainage / conveyance / detention / treatment systems;
- Spill containment and waste treatment facilities;
- Marine, truck, or air transport, storage, and handling of fuel and cargo;
- Natural gas pipeline infrastructure; and
- Collection, conveyance, treatment, and storage of waste and ore processing effluent.

Evaluating the pathways and mechanisms and related issues within the context of these project features and activities provides a basis for identifying impacts and avoidance / minimization and mitigation approaches that have been considered and, where appropriate, incorporated into the project alternatives.

Table 3.13-22 provides the assessment criteria used to assess the relative level of impacts to fish and aquatic resources for several mechanisms of effect (broadly associated with behavioral disturbance, habitat alterations, or injury / mortality / sustainability). These effects have been systematically assessed based on intensity, duration, extent or scope, and context as described below.

Table 3.13-22: Impact Methodology for Effects on Aquatic Resources

Type of Impact	Impact Factor	Assessment Criteria		
Behavioral Disturbance	Magnitude or Intensity	Changes in behavior of fish or other aquatic biota due to project activity may not be noticeable; fish populations remain in the vicinity.	Noticeable changes in behavior of fish or other aquatic biota due to project activity that may affect reproduction, feeding, or survival of individuals.	Acute or obvious/abrupt change in fish or other aquatic biota behavior due to project activity; life functions are disrupted; populations are indirectly reduced in the EIS Analysis Area.
	Duration	Behavior patterns of fish and other aquatic biota are infrequently altered, but not longer than the span of Construction and would be expected to return to pre-activity levels after actions causing impacts were to cease.	Behavior patterns of fish or other aquatic biota are altered by ongoing activity and would return to pre-activity levels after actions causing impacts cease.	Change in behavior patterns of fish or other aquatic biota would continue even if actions that caused the impacts were to cease; behavior would not be expected to return to previous patterns.
	Extent or Scope	Impacts to fish or other aquatic biota would be limited geographically to waters in the vicinity of the project footprint and the associated watershed(s).	Impacts would affect fish or other aquatic biota beyond a local reach of stream or watershed, potentially extending throughout the EIS Analysis Area including offshore marine waters.	Impacts would affect fish or other aquatic biota beyond the region or EIS Analysis Area.
	Context	Impacts would affect individual fish or other aquatic biota that are often found in the EIS Analysis Area and are not under special regulatory protection; populations would not be depleted in the locality.	Impacts would affect individuals or populations of fish or other aquatic biota nearing depletion within the locality or region or that are subject to special regulatory protection.	Impacts would affect populations of fish or other aquatic biota subject to special regulatory protection; the affected populations fill a unique ecosystem role within the locality or region.
Habitat Alterations	Magnitude or Intensity	Changes in the character or quantity of aquatic habitat may not be measurable or noticeable.	Changes in the character and quantity of aquatic habitat would be noticeable.	Changes to the character and quantity of aquatic habitat would be acute or obvious.
	Duration	The character or quantity of aquatic habitat would be reduced infrequently but would be expected to return to pre-activity levels.	The character or quantity of aquatic habitat would be reduced beyond the life of the project.	The character or quantity of aquatic habitat would not be anticipated to return to its pre-disturbance character or levels.
	Extent or Scope	Impacts to aquatic habitat would be limited geographically to waters in the vicinity of the project footprint and the associated watershed(s).	Impacts to aquatic habitat would extend beyond a local reach of stream or watershed and potentially throughout the EIS Analysis Area including offshore marine waters.	Impacts to aquatic habitat would extend beyond the region or EIS Analysis Area.

Table 3.13-22: Impact Methodology for Effects on Aquatic Resources

Type of Impact	Impact Factor	Assessment Criteria		
	Context	Impacts would affect aquatic habitat that is often found in the EIS Analysis Area and is not subject to special regulatory protection; such habitat would not be depleted in the locality.	Impacts would affect aquatic habitat that is becoming depleted within the locality or region or that is subject to special regulatory protection.	Impacts would affect aquatic habitat subject to special regulatory protection; the affected habitat fills a unique ecosystem role within the locality or region.
Injury and Mortality[1]	Magnitude or Intensity	No noticeable incidents of injury or mortality to individual fish or other aquatic biota; population level effects are not detectable.	Incidents of injury or mortality to individual fish or other aquatic biota are detectable; populations remain within normal variation.	Incidents of mortality or injury to individual fish or other aquatic biota create population-level effects.
	Duration	Events with potential for causing mortality or injury to fish or other aquatic biota would occur for a brief, discrete period lasting less than one year, or up to the duration of Construction.	Events with potential for causing mortality or injury to fish or other aquatic biota would continue for up to the life of the project.	Potential for mortality or injury to fish or other aquatic biota would persist after actions that caused the disturbance have ceased.
	Extent or Scope	Impacts to fish or other aquatic biota would be limited geographically to the vicinity of the project footprint and the affected watershed.	Impacts would affect fish or other aquatic biota beyond a local reach of stream or watershed, potentially extending throughout the EIS Analysis Area including offshore marine waters.	Impacts would affect fish or other aquatic biota beyond the region or EIS Analysis Area.
	Context	Impacts would affect individual fish or other aquatic biota that are often found in the EIS Analysis Area and are not under special regulatory protection; individuals would not be depleted in the locality.	Impacts would affect individuals or populations of fish or other aquatic biota nearing depletion within the locality or region or that are subject to special regulatory protection.	Impacts would affect populations of fish or other aquatic biota subject to special regulatory protection; the affected populations fill a unique ecosystem role within the locality or region.

Notes:

1 Injury or mortality impacts from contamination from fuel or chemical spills is discussed in Section 3.24, Spills.

3.13.3.1 ALTERNATIVE 1 – NO ACTION ALTERNATIVE

Under the No Action Alternative, the Donlin Gold Project would not be developed. Consequently, project-related impacts on fish and aquatic resources, whether adverse or beneficial, would not occur. Existing land management trends or potential future developments (if any) may occur, but their associated impacts would not be related to the proposed project.

As described in Section 3.5, Surface Water Hydrology, Kuskokwim River bank erosion related to natural erosion processes, such as ice jams and ice flows during spring break-up and thermoerosional niching that contribute to roughly 10 to 15 feet of bank erosion per year, would continue. Additionally, waves generated from existing boat traffic (barge, recreational, and fishing) that currently contribute to bank erosion, would continue under Alternative 1. Fish spawning habitat disruption from dislodging of eggs or sedimentation can result from natural flooding, ice break up, bank erosion, and riverbed scour from both natural causes and existing boat traffic. Additionally, bed scour from existing barge traffic, flooding, and ice-out conditions also contribute to sediment resuspension and displacement of fish eggs and larvae and other aquatic biota. These conditions would continue under Alternative 1.

3.13.3.2 ALTERNATIVE 2 – DONLIN GOLD'S PROPOSED ACTION

All action alternatives would involve construction and operation of facilities and infrastructure required to mine, process, and produce gold from the Donlin Gold Mine to off-site markets. The following section describes potential impacts on fish and aquatic resources that would result from all phases of the Mine Site component and the related facilities and infrastructure described in Chapter 2, Alternatives.

Based on comments on the Draft EIS from agencies and the public, one route option has been included in Alternative 2 to address concerns due to pipeline crossings of the Iditarod National Historic Trail (INHT):

- North Option: The MP 84.8 to 112 North Option would realign this segment of the natural gas pipeline crossing to the north of the INHT before the Happy River crossing and remain on the north side of the Happy River Valley before rejoining the alignment near MP-112 where it enters the Three Mile Valley. The North Option alignment would be 26.5 miles in length, compared to the 27.2 mile length of the mainline Alternative 2 alignment it would replace, with one crossing of the INHT and only 0.1 mile that would be physically located in the INHT right-of-way (ROW). The average separation distance from the INHT would be 1 mile.

3.13.3.2.1 MINE SITE

As described in Chapter 2, Alternatives, Mine Site development includes construction housing for the workforce; a power plant, utilities, services, and related infrastructure (e.g., fuel conveyance and storage facilities; roads and pads; and the transport, installation, and commissioning of facility modules); development of the proposed open pit mine, mill and ore processing, raw materials storage facilities, TSF, WRF and overburden stockpiles; and mine maintenance and safety controls. Most of these features would be constructed within the Crooked Creek watershed which drains an area of about 333 mi^2 or less than 1 percent of the 50,000 mi^2 Kuskokwim River watershed. The proposed features and facilities presenting potential risks to aquatic biota during all phases primarily involve those that ultimately could directly or indirectly alter or degrade surface or groundwater and aquatic habitats. This includes construction of mine infrastructure, access roads, and related facilities; mining and earth moving activities; pumping/dewatering and other management practices involving groundwater, surface water, and stormwater; wastewater or contact water conveyance, treatment, and disposal; storage and handling of fuel, process chemicals/byproducts, and hazardous waste; and other site management practices near and upslope, or otherwise hydraulically connected to surface waters that might be a source of contamination. Such activities could result in several mechanisms or key factors that directly or indirectly affect aquatic resources. These mechanisms, discussed in further detail in the following sections, include:

- In-stream habitat removal and fish loss;
- Water quality and water management practices;
- Wetland and riparian buffer removal;
- Streamflow changes and overall aquatic habitat;
- Streamflow changes and off-channel aquatic habitat;
- Streamflow changes and salmon spawning habitat;
- Streamflow changes and freezing of spawning substrates;
- Streamflow changes and salmon production;
- Other impacts of streamflow changes on aquatic habitat (e.g., drainage configuration);
- Stream temperature changes; and
- Erosion, sedimentation, and metals emissions.

Table 3.13-23 presents the anticipated stream channel distances within the vicinity of the Mine Site where direct impacts to aquatic habitat would occur and corresponding estimates of anticipated fish losses. At the Mine Site area, there would be a total direct loss of eight miles of perennial stream habitat consisting of 5.6 miles of aquatic habitat in American and Anaconda creeks. Of this, 0.66 mile is classified as anadromous waters and regulated as EFH. In addition, 2.36 miles of perennial stream habitat would be lost from direct impacts to Lewis and Snow gulches (non-anadromous waters). Virtually all of this loss would involve Lewis Gulch which studies have shown to be unoccupied by fish. Because fish populations are distributed unevenly (particularly Dolly Varden), the data presented in Table 3.13-22 should be considered estimates.

American Creek. Construction and Operations phases of the open pit, WRF, and contact water dams would require removal of the stream channel in the American Creek watershed. This would cause an acute or obvious loss of 4.1 miles of perennial aquatic habitat and associated fish and macroinvertebrate populations in the mainstem of this tributary, about 0.5 mile of which is documented as an Anadromous Water for coho salmon rearing by ADF&G (Johnson and Litchfield 2016). In addition, there would be a loss of other (non-fish) aquatic life associated with about 6 miles of relatively small, perennial tributaries to the mainstem channel (Ottertail 2012b). These habitat losses would not be anticipated to return to its pre-disturbance character or levels. During the Mine Site Closure Phase, drainage from the reclaimed WRF would be directed through a newly constructed channel for American Creek that would terminate in a pit lake downstream of the WRF. As a result, the American Creek drainage would experience an acute or obvious loss of aquatic habitat and fish that would not be anticipated to return to its pre-disturbance character or levels.

As shown in Table 3.13-23, habitats that would be lost in this drainage have fish populations that have been determined to consist of slimy sculpin (73 percent), Dolly Varden (14 percent), coho salmon (11 percent), and less than 1 percent each for Arctic grayling and burbot. Based on the species and density of fish populations captured in this drainage, habitat elimination could result in a predicted loss of approximately 4,300 fish (Table 3.13-23), however, an unknown proportion of these could be displaced to other stream segments in the drainage which may or may not be at carrying capacity. The greatest number and proportion of potential fish loss (about 2,800 or 65 percent) would involve Dolly Varden, and about 200 age 0 and age 1 juvenile coho salmon. Additional losses are anticipated for slimy sculpin, Arctic grayling, and burbot.

Overall, the anticipated direct impacts to American Creek would result in acute or obvious changes to the character and quantity of fish and aquatic habitat. These changes to American Creek would not be anticipated to return to its pre-disturbance character or levels. The extent or scope of these impacts would be limited geographically to waters in the vicinity of the project footprint. The context of these impacts would affect individuals or populations of fish or other aquatic biota classified as EFH. The anticipated indirect impacts to American Creek would include reduced recruitment of sediment and woody debris from the American Creek watershed, which represents about 2 percent of the Crooked Creek watershed. These changes in the character of aquatic habitat may not be measurable or noticeable. The extent or scope of these indirect impacts would be limited geographically to waters in the vicinity of the project footprint.

Lewis Gulch. Construction and Operations phases of the open pit would eliminate 2.3 miles of perennial aquatic habitat in Lewis Gulch. The anticipated direct impacts to Lewis Gulch would result in acute or obvious changes to the character and quantity of fish and aquatic habitat that would not be anticipated to return to its pre-disturbance character or levels. The extent or scope of these impacts would be limited geographically to waters in the vicinity of the project footprint. The context of these impacts would affect individual fish or other aquatic biota that are often found in the EIS Analysis Area and are not classified as EFH. No fish were observed or captured here during 2009 electrofishing surveys (Ottertail 2012b). Lower portions of the stream have been disrupted and channelized by historic placer mining operations. In addition, habitat removal in Lewis Gulch would result in indirect impacts in Crooked Creek because of the reduced recruitment of sediment and woody debris from Lewis Gulch. These indirect impacts may not be measurable or noticeable. This would result in impacts to aquatic habitat limited geographically to waters in the vicinity of the project footprint and immediately downstream from the Lewis Gulch confluence. Indirect impacts would not be anticipated to return to its pre-disturbance character or levels.

Anaconda Creek. Construction and Operations phases of the TSF would cause a loss of approximately 70 percent of the stream channel within the Anaconda Creek watershed. Direct loss would involve about 1.5 miles of aquatic habitat and associated fish and macroinvertebrate communities as a result of the complete burial of the main channel by the TSF. Catalogued as an Anadromous Water for coho salmon rearing by ADF&G (Johnson and Litchfield 2016), fish population densities in Anaconda Creek were determined to be considerably lower than American Creek and other similarly sized Crooked Creek drainages (Table 3.13-3).

The anticipated direct impacts would result in acute or obvious changes to the character and quantity of fish and aquatic habitat, including a loss of a local population of about 90 Dolly Varden. Immediately downstream from the Anaconda Creek confluence in Crooked Creek, indirect impacts to the morphological character and availability of certain instream habitat constituents are anticipated due to the reduced recruitment of stream substrates and large woody debris from this drainage. These indirect impacts may not be measureable or noticeable. Direct and indirect impacts would not be anticipated to return to its pre-disturbance character or levels. In addition, a loss of other (non-fish) aquatic life is anticipated and associated with

4.67 miles of relatively small, perennial tributaries to Anaconda Creek (Ottertail 2012b). The extent or scope of direct and indirect impacts would be limited geographically to waters in the vicinity of the project footprint and associated watersheds. The context of these impacts would affect individuals or populations of fish or other aquatic biota classified as EFH.

Snow Gulch. Construction and Operations of a dam and freshwater reservoir in the middle reach of the Snow Gulch watershed are proposed as a source of freshwater for the ore processing plant. The dam would displace 262 feet (0.05 mile) of stream channel, while the reservoir (at full capacity) would convert 0.89 mile of stream habitat upstream of the constructed dam into open-water lake habitat. In-stream construction at the dam site would cause a direct loss of habitat within the affected stream channel resulting in the potential loss or displacement of a small population of Dolly Varden, estimated at about three fish. Dam construction would create a fish migration barrier and cause a noticeable change in aquatic habitat as fish seek aquatic habitat undisturbed by construction (Table 3.13-13). These changes would not be anticipated to return to pre-disturbance levels. While the newly created reservoir likely would not result in direct losses of fish upstream of the proposed dam, indirect effects to fish in the downstream segment (estimated at about 60 Dolly Varden) could occur as a result of reduced flows depending on how water releases below the proposed dam are managed. In addition, fish passage has not been incorporated into the dam structure so Dolly Varden, or other species of fish, would not be able to migrate from the lower reaches of Snow Gulch, or Crooked Creek, past the dam into the upper watershed. While two coho salmon adults were observed in the lower portions of Snow Gulch in 2008, ongoing placer mine operations since then have likely precluded upstream migration of adult coho salmon and other fish from Crooked Creek into Snow Gulch (Ottertail 2012b).

An unknown number of Dolly Varden that would be isolated in the upper watershed by the proposed dam may periodically pass downstream over the dam’s spillway. Large woody debris, however, would not be able to pass from the upper watershed over the spillway into the lower reaches of this stream. This may result in an undetermined reduction of fish rearing and refuge habitat and woody substrate materials that support fish and aquatic invertebrates downstream of the dam (House and Boehne 1986; Marcus et al. 1990). Unless the reservoir above the proposed dam would become filled with sediment (which is not expected), its deeper water would offer substantial additional overwintering and foraging habitat for the population of Dolly Varden and other fishes that may become isolated upstream of the dam. Under normal perception conditions, water levels in the Snow Gulch reservoir would not substantially change. As described in Section 3.5.3.2.1, except when water is being withdrawn for use as process water, the reservoir would be kept at its maximum capacity such that the spillway would be used on a continuous basis.

Water Quality and Water Management Practices

Non-contact freshwater, including surface water flows and stormwater runoff, would be intercepted at the Mine Site area to control erosion, avoid contact with stockpiles and other mining infrastructure, and minimize potential water quality impacts to aquatic biota (see detailed figures in Chapter 2, Alternatives). Collected non-contact freshwater would be conveyed to stormwater/sedimentation control and storage facilities before being returned directly to other tributaries downstream or Crooked Creek. While it is possible the outflows from such storage facilities could have reduced levels of suspended sediments, this likely would be silt-laden runoff that naturally enters these drainages downstream where stream banks and channels are incised, erodible, and silt-laden, irrespective of mine development. A temporary fresh water diversion dam (FWDD) would be constructed in American Creek during the first year of operations to minimize flows to the lower contact water pond in the early stages of the WRF use. Flows exceeding the capacity of the dam would be discharged out of American Creek. Two additional temporary FWDDs would be constructed in the tributaries upstream of the TSF on Anaconda Creek to minimize runoff into the facility. Water from upper Anaconda Creek would be diverted around the TSF and released downstream. A dam also would be constructed on the middle section of Snow Gulch to provide a supply of freshwater for consumption during Operations.

Contact water is defined as surface water or groundwater that has contacted mining infrastructure, and includes 'mine drainage' defined in the Code of Federal Regulations (40 CFR 440.132(h)) as any water drained, pumped, or siphoned from a mine. As described in Chapter 2, contact water will involve a variety of sources including surface water, stormwater runoff, snowmelt, and groundwater seepage. Contact water also would include drainage from the open pits, WRF, and stockpiles conveyed to the lower and upper contact water ponds in American Creek where it would be stored and reclaimed for use in ore processing. During the Operations Phase of Alternative 2, groundwater from the pit-perimeter and in-pit dewatering wells would be routed to the water treatment plant prior to discharge to Crooked Creek below Omega Gulch (SRK 2017b). All water routed to the water treatment plant would be treated to meet applicable water quality requirements and standards of the APDES permit before discharge. Contact water that is not treated would be reused in the process circuit throughout the Operations Phase. Compliance monitoring would be conducted to assure that water quality standards during mine operations, closure, and reclamation are maintained and so potential water quality impacts on fish and aquatic life in the Crooked Creek drainage would be avoided or minimized. Specific monitoring standards and testing protocols would be stipulated in discharge permits.

Perimeter wells around the ACMA and Lewis open pits would remove groundwater during Construction, and Operations phases of the mine to ensure the stability of pit walls. Additional in-pit dewatering wells would be installed at lower elevations as the pit deepens. Although not considered contact water, water from dewatering wells (about 1,400 gpm) would be conveyed to the water treatment plant and treated in compliance with APDES permit requirements and ADEC water quality standards to ensure protection of aquatic life.

During Operations, about 60 percent of the groundwater intercepted from the in-pit wells would be treated and discharged to Crooked Creek below Omega Gulch (CCBO). The remaining third (about 580 gpm or about 1 cfs) would be conveyed to the process plant where it would be consumed as a source of freshwater. Diverting less than 1 cfs of the groundwater intercepted by dewatering wells to the process plant would have a de minimis effect on fish habitat and associated populations in Omega Gulch since fish are not known to utilize this drainage. Alterations of streamflow and effects on fish and aquatic habitat in Crooked Creek and its tributaries are described subsequently in this and Section 3.5, Surface Water Hydrology.

Table 3.13-23: Direct Aquatic Habitat Loss and Corresponding Predicted Fish Loss for Streams within the Facilities Study Area

Stream	Facility	Sampling	Distance Removed[1]		Fish		Fish Population Estimates[2]				Fish Removed[3]	
		Site	mi	km	Species	% Composition	#/mi	SE	#/km	SE	#	SE
American Creek	Open Pit	AM1	1.58	2.54	Dolly Varden	14.4	161	33	100	20	254	52
					Slimy sculpin	73.3	818	316	508	196	1,289	498
					Arctic grayling	0.7	8	5	5	3	13	9
					Burbot	0.5	5	3	3	2	8	5
					Coho salmon	11.1	123	61	77	38	194	96
	Open Pit Subtotal		1.58	2.54		100.0	1,116	419	693	260	1,758	660
	WRF Subtotal	AM2	2.51	4.05	Dolly Varden	100.0	1,003	379	623	236	2,522	953
	Total		4.09	6.59			2,119	798	1,316	496	4,280	1,613
Anaconda Creek	TSF	AN2	1.53	2.46	Dolly Varden	100.0	61	17	38	11	92	26
Snow Gulch	Freshwater Reservoir	SN2	0.05	0.08	Dolly Varden	100.0	69	29	43	18	3	1
Lewis Gulch	Open Pit	LE1	2.31	3.72	No Fish Collected	0.0	0	na	0	na	0	na
Totals			**7.98**	**10.38**			**2,249**	**845**	**1,397**	**525**	**4,376**	**1,641**

Notes:

1 Distances were calculated using only the mainstem portions of affected streams assuming side drainages have limited to no fish populations. Distances removed reflect infrastructure conditions based on ARCADIS geographic information system (GIS) data source: INFRASTRUCTURE_2011_OP_POLY dated 5/17/2011.

2 Ottertail's electrofishing population estimates are based on single pass electrofishing results. Note a single pass does not enable true population estimates but rather documents minimum population within the reach.

3 Fish removed estimates = (# fish/mile)*(miles removed). Because fish populations are distributed unevenly, these numbers should be considered an estimate. Sites AM1, AM2, AN2, SN2, and LE1 shown on Figure 3.13-1.

SE -Standard error for fish population estimates = standard deviation/√ (n years sampled).

na = not available

Source: Ottertail 2012b

During mining, water withdrawals from the in-pit and perimeter dewatering wells would result in a cone of depression of the groundwater level that would extend beyond and below the footprint of the open pit and dewatering well system. By the time mining ends, the western perimeter of the open pit would extend to within 980 feet of Crooked Creek, with the pit depth about 1,310 feet below the elevation of the creekbed. As shown in Figure 3.13-3, the anticipated zone of groundwater drawdown would extend west to Crooked Creek from Queen Gulch to Omega Gulch. The decrease in groundwater discharges that would normally support baseflow stream conditions, the decreased rate of aquifer recharge because of stream leakage, and the diversion of flows at the mine would have a combined effect that would reduce surface flows in nearby tributaries and in the middle reaches of Crooked Creek (BGC 2014c, 2015c).

The upward hydraulic gradients found near Crooked Creek and the elevations of shallow groundwater levels higher than the stream support the inference that Crooked Creek is mostly a gaining stream near the proposed mine. Also, the presence of wintertime flow in the stream is generally regarded as evidence of a gaining stream. Additional analysis in in BGC (2017a) shows that numerous short alternating segments of gaining and losing creek may be present, possibly associated with short-term dynamics or local stream / aquifer conditions.

During Closure, pit de-watering activities would cease operation and, over time, surrounding groundwater levels would eventually recover to nearly pre-dewatering conditions. About 50-55 years after mining ends, water would fill the pit until it reaches an elevation of 331 feet above MSL or about 10-30 feet below the level of Crooked Creek. The water elevation in the pit would be managed at this level by pumping water to a treatment facility to ensure discharges to Crooked Creek are in compliance with applicable water quality standards established to protect aquatic life and as specified in the APDES discharge permit. Pumping, treating and discharging water from the pit lake would maintain a shallow cone of depression in perpetuity.

During Operations and Closure phases, water from the treatment plant would be discharged to Crooked Creek below Omega Gulch between the confluence of American Creek and Anaconda Creek. Compliance monitoring at the point of discharge would assure that water quality standards are maintained so potential impacts to fish and aquatic life would be avoided or minimized. Specific monitoring requirements will be included in the APDES discharge permit in accordance with ADEC water quality standards.

The overall anticipated direct and indirect water quality impacts on fish and aquatic habitat in Crooked Creek may be measurable or noticeable. Tributary drainages directly affected by earth moving and grading activities during construction would cause noticeable changes in the character and quantity of aquatic habitat. These changes would not be anticipated to return to pre-disturbance levels. The extent or scope of potential water quality impacts would be limited to the Crooked Creek drainage primarily in the vicinity of the mine site. The context of impacts would affect individuals or populations of fish in the Crooked Creek and lower reaches of American and Anaconda creeks classified as EFH.

Wetland and Riparian Buffer Removal

Wetlands provide important natural functions that benefit aquatic biota. These include water storage, water quality maintenance, and (where there are direct connections to perennial streams) fish rearing habitat. Water quality functions occur through a variety of mechanisms including physical processes whereby debris and suspended solids may be removed from surface waters by filtering and sedimentation. In addition, nutrients and dissolved solids may be removed or degraded by biological processes, or incorporated into plant biomass. Similarly, microbial activities that occur in oxygen-depleted wetland sediments may chemically reduce certain forms of iron and sulfate so they become removed from water as insoluble precipitates. Other water quality functions can be provided by reducing the solubility, mobility, and bio-availability of certain metals that become captured within sediments. For example, arsenic (in association with iron) has been shown to accumulate in wetlands in areas influenced by mining (SRK 2012b).

Under Alternative 2, clearing, excavations, grading, surface water diversions, and groundwater dewatering would directly or indirectly disturb or eliminate wetlands, riparian buffers, and upland vegetation in the American Creek, Omega Gulch, Anaconda Creek, Snow Gulch, and Crooked Creek drainages. Adverse impacts to local fish populations would occur where wetlands and riparian plant communities that provide off-channel fish habitat or other natural functions along perennial streams are indefinitely eliminated or where water sources needed to sustain wetland communities are removed. Loss of water storage and infiltration functions can affect baseflow conditions in downstream reaches of these drainages and in Crooked Creek. Wetland loss also can increase runoff and flooding that can adversely affect aquatic habitats. Elevated stream temperatures also could occur when trees and other riparian plants are removed.

Wetlands within the cone of depression from dewatering activities could be impacted by groundwater drawdown, particularly in lower portions of the affected drainages. Such impacts are predicted to affect a total of about 550 acres of wetlands. This includes 104 acres classified as riverine wetlands or river channel involving 1.3 miles of intermittent streams and 5.5 miles of perennial streams. Wetland functions in these wetlands related to the capture and transfer of nutrients, suspended solids, metals, or other soil constituents also would be adversely affected by direct and indirect effects to wetlands.

As mentioned previously, wetland impacts also can affect the capture and distribution of certain metals including arsenic, mercury, lead, and zinc that would otherwise be retained in wetland sediments. As wetlands are filled, metals-containing runoff from natural sources or mining operations would be conveyed to local surface waters instead of being filtered and retained. Potential effects of wetland losses on water quality in the vicinity of the Mine Site are expected to be offset by the capture and treatment of water that comes into contact with disturbed soils or mine drainage prior to discharge to Crooked Creek. Additional information on potential impacts of metals associated with wetlands and fish resources is described in the subsequent section on erosion and sedimentation.

The anticipated direct and indirect impacts from wetland and riparian buffer removal on fish and aquatic habitat would be noticeable and may be acute or obvious. During Construction and Closure, the duration of impacts would last up to five years. During Operations when pit dewatering activities end, the duration of impacts may be expected to last during and beyond the life of the project. The extent or scope of impacts would be limited to sub drainages in the Crooked Creek watershed. The context of impacts associated with perennial streams that support salmon populations would affect fish and habitat, some of which are classified as EFH.

Further information on the nature and extent of wetland impacts as related to surface and groundwater hydrology and water quality in the Crooked Creek drainage is provided in Sections 3.11, Wetlands; 3.5, Surface Water Hydrology; 3.6, Groundwater Hydrology; and 3.7, Water Quality.

Streamflow Changes and Overall Aquatic Habitat

Fish and aquatic biota can be affected by alteration of flow regimes that, in turn, modify sediment transport and other mechanisms that define the geomorphological character of streams and other water bodies. Specific changes occur on the basis of stream type; geologic, geomorphic, and climatic factors that influence channel stability; and the intensity and duration of altered flows.

Increases in flow can create excessive shear stress and other hydraulic forces that result in aquatic habitat alteration from channel enlargement or degradation and excessive bank erosion. Other impacts from increased flow may include increased energy consumption by fish of various life stages as they encounter higher water velocities; rearing and migration habitat that becomes more restricted to backwaters and the margins of stream channels; and elevated turbidity, increased suspended sediment loads, and decreased sediment deposition. Beneficial impacts may include increased pool depth; increased stream wetted area; increased duration of mainstem connectivity to off-channel habitats; increased recruitment and transport of spawning substrates; decreased probability of bottom freezing events in winter and associated increased overwinter survival rates for fish and macroinvertebrates; and in extreme cases, the elimination of fish migration barriers.

Decreases in flow can reduce shear stress and other hydraulic forces within stream channels resulting in a loss of sediment transport capacity and causing channel aggradation. Changes in these mechanisms can alter the availability and quantity/quality of aquatic habitat; channel morphology; connectivity to both off-channel and upstream habitats; downstream macroinvertebrate drift and overwintering survival; and changes in water quality. Decreased flow can also impact buried salmon eggs in redds. Eggs buried in gravel could desiccate as a result of reduced water flows. Other potential impacts of decreased flow include decreased stream-wetted areas; decreased pool depth; and increased probability of bottom freezing in winter causing reduced overwinter survival rates for macroinvertebrates and fish. Stream bed freezing events can particularly affect incubating fish eggs and newly hatched fry occupying stream gravels. In extreme cases, winter freeze events during periods of low flow can, at times, form complete barriers to fish passage. Potential beneficial impacts of decreased flow may include reduced stream bank erosion and channel down-cutting; decreased sedimentation and turbidity; and increased availability of productive shallow-water habitat along stream margins.

During the Operations Phase, surface runoff in many parts of the vicinity of the Mine Site resulting from rainfall, snowmelt, and groundwater seepage would be diverted and captured (stored). These waters would be subsequently entrained in the tailings, lost in the milling processes, consumed in the power plant operations, or lost to the atmosphere through evaporation, or treated based on a water treatment process prior to release to Crooked Creek near the confluence of Omega Gulch. In addition, flows from pit dewatering and perimeter wells would be diverted and transferred to storage reservoirs for use in mill processing operations or treated and released to Crooked Creek near the confluence of Omega Gulch.

Pit dewatering operations, diversion of stormwater and surface flows from American Creek and other drainages east of Crooked Creek, advanced water treatment, and other water management practices as previously described were considered in combination with groundwater and surface water modeling as part of an integrated modeling approach to predict flow reductions in the mainstem of Crooked Creek in response to proposed mining during Operations, and after Closure. Based on the analysis, the greatest flow reductions in Crooked

Creek were predicted to occur in reaches adjacent to the open pits, primarily from the confluence of American Creek to below Crevice Creek, during winter as described below (BGC 2014c, 2015c). Regardless of the final use or consumption of these waters, flows ultimately reaching Crooked Creek would be less than the historical seasonal variations during average and low-flow years (BGC 2013f, 2014c, 2015c).

In the vicinity of the Mine Site, predicted maximum flow reductions in the mainstem of Crooked Creek would be greatest during typical low-flow periods of winter (December to March). A maximum flow reduction of 33 percent is predicted to occur in March for Year 20 based on a 10th percentile low-flow-year scenario. Based on the average flow year scenario, predicted winter maximum flow reductions in Year 20 would be greatest in January at 23 percent (BGC 2015c).

As shown in Table 3.13-24, predicted maximum reductions of winter low flows in Crooked Creek from the American Creek confluence to below Crevice Creek would reduce aquatic habitat surface area by a total of about 4 acres (from 75.98 to 71.78 acres) or 6 percent with about 1 acre of this consisting of riffle habitat and nearly 3 acres consisting of run habitat. Pool habitat within this overall reach would be reduced by about a quarter acre. The greatest reduction in aquatic habitat surface area within this reach is predicted to occur below Crevice Creek. In this reach, aquatic habitat surface area would be reduced by a total of 2.65 acres with nearly 2 acres of this consisting of run habitat.

Based on the proposed mining operations under Alternative 2, predicted maximum flow reductions in Crooked Creek would be greatest during winter, particularly in January (representing the typical lowest flows for a 50th percentile average flow year) and March (representing the typical lowest flows for a 10th percentile low flow year). More severe flow reductions also have been predicted, under a High K scenario (high hydraulic conductivity), should geologic conditions ultimately reflect a high level of hydraulic conductivity between the Crooked Creek streambed and the underlying zone of groundwater depression caused from the operation of the pit dewatering wells. See Section 3.6.2.2.1 for a discussion of hydraulic conductivity.

To evaluate the sensitivity of the predictive model relative to flow reduction estimates and the degree of hydraulic conductivity, the model will be reviewed after the initial 3 years of dewatering and every 5 years thereafter. Table 3.5-26 (Surface Water Hydrology) presents predictions of the percent flow reductions in Crooked Creek, and in the mine site area tributaries, during Year 10 and Year 20 of mine operations for low flow, average flow, and low flow - High K conditions. A summary of the table is as follows:

During Year 10 of Operations, the maximum winter flow reductions in stream reaches near the mine site (between the confluence of American Creek and below Crevice Creek) and in lower Crooked Creek would vary from:

- 16-20 percent in January based on an average flow year scenario; flows would be reduced by 18 percent at Crevice Creek, 9 percent below Getmuna Creek, and 7 percent below Bell Creek;
- 22-28 percent in March based on a low flow year scenario; flows would be reduced by 23 percent at Crevice Creek, 11 percent below Getmuna Creek, and 9 percent below Bell Creek;

- 45-60 percent in January based on an average flow year and High K scenario; flows would be reduced by 45 percent at Crevice Creek, 21 percent below Getmuna Creek, and 16 percent below Bell Creek; and
- 76-100 percent in March based on a low flow year and High K scenario; flows would be reduced by 76 percent at Crevice Creek; 36 percent below Getmuna Creek, and 28 percent below Bell Creek.

During Year 20 of Operations, the maximum winter flow reductions in stream reaches near the mine site and in lower Crooked Creek would vary from:

- 18-23 percent in January based on an average flow year scenario; flows would be reduced by 20 percent at Crevice Creek, 10 percent below Getmuna Creek, and 7 percent below Bell Creek;
- 25-33 percent in March based on a low flow year scenario; flows would be reduced by 26 percent at Crevice Creek, 12 percent below Getmuna Creek, and 10 percent below Bell Creek;
- 49-67 percent in January based on an average flow year and High K scenario; flows would be reduced by 49 percent at Crevice Creek, 23 percent below Getmuna Creek, and 18 percent below Bell Creek; and
- 85-100 percent in March based on a low flow year and High K scenario; flows would be reduced by 85 percent at Crevice Creek, 40 percent below Getmuna Creek, and 31 percent below Bell Creek.

During Closure, after the pit lake is filled and at capacity, winter flow reductions in Crooked Creek would be considerably less in stream reaches between the confluence of American Creek and below Crevice Creek and in lower Crooked Creek as compared to Year 10 or 20 of operations (see Table 3.5-26 and Table 3.5-28 in Section 3.5, Surface Water Hydrology). During mine Closure, maximum flow reductions would vary from:

- 11-13 percent in January based on an average flow year scenario; flows would be reduced by 12 percent at Crevice Creek, 6 percent below Getmuna Creek, and 4 percent below Bell Creek; and
- 13-17 percent in March based on a low flow year scenario; flows would be reduced by 13 percent at Crevice Creek, 6 percent below Getmuna Creek, and 5 percent below Bell Creek.

During summer operations (May to October), flow reductions are predicted to be less due to the seasonally higher levels of surface flows from the upper Crooked-Donlin Creek watershed.

Because of the potential effects of pit dewatering on surface water flow and upwellings in Crooked Creek, a detailed analysis of upwelling and downwelling groundwater into and out of Crooked Creek was performed (BGC 2017a; Owl Ridge 2017d). The analysis found that pre-mining, there is a net wintertime upwelling and gain in Crooked Creek flow of 1.24 cfs in the affected reach near the mine. During mining in Year 20, downwelling flows are predicted to exceed upwelling flows to the streambed, and result in a net wintertime streamflow loss of 2.10 cfs. During post-Closure pit lake management, upwelling flows to the streambed would exceed downwelling flows, but upwelling flows would be lower than pre-mining by as much as 5 percent. Outside of the radius of influence of mine pit dewatering, affecting approximately a

4.4-mile stretch of alluvium adjacent to the mine, no changes in groundwater levels are predicted. Additional details on Crooked Creek upwelling and downwelling is described in Section 3.6.2.2.1, Groundwater Hydrology.

Based on flow reduction estimates developed for the Year 20 low-flow scenario as described above, impacts to aquatic habitat would be noticeable and may be acute or obvious. In the middle reaches of Crooked Creek near the mine, winter low flows could be reduced by up to 33 percent. In lower Crooked Creek below Getmuna Creek, winter low flows could be reduced by 12 percent. Except for the High K scenario, flow reductions near the mine would be offset in lower Crooked Creek by substantial tributary inflows from the undisturbed Getmuna and Bell creek drainages. Under a High K scenario, however, the intensity of impacts to aquatic habitat in reaches near the mine and in lower Crooked Creek would be acute or obvious. Flow reductions up to 100 percent could occur in the vicinity of the Mine Site, while farther downstream reductions of 40 percent are predicted below Getmuna Creek where a high proportion of the salmon spawning and rearing in the Crooked Creek drainage occurs. The extent or scope of such impacts on the Crooked Creek mainstem would be limited to waters in the vicinity of the project footprint and primarily from the confluence of Queen Gulch to the confluence of Crevice Creek. The duration of surface flow reductions in the affected tributaries and middle reaches of Crooked Creek would last for the life of the project and into the Closure Phase. During Closure with the pit lake at capacity, flow reductions in Crooked Creek from the vicinity of the mine site to the Kuskokwim River confluence would persist but may not be measurable or noticeable. The context of flow impacts would affect fish and habitat, some of which are classified as EFH that that support key life stages of salmon and other fish in the Kuskokwim River subsistence community.

Section 3.5, Surface Water Hydrology; Section 3.6, Groundwater; and Section 3.7, Water Quality, provide additional information on predicted surface water and groundwater flow modifications related to the project.

Streamflow Changes and Off-Channel Aquatic Habitat

During all phases of the project, a reduction in Crooked Creek streamflow could cause geomorphic changes to the stream channel. This could include a slight narrowing of the bank full width of the channel and encroachment (expanded growth) of riparian vegetation. Reduced flows also could affect the frequency with which off-channel habitat maintains connection with the main channel. This is an important consideration because although off-channel habitats would likely reconnect to the main channel at some point during the year when the water stage increases, connections may no longer occur during very low flow periods in summer or winter resulting in infrequent isolation of off-channel habitats from the main channel. This could affect rearing or spawning life phases of fish due to fish stranding and potential mortalities. Furthermore, a reduction in off-channel (or in-channel) winter habitat may adversely affect the survival of overwintering fish or incubating eggs if flows are reduced to the point where the water column becomes too shallow and freezes completely. Fish species potentially affected by flow reductions along various reaches of Crooked Creek and its tributaries in the lower, middle, and upper watershed are described in Section 3.13.2.1.2.

As shown in Table-3.13-25, the number of off-channel units and corresponding areas connected to the main channel relative to estimates of total off-channel habitat surface area were calculated for baseflow conditions minus 16 percent, at baseflow, and at increasing levels of flow representing 25, 50, 75, and 100 percent of bankfull stage (Ottertail 2012e). A series of maps, covering a distance of about 33 miles, of various habitat types extending from the convergence of Flat Creek and Donlin Creek to the mouth of Crooked Creek was developed from field surveys conducted from August 14 to September 15, 2009 (Ottertail 2014a). The average discharge during the study was 202 cfs at the USGS gauge at Crooked Creek. At the confluence of Bell Creek and Crooked Creek, upstream of the USGS gage, the calculated low flow for this time period is 260-273 cfs while the average flow is 531-540 cfs (BGC 2014c).

From the convergence of Donlin Creek and Flat Creek to the confluence of Crooked Creek at the Kuskokwim River, nearly three quarters (73 percent) or about 15 acres of the off-channel habitat surface area is connected to the main channel at baseflow conditions. A 16 percent flow reduction from baseflow conditions, based on predicted flow depletion estimates in Year 20 of operations, would result in a 9 percent reduction in off-channel habitat connectivity (from 73 to 64 percent). This would result in a reduction of connected off-channel habitat surface area by 4 acres (from 15.3 to 11.3 acres, or 26 percent) (Ottertail 2012e). Reductions in off-channel habitat connectivity also were evaluated for specific reaches along Crooked Creek as described below.

From the convergence of Donlin Creek and Flat Creek downstream to American Creek, Crooked Creek has a high percentage (89 percent) of off-channel habitat surface area connected to the main channel at baseflow conditions. This represents a high frequency of off-channel habitat connectivity to the main channel during an average flow year. A 16 percent flow reduction from baseflow conditions, based on predicted flow depletion estimates in Year 20 of operations, is predicted to result in less than a 5 percent reduction in off-channel habitat connectivity (from 89 to 84 percent). This would reflect a reduction on connected off-channel habitat surface area by 0.13 acre (from 0.66 to 0.53 acre, or 20 percent) (Ottertail 2012e).

From American Creek downstream to Anaconda Creek, Crooked Creek also has a high percentage of off-channel habitat surface area connected to the main channel at baseflow conditions (97 percent). A 16 percent flow reduction from baseflow conditions is predicted to result in <1 percent change in off-channel habitat connectivity and a reduction of connected off-channel habitat surface area by 0.37 acre (from 2.20 to 1.83 acres, or by 17 percent) (Ottertail 2012e).

From Anaconda Creek to Crevice Creek, predicted baseflow reductions in Crooked Creek in Year 20 of Operations would have the greatest effect on off-channel habitat connectivity during low flow conditions of summer and winter, especially during dry years. About 1.8 acres of off-channel habitat surface area within this reach is connected to Crooked Creek at baseflow conditions. A 16 percent reduction from baseflow conditions is predicted to result in two backwater habitat units losing their connectivity with the main channel. This would result in a reduction of connected off-channel habitat surface area by 0.93 acre (from 1.75 to 0.82 acre, or by 53 percent) (Ottertail 2012e).

From Crevice Creek to Getmuna Creek, Crooked Creek has about 66 percent of its off-channel habitat surface area connected to the main channel at baseflow conditions. A 16 percent reduction from baseflow conditions in this reach is predicted to result in two backwater habitat units experiencing a reduced frequency of connectivity with the mainstem. This would result in a reduction of connected off-channel habitat surface area by 2.47 acres (from 8.22 to 5.75 acres, or by 30 percent) (Ottertail 2012e). Tributary contributions along this section, particularly from post-Closure diversion flows into and from Crevice Creek and from Bell Creek farther downstream, are expected to moderate the impacts of predicted baseflow reduction downstream of Crevice Creek.

From Getmuna Creek to the Kuskokwim River confluence, Crooked Creek has about 64 percent of its off-channel habitat surface area connected to the main channel at baseflow conditions. A 16 percent reduction from baseflow conditions in this reach is predicted to result in one backwater habitat unit experiencing a reduced frequency of connectivity with the mainstem. This would result in a reduction of connected off-channel habitat surface area by 0.11 acre (from 2.45 to 2.34 acres, or by 4 percent) (Ottertail 2012e).

Along the Crooked Creek corridor between Donlin Creek and the Kuskokwim River, flow reductions have been predicted for Year 10 and Year 20 of operations (BGC 2015c). During the typical driest month of the year (March) under a 10th percentile low-flow year scenario for Year 20 of operations, flows in Crooked Creek at the American Creek confluence are predicted to be reduced by a maximum of 33 percent. As a result of tributary inflows farther downstream near Bell Creek, flow reductions are predicted to be lessened to 10 percent. During Closure, after the pit lake is filled to capacity, winter flow reductions in Crooked Creek would be considerably less in stream reaches between the confluence of American Creek and below Crevice Creek and in lower Crooked Creek as compared to Year 10 or 20 of operations. Near the mine site, flow reductions in Crooked Creek would range from a maximum of 11-13 percent during March of a typical low flow year with reductions of 6 percent below Getmuna Creek and 5 percent below Bell Creek.

Under such low-flow scenarios as described above, the overall intensity of predicted flow reductions on connected off-channel habitat surface area may not be measurable or noticeable in lower Crooked Creek, but may be noticeable near the Mine Site during Construction and Operations Phases. Between American Creek and Crevice Creek, the extent or scope of impacts on connected off-channel habitat would be limited to populations of rearing coho and chum salmon in the vicinity of the project footprint. The context of such impacts would affect Crooked Creek and certain reaches of its tributaries that are classified as EFH.

The intensity of predicted flow reductions that would affect off-channel habitat surface area between American Creek and Crevice Creek could be higher depending on the hydraulic continuity between the streambed and the predicted zone of groundwater drawdown from nearby pit dewatering operations. Based on a High K scenario, predicted winter (March) flow reductions during 10th percentile years of low flow in the middle reaches of Crooked Creek could reach a maximum of 85 to 100 percent during Year 20 of Operations. During a similar flow scenario, maximum flow reductions of 40 and 31 percent could occur in Crooked Creek below Getmuna and Bell creeks, respectively. This would result in acute or obvious impacts to off-channel habitat area in the middle and lower reaches of Crooked Creek.

Streamflow Changes and Mainstem Aquatic Habitat

Besides off-channel impacts, predicted streamflow decreases also would reduce the amount of aquatic habitat available in the mainstem channel of Crooked Creek. As flows become reduced, the water elevation (stage) would drop thereby decreasing the wetted stream channel surface area. This would cause less aquatic habitat (e.g., pools, runs, and riffles) to be available for fish and benthic invertebrate production. Potential changes in water depth in Crooked Creek during the Operations Phase would vary seasonally with the particular phase of mining operations and with the distance downstream from the vicinity of the mine site. Using stage-discharge rating curves and stream channel contour mapping, impacts of flow decreases on aquatic habitat surface area in the mainstem channel of Crooked Creek were estimated for summer and winter season low flow conditions (Ottertail 2015).

Estimates of Crooked Creek habitat loss were predicted based on Year 20, monthly 10-year low flow projections (Table 3.13-24). As described in the sections below, estimates for summer and winter low-flow scenarios provide a high-end (most conservative case) estimate of potential aquatic habitat loss as a result of proposed project operations (however, they did not predict habitat losses corresponding to High K scenario flow reductions). On a percentage basis, the greatest reduction in streamflows in Crooked Creek during Year 20 of operations on an annual basis was predicted to occur in winter (March) between American Creek and Omega Gulch based on a 10-year low flow scenario (Table 3.5-26 in Surface Water Hydrology). During such time and conditions, streamflows were predicted to be reduced by about 33 percent (BGC 2015c). This would result in noticeable changes in the character and quantity of aquatic habitat (Table 3.13-24).

The lowest summer streamflows for Crooked Creek typically occur in June. The greatest percentage reduction in Crooked Creek summer streamflows during Operations also was predicted to occur between American Creek and Omega Gulch during Year 20 under a 10-year low flow scenario where flows in this reach would be reduced by a maximum of 25 percent (BGC 2015c). This also would result in noticeable changes in the character and quantity of aquatic habitat.

Table 3.13-24 summarizes predicted reductions in aquatic habitat surface area by habitat types (riffles, runs, and pools) by comparing undisturbed summer and winter baseflow conditions, based on a 10-year low flow frequency, with corresponding disturbed conditions during Operations in various reaches of Crooked Creek. Predicted winter and summer changes in water stage and corresponding changes in aquatic habitat types in the mainstem channel are summarized below for specific segments of Crooked Creek.

Winter Streamflow Changes

The lowest annual flows in Crooked Creek typically occur in winter (March). As shown in Table 3.5-26 and based on a 10-year low flow scenario in March during Year 20 of proposed project operations, flow reductions are predicted to range from 25 percent (below Omega Gulch) to 33 percent (below American Creek) (BGC 2015c).

The predicted reduction in Crooked Creek flows, between American Creek and Omega Gulch during Year 20 of Operations under a winter 10-year low flow scenario, would reduce the water surface elevation (stage) by 0.13 feet (1.5 inches) resulting in a 5 percent reduction of aquatic habitat (0.44 acres) when all habitat types are considered. Relative to specific habitat types, such a change in water surface elevation would reduce riffle habitat by 12 percent, run habitat by 4 percent, and pool habitat by 3 percent. This also would contribute to a slight reduction in the maximum depth of over-wintering habitat throughout this and other affected reaches of Crooked Creek. Water depth measurements at redds collected by Ottertail (2014a) along this stream reach ranged from 6.9 to 16.8 inches. These flow reductions would change these water depths to 5.3 to 15.3 inches, respectively. Historic undisturbed pre-project flow conditions in this reach reflect winter (March) baseflows that have varied from a monthly average of 30.9 cfs to a 10-year low of 9.9 cfs, a reduction of about 68 percent. Corresponding water surface elevations for these flows vary historically from 14.6 inches to 8.3 inches, respectively, or a reduction of about 43 percent.

The predicted reduction in Crooked Creek flows, between Omega Gulch and Anaconda Creek during Year 20 of proposed project operations under a winter 10-year low flow scenario, would reduce the water stage by 0.10 feet (about 1 inch) resulting in an overall loss of aquatic habitat in this stream segment of about 3 percent (0.39 acres). Relative to specific habitat types, this change in water surface elevation was estimated to result in a 6 percent reduction in riffle habitat, a 3 percent reduction in run habitat, and a 2 percent reduction in pool habitat. The maximum depth of over-wintering habitat in this segment of Crooked Creek also would be slightly reduced. No redds were observed by Ottertail (2014a) along this stream reach; thus no estimates in changes to water depths are provided here. Historic undisturbed pre-project flow conditions in this reach reflect winter (March) baseflows that have varied from a monthly average of 39.1 cfs to a 10-year low of 12.5 cfs, a reduction of about 68 percent. Corresponding water surface elevations for these flows have varied from 13.4 inches to 6.7 inches, respectively or a reduction of about 50 percent.

The predicted reduction in flows between Anaconda Creek and Crevice Creek, during Year 20 of proposed project operations under a winter 10-year low flow scenario, would reduce the water stage by 0.11 feet (about 1 inch). The resulting overall loss of aquatic habitat is estimated to be about 9 percent (0.72 acres). This reflects a 22 percent reduction in riffle habitat, an 8 percent reduction in run habitat, and a 4 percent reduction in pool habitat. Water depth measurements at redds collected by Ottertail (2014a) along this stream reach ranged from 10.0 to 13.9 inches. These flow reductions would change these water depths to 8.7 to 12.5 inches, respectively. Historic undisturbed pre-project flow conditions in this reach reflect winter (March) baseflows that have varied from a monthly average of 43.0 cfs to a 10-year low of 13.8 cfs, a reduction of about 68 percent. Corresponding water surface elevations for these flows have varied from 13.4 inches to 6.3 inches, respectively, or a reduction of about 53 percent.

The predicted reduction in flows in Crooked Creek immediately downstream of Crevice Creek to Getmuna Creek, during Year 20 Operations under a winter 10-year low flow scenario, would reduce the water stage by 0.11 feet (about 1 inch). The resulting overall loss of aquatic habitat is estimated to be about 6 percent (2.65 acres). This reflects a 10 percent reduction in riffle habitat, a 5 percent reduction in run habitat, and a 4 percent reduction in pool habitat. Water depth measurements at redds collected by Ottertail (2014a) along this stream reach ranged from 13.7 to 22.0 inches. These flow reductions would change these water depths to 12.3 to 20.6 inches, respectively. Historic undisturbed pre-project flow conditions in this reach reflect winter (March) baseflows that have varied from a monthly average of 48.1 cfs to a 10-year low of 15.1 cfs, a reduction of about 68 percent. Corresponding water surface elevations for these flows have varied from 13.8 inches to 6.3 inches, respectively, or a reduction of about 54 percent.

Summer Streamflow Changes

The lowest summer flows in Crooked Creek typically occur in June. Based on a 10-year low flow scenario during Year 20 of proposed project operations, predicted flow reductions in June in Crooked Creek from American Creek to below Crevice Creek would range from 11 percent to 25 percent (BGC 2015c).

The predicted reduction in flows in Crooked Creek between American Creek and Omega Gulch, during Year 20 of Operations under a summer 10-year low flow scenario, would reduce the water stage by 0.08 feet (about 1 inch). The resulting overall loss of aquatic habitat is estimated to be about 3 percent (0.3 acres) with reductions in riffle, run, and pool habitat of about 6, 2, and 2 percent, respectively. Water depth measurements at redds collected by Ottertail (2014a) along this stream reach ranged from 6.9 to 16.8 inches. These flow reductions would change these water depths to 5.9 to 15.9 inches, respectively. Historic undisturbed pre-project flow conditions in this reach reflect summer (June) baseflows that have varied from a monthly average of 54.3 cfs to a 10-year low of 24.2 cfs, a reduction of about 55 percent. Corresponding water surface elevations for these flows have varied from 19.3 inches to 12.6 inches, respectively, representing a reduction of about 35 percent.

The predicted reduction in flows in Crooked Creek between Omega Gulch and Anaconda Creek, during Year 20 of proposed project operations under a summer 10-year low flow scenario, would reduce the water stage by 0.06 feet (or less than 1 inch). The resulting overall loss of aquatic habitat is estimated to be about 2 percent (0.25 acres) with reductions in riffle, run, and pool habitat of about 3, 2, and 1 percent, respectively. No redds were observed by Ottertail (2014a) along this stream reach; thus no estimates in changes to water depths are provided here. Historic undisturbed pre-project flow conditions in this reach reflect summer (June) baseflows that have varied from a monthly average of 68.6 cfs to a 10-year low of 30.6 cfs, a reduction of about 55 percent. Corresponding water surface elevations for these flows have varied from 18.9 inches to 11.8 inches, respectively, representing a reduction of about 38 percent.

The predicted reduction in flows in Crooked Creek between Anaconda Creek and Crevice Creek, during Year 20 of Operations under a summer 10-year low flow scenario, would reduce the water stage by 0.05 feet (or less than 1 inch). The resulting overall loss of aquatic habitat is estimated to be about 3 percent (0.32 acres) with reductions in riffle, run, and pool habitat of about 7, 3, and 2 percent, respectively. Water depth measurements at redds collected by Ottertail (2014a) along this stream reach ranged from 10.0 to 13.9 inches. These flow reductions would change these water depths to 9.4 to 13.3 inches, respectively. Historic undisturbed pre-project flow conditions in this reach reflect summer (June) baseflows that have varied from a monthly average of 75.6 cfs to a 10-year low of 33.7 cfs, a reduction of about 55 percent. Corresponding water surface elevations for these flows have varied from 19.3 inches to 11.4 inches, respectively, representing a reduction of about 41 percent.

The predicted reduction in flows in Crooked Creek immediately downstream of Crevice Creek, during Year 20 of Operations under a summer 10-year low flow scenario, would reduce the water stage by 0.09 feet (about 1 inch). The resulting overall loss of aquatic habitat is estimated to be 4 percent (2.31 acres) with reductions in riffle, run, and pool habitat of about 6, 4, and 3 percent, respectively. Water depth measurements at redds collected by Ottertail (2014a) along this stream reach ranged from 13.7 to 22.0 inches. These flow reductions would change these water depths to 12.6 to 20.9 inches, respectively. Historic undisturbed pre-project flow conditions in this reach reflect summer (June) baseflows that have varied from a monthly average of 82.7 cfs to a 10-year low of 37.2 cfs, a reduction of about 55 percent. Corresponding water surface elevations for these flows have varied from 20.1 inches to 11.4 inches, respectively, representing a reduction of about 43 percent.

Downstream of Getmuna Creek, impacts on Crooked Creek streamflows during proposed project operations would be imperceptible due to the large inflow contributions from Getmuna Creek and Bell Creek, key tributaries that drain approximately 98.6 mi^2 and 71.3 mi^2, respectively. For this reason, impacts on aquatic habitat from potential flow reductions resulting from mining operations were not modeled for the lower reaches of Crooked Creek.

Overall, predicted impacts of flow reductions as described above would involve noticeable changes in the character or quantity of aquatic habitat in the mainstem of Crooked Creek with the greatest combined impacts to riffle, run, and pool habitat occurring downstream of Crevice Creek. The duration of impacts may be expected to last during and beyond the life of the project. The extent or scope of such impacts would be limited to waters in the vicinity of the project footprint primarily affecting the middle reaches of Crooked Creek near the Mine Site. The context of these impacts would affect Crooked Creek and certain reaches of its tributaries regulated as EFH.

If flow reductions in Crooked Creek ultimately reflect a high level of hydraulic continuity between the streambed and the zone of groundwater depression caused by mine dewatering activities, then anticipated impacts to aquatic habitat in the mainstem in both the middle and lower reaches of Crooked Creek would be acute or obvious.

Streamflow Changes and Salmon Spawning Habitat

Estimated habitat losses from flow reductions can generally result in adverse impacts to both the availability of suitable spawning areas and the viability of eggs incubating in salmon redds[1] during winter, particularly under low flow conditions. Based on the distribution of salmon redds documented in the mainstem Crooked Creek in 2009 by Ottertail (2012e), there would not be an impact to salmon spawning habitat in the lower reaches of the creek (CR-R2 and CR-R1) despite predicted flow reductions in the middle reaches of the mainstem near the mine (CR-R3 and CR-R4). This is primarily due to the large proportion of inflows contributed to the mainstem channel in the lower drainage from Getmuna and Bell creeks. Additionally, salmon redds observed in 2009 were distributed far more abundantly in the lower reaches of Crooked Creek, particularly near the confluence of Getmuna Creek, where proportionally higher baseflows typically occur as compared to reaches farther upstream near the mine (Ottertail 2012e). During this study, no effort was made to associate redds with salmon species. Although redds were not associated with a specific salmon species, adult salmon aerial surveys conducted concurrently show, as expected, coho salmon to be the most abundant species present during summer surveys.

Of the 532 salmon redds observed in 2009 during ground surveys along the mainstem Crooked Creek, more than 94 percent were located downstream of Crevice Creek and over 88 percent were located from above Getmuna Creek to the Kuskokwim River (CR-R2 and CR-R1) (Ottertail 2014a). As shown in Table 3.13-6 and Figure 3.13-1, aerial observations from surveys conducted from 2004-2010 documented an annual average of 354 adult salmon in the Crooked Creek mainstem with 314 (88 percent) observed between Crevice Creek and the Kuskokwim River (CR-R3, CR-R2, and CR-R1) and 295 (83 percent) observed from above Getmuna Creek to the Kuskokwim River (CR-R2 and CR-R1). Along the middle reaches of the creek near the mine (CR-R5 and CR-R4), the observed adult salmon density was considerably lower where an annual average of 40 adult salmon (12 percent) were observed that consisted primarily of coho and chum salmon. Based on these ground and aerial surveys in recent years, salmon

1 For this discussion, redds refer to nests excavated by Pacific salmon (i.e., coho salmon, chum salmon, Chinook salmon, sockeye salmon, or pink salmon).

distribution has been relatively limited in the middle reaches of Crooked Creek suggesting that only the relatively fewer number of redds likely to be distributed along reaches near the mine site would be subject to predicted flow reductions during Operations.

Impacts of flow reductions from Mine Site Construction and Operations on salmon spawning redds were evaluated based on a flow depletion model's predicted conservative estimates of decreases in water surface elevation and known locations and depths of salmon redds as measured during 2009 spawning surveys. The evaluation of flow reduction on spawning habitat determined that 65 percent (11 of 17) of the redds in Crooked Creek between American Creek and Anaconda Creek and 78 percent (7 of 9) of redds between Anaconda Creek and Crevice Creek were located in gravels that would be outside the predicted wetted portions of the stream channel during winter low flow conditions during construction and operations. From Crevice Creek to Getmuna Creek, only 2 percent (3 of 144) of redds observed during the 2009 survey would have been above the predicted winter low flow water line during proposed project operations. Overall, the 21 redds that the flow depletion model predicted would be outside the wetted channel during winter low flow conditions during mining operations represents 4 percent (21 of 519) of the redds observed in 2009 in Crooked Creek below American Creek (Ottertail 2012e).

Donlin Gold modified their proposed project design to include treating and discharging excess water using advanced water treatment. An updated streamflow model showed that the additional discharge had only a small (positive) effect on the flow depletions; therefore flow reduction impact analyses were not revised.

The effects of Crooked Creek upwelling and downwelling as described in Section 3.6.2.2.1, include reduce intergravel flow and egg survival in the segment of creek adjacent to the mine during mining operations. During post-Closure, It is likely that the loss of average winter flow would not affect egg survival when compared to pre-mining conditions (Owl Ridge 2017d).

Overall, impacts of streamflow changes and salmon spawning habitat as described above would involve noticeable changes in the character or quantity of aquatic habitat. The duration of these impacts may be expected to last during and beyond the life of the project. The extent or scope would be limited to waters in the vicinity of the project footprint and middle reaches of Crooked Creek near the mine site. The context of these impacts would affect Crooked Creek and certain reaches of its tributaries regulated as EFH.

If predicted flow reductions of 85 to 100 percent occur in the middle reaches of Crooked Creek reflecting a high level of hydraulic continuity between the streambed and the zone of groundwater depression caused by mine dewatering activities, then anticipated impacts to aquatic habitat in the mainstem in both the middle and lower reaches of Crooked Creek would involve acute or obvious changes to the character and quantity of aquatic habitat.

Table 3.13-24: Estimated Reductions in Aquatic Habitat Surface Area for Summer and Winter Average and Low Flow Conditions during Year 20 of Mine Operations*

Crooked Creek Stream Section	Parameter	Habitat Type	# of Units	Summer				Winter			
				Undisturbed Summer Mapped Discharge Average	Undisturbed Summer (June) Lowflow (10th Percentile)	Disturbed Summer (June) Lowflow (10th Percentile) 20-year operations	Percent Reduction of Habitat from Lowflow	Undisturbed Winter (Jan) Average	Undisturbed Winter (March) Lowflow (10th Percentile)	Disturbed Winter (March) Lowflow (10th Percentile) 20-year operations	Percent Reduction of Habitat from Lowflow
Crooked Creek Below American Creek (CCBAM)	Stage (ft)			1.49	1.09	1.01		1.00	0.69	0.56	
	Habitat Area (ac)	Riffles	29	2.70	1.61	1.52	6%	1.51	1.14	1.00	12%
		Runs	55	7.40	6.29	6.14	2%	6.13	5.58	5.35	4%
		Pools	32	3.32	2.94	2.89	2%	2.89	2.71	2.64	3%
		Total	**116**	**13.42**	**10.84**	**10.54**	**3%**	**10.53**	**9.43**	**8.99**	**5%**
	Habitat Area	Riffles	29	20%	15%	14%		14%	12%	11%	
		Runs	55	55%	58%	58%		58%	59%	59%	
		Pools	32	25%	27%	27%		27%	29%	29%	
		Total	**116**	**100%**	**100%**	**100%**		**100%**	**100%**	**100%**	
Crooked Creek Below Omega Gulch (CCBO)	Stage (ft)			1.45	1.01	0.95		0.91	0.58	0.48	
	Habitat Area (ac)	Riffles	22	2.01	1.15	1.12	3%	1.09	0.90	0.84	6%
		Runs	54	13.35	10.97	10.78	2%	10.67	9.7	9.42	3%
		Pools	19	2.82	2.50	2.47	1%	2.45	2.30	2.25	2%
		Total	**95**	**18.18**	**14.62**	**14.37**	**2%**	**14.22**	**12.90**	**12.51**	**3%**
	Habitat Area	Riffles	22	11%	8%	8%		8%	7%	7%	
		Runs	54	73%	75%	75%		75%	75%	75%	
		Pools	19	16%	17%	17%		17%	18%	18%	
		Total	**95**	**100%**	**100%**	**100%**		**100%**	**100%**	**100%**	
Crooked Creek Below Anaconda Creek (CCBA)	Stage (ft)			1.46	0.92	0.87		0.87	0.53	0.42	
	Habitat Area (ac)	Riffles	14	3.25	1.04	0.98	7%	1.00	0.67	0.53	22%
		Runs	24	10.64	8.41	8.16	3%	8.25	7.19	6.64	8%
		Pools	3	0.58	0.49	0.48	2%	0.48	0.44	0.42	4%
		Total	**41**	**14.47**	**9.94**	**9.62**	**3%**	**9.73**	**8.31**	**7.59**	**9%**
	Habitat Area	Riffles	14	22%	11%	10%		10%	8%	7%	
		Runs	24	74%	85%	85%		85%	87%	87%	
		Pools	3	4%	5%	5%		5%	5%	6%	
		Total	**41**	**100%**	**100%**	**100%**		**100%**	**100%**	**100%**	

Table 3.13-24: Estimated Reductions in Aquatic Habitat Surface Area for Summer and Winter Average and Low Flow Conditions during Year 20 of Mine Operations*

Crooked Creek Stream Section	Parameter	Habitat Type	# of Units	Summer				Winter			
				Undisturbed Summer Mapped Discharge Average	Undisturbed Summer (June) Lowflow (10th Percentile)	Disturbed Summer (June) Lowflow (10th Percentile) 20-year operations	Percent Reduction of Habitat from Lowflow	Undisturbed Winter (Jan) Average	Undisturbed Winter (March) Lowflow (10th Percentile)	Disturbed Winter (March) Lowflow (10th Percentile) 20-year operations	Percent Reduction of Habitat from Lowflow
Crooked Creek Below Crevice Creek (CCAC)	Stage (ft)			1.52	0.99	0.90		0.89	0.53	0.43	
	Habitat Area (ac)	Riffles	64	18.73	10.45	9.77	6%	9.69	6.70	6.01	10%
		Runs	81	53.83	43.19	41.66	4%	41.47	35.67	33.82	5%
		Pools	13	4.22	3.50	3.39	3%	3.38	2.98	2.85	4%
		Total	**158**	**76.78**	**57.14**	**54.83**	**4%**	**54.54**	**45.34**	**42.69**	**6%**
	Habitat Area	Riffles	64	24%	18%	18%		18%	15%	14%	
		Runs	81	70%	76%	76%		76%	79%	79%	
		Pools	13	5%	6%	6%		6%	7%	7%	
		Total	**158**	**100%**	**100%**	**100%**		**100%**	**100%**	**100%**	
Total	Habitat Area (ac)	**Riffles**	**129**	**26.69**	**14.25**	**13.38**	**6%**	**13.29**	**9.41**	**8.38**	**11%**
		Runs	**214**	**85.22**	**68.86**	**66.75**	**3%**	**66.52**	**58.14**	**55.23**	**5%**
		Pools	**67**	**10.94**	**9.42**	**9.23**	**2%**	**9.20**	**8.43**	**8.17**	**3%**
		Total	**410**	**122.85**	**92.53**	**89.36**	**3%**	**89.02**	**75.98**	**71.78**	**6%**
	Habitat Area	**Riffles**	**129**	**22%**	**15%**	**15%**		**15%**	**12%**	**12%**	
		Runs	**214**	**69%**	**74%**	**75%**		**75%**	**77%**	**77%**	
		Pools	**67**	**9%**	**10%**	**10%**		**10%**	**11%**	**11%**	
		Total	**410**	**100%**	**100%**	**100%**		**100%**	**100%**	**100%**	

Notes:

Some totals may not sum due to rounding.
ac = acres

Source: *Ottertail 2014a, predicted changes to streamflow based on BGC 2015c

Table 3.13-25: Off-channel Habitat Connectivity and Estimated Surface Area for Various Flow Conditions for Mainstream Crooked Creek (2009)

Flow Conditions	Parameter	Reach Description	HAB5 Flat to American	HAB4 American to Anaconda	HAB3 Anaconda to Crevice	HAB2 Crevice to Getmuna[2]	HAB1 Getmuna to Mouth[3]	Total
Baseflow Minus 16%[1]	Total Area	acres	0.63	1.90	1.47	10.4	3.20	17.60
		hectares	*0.2532*	*0.7696*	*0.5947*	*0.42094*	*1.2959*	*7.1230*
	Units Connected	#	7	11	1	10	2	31
	Area Connected	acres	0.53	1.83	0.82	5.75	2.34	11.27
		hectares	*0.2139*	*0.7396*	*0.3333*	*2.3253*	*.9479*	*4.5600*
	% Connected[4]	%	84	96	56	55	73	64
Baseflow	Total Area	acres	0.74	2.26	1.75	12.38	3.81	20.95
		hectares	*0.3015*	*0.9162*	*0.7080*	*5.0112*	*1.5428*	*8.4797*
	Units Connected	#	10	11	3	12	3	39
	Area Connected	acres	0.66	2.20	1.75	8.22	2.45	15.29
		hectares	*0.2686*	*0.8907*	*0.7080*	*3.3283*	*0.9918*	*6.1874*
	% Connected[4]	%	89	97	100	66	64	73
25% Bankfull[1]	Total Area	acres	0.98	3.36	2.36	17.37	5.63	29.70
		hectares	*0.3984*	*1.3596*	*0.9533*	*7.0296*	*2.2778*	*12.0187*
	Units Connected	#	12	13	3	12	3	43
	Area Connected	acres	0.91	3.33	2.36	11.34	3.92	21.86
		hectares	*0.3686*	*1.3477*	*0.9533*	*4.5897*	*1.5869*	*8.8463*
	% Connected[4]	%	93	99	100	65	70	74
50% Bankfull[1]	Total Area	acres	1.22	4.46	2.96	22.36	7.44	38.44
		hectares	*0.4954*	*1.8029*	*1.1986*	*9.0480*	*3.0128*	*15.5577*
	Units Connected	#	13	14	3	14	3	47
	Area Connected	acres	1.22	4.46	2.96	15.64	5.39	29.67

Table 3.13-25: Off-channel Habitat Connectivity and Estimated Surface Area for Various Flow Conditions for Mainstream Crooked Creek (2009)

Flow Conditions	Parameter	Reach Description	HAB5 Flat to American	HAB4 American to Anaconda	HAB3 Anaconda to Crevice	HAB2 Crevice to Getmuna[2]	HAB1 Getmuna to Mouth[3]	Total
		hectares	*0.4954*	*1.8029*	*1.1986*	*6.3275*	*2.1820*	*12.0065*
	% Connected [4]	%	100	100	100	70	72	77
75% Bankfull[1]	Total Area	acres	1.67	6.31	4.31	30.58	10.33	53.20
		hectares	*0.6752*	*2.5539*	*1.7434*	*12.3763*	*4.1814*	*21.5302*
	Units Connected	#	13	14	3	14	3	47
	Area Connected	acres	1.67	6.31	4.31	25.32	7.08	44.68
		hectares	*0.6752*	*2.5539*	*1.7434*	*10.2450*	*2.8658*	*18.0833*
	% Connected[4]	%	100	100	100	83	69	84
Bankfull[1]	Total Area	acres	2.11	8.17	5.65	38.81	13.22	67.96
		hectares	*0.8550*	*0.33049*	*2.2882*	*15.7045*	*5.3500*	*27.5026*
	Units Connected	#	13	14	3	21	4	55
	Area Connected	acres	2.11	8.17	5.65	38.81	13.22	67.96
		hectares	*0.8550*	*3.3049*	*2.2882*	*15.7045*	*5.3500*	*27.5026*
	% Connected[4]	%	100	100	100	100	100	100

Notes:

1 Table represents off-channel habitats with connectivity at or below bankfull stage only. A 16 percent reduction represents a flow depletion in Crooked Creek at American Creek (BGC 2011b).
2 Lower portions of reach HAB2 may not experience 16 percent flow reductions due to tributary contributions.
3 Getmuna to the mouth of Crooked Creek would not likely experience a 16 percent reduction in baseflow due to tributary contributions.
4 % Connected = Area Connected/Total Area.

Source: Ottertail 2012e

Streamflow Changes and Freezing of Spawning Substrates

From late September 2010 to early June 2011, a pilot study was conducted to assess the depth of stream substrate freezing along the mainstem of Crooked Creek between Flat Creek and Getmuna Creek. This study was conducted under low flow conditions and focused on areas where potential salmon spawning would be expected near the tails of pools. Based on the flow conditions observed during the study, substrate freezing was not observed in water depths greater than 1.6 ft. This suggests that potential over-wintering habitat for fish and incubating salmon eggs exists in certain areas of Crooked Creek (Ottertail 2012d).

In the summer of 2009, water depth measurements collected at 532 salmon redds in Crooked Creek during baseflow conditions showed that 68 percent were located in areas where water depths ranged from 1 foot (0.3 m) to greater than 1.6 feet (0.5 m) with minimum depths of redds measured at 4 inches (0.23 m) (Ottertail 2012e; Ottertail 2014a). Regarding redd distribution, 65 percent were located downstream of Getmuna Creek while 92 percent were downstream of Crevice Creek (Ottertail 2012e). According to Hanrahan et al. (2004), the minimum spawning depth for Chinook salmon redds is 11.8 in (0.3 m).

The distribution of reduced winter low flows near the vicinity of the mine site during Year-20 of operations could affect winter freeze conditions. This would vary by location and habitat type between American Creek and Getmuna Creek. Overall through this area, riffle habitat would be reduced from 9.4 acres to 8.4 acres (by 10.6 percent); run habitat would be reduced from 58.4 to 55.9 acres (by 4.3 percent); and pool habitat would be reduced from 8.4 to 8.2 acres (by 2.4 percent). Spatially, the percent reductions of all three habitat types during winter low flows in Year-20 of operations would be greatest between Anaconda Creek and Crevice Creek. In this reach, riffle, run, and pool habitats would be reduced by 22, 8, and 4 percent, respectively. Pool habitat, important to over-winter fish survival, would consist of less than 0.5 acre between Anaconda Creek and Crevice Creek based on the winter average flow as well as both undisturbed and disturbed low flow conditions or about 5 percent of the aquatic habitat in this area. In contrast, 87 percent of this reach consists of run habitat.

While summer and winter flow reductions up to 25 and 33 percent, respectively, are anticipated in the middle reaches of Crooked Creek near the mine site during Year 20 of Operations, overall impacts on salmon redds in the Crooked Creek mainstem may not be measurable or noticeable relative to dewatering or freezing. This is because the majority of observed spawning habitat and adult salmon spawning distribution has been documented to occur in the lower river where predicted winter baseflow reductions during Year 20 of operations would be 7 to 10 percent due to substantial tributary inflows primarily from Getmuna and Bell creeks (BGC 2015h; SRK 2017b). As shown in Table 3.13-24, anticipated water stage reductions that would result from predicted flow reductions in the middle reaches of Crooked Creek during Year 20 of Operations would be less than 1.5 feet. The duration of these impacts may be expected to last during and beyond the life of the project. The extent or scope would be limited to waters in the vicinity of the project footprint and middle reaches of Crooked Creek. The context of impacts would affect Crooked Creek and certain reaches of its tributaries regulated as EFH.

If predicted flow reductions of 85 to 100 percent occur in the middle reaches of Crooked Creek reflecting a high level of hydraulic continuity between the streambed and the zone of groundwater depression caused by mine dewatering activities, then anticipated impacts relative to potential freezing of salmon spawning substrates in the middle and lower reaches of Crooked Creek would involve acute or obvious changes to the character and quantity of aquatic habitat.

Streamflow Changes and Salmon Production

Estimated changes to the flow regime in the Crooked Creek mainstem during all phases are expected to result in impacts on salmon production relative to the overall Kuskokwim River system that may not be measurable or noticeable because the Crooked Creek drainage comprises less than 1 percent of the total area of the Kuskokwim River watershed (Wang 1999). Based on 2008 to 2012 weir counts near the mouth of Crooked Creek, the average annual salmon escapement totaled 3,600 fish. The annual averages consisted of 59 Chinook salmon (range 29 to 100); 1,907 chum salmon (range 832 to 3,755); and 1,634 coho salmon (range 591 to 4,204) (Ottertail 2014c).

The extent of predicted flow reduction in Crooked Creek would be primarily limited to the mine site vicinity upstream of Crevice Creek. Even with the proposed supplemental release of treated water to Crooked Creek via the Omega Gulch drainage, the intensity of flow reduction in this area could be acute or obvious depending on whether there is a high level of hydraulic conductivity between the streambed and the predicted zone of groundwater drawdown from nearby pit dewatering operations (High K scenario). Assuming the predicted level of hydraulic conductivity, predicted winter (March) flow reduction between American Creek and Crevice Creek during a 10th percentile low flow year scenario, would be 25 to 33 percent during Year 20 of operations. Farther downstream in Crooked Creek and under a similar flow scenario, streamflows are predicted to be reduced by 12 to 10 percent near Getmuna and Bell creeks, respectively.

These flow reductions would affect limited populations of spawning and rearing salmon near the mine site. From 2004 to 2010, an annual average of about 40 adult, mostly coho, salmon (12 percent of the total annual average of 354 salmon for these years) were observed near the mine site upstream of Crevice Creek (Table 3.13-6). The other 88 percent of the adult salmon in Crooked Creek during these years was observed farther downstream between Crevice Creek and the Kuskokwim River.

Based on estimates of aquatic habitat reductions described earlier, predicted flow reductions of 25 to 33 percent in Crooked Creek near the mine site would result in noticeable impacts relative to salmon production. These impacts may be expected to last during and beyond the life of the project. The extent or scope would be limited to waters in the vicinity of the project footprint and associated watershed. The context of impacts would affect Crooked Creek and certain reaches of its tributaries regulated as EFH.

Should the underlying geology of Crooked Creek reflect a high level of hydraulic conductivity, flow reductions in Crooked Creek between American Creek and Crevice Creek could be as high as 85 to 100 percent during Year 20 of Operations. Farther downstream in Crooked Creek, flow reductions of 40 to 31 percent could occur near Getmuna and Bell creeks, respectively (BGC 2015c). In this case, predicted streamflow reductions of such intensity would result in acute or obvious impacts to salmon production in the middle and lower reaches of Crooked Creek.

The ADF&G drainage-wide sustainable escapement goal for the Kuskokwim River Chinook salmon was 65,000 to 120,000 (Conitz et al. 2016). By comparison, the average 2008 to 2012 Chinook salmon escapement at the Crooked Creek weir observed by Ottertail (2012b) represents between 0.1 and 0.2 percent of the above total escapement goal for the Kuskokwim River Chinook salmon.

Similarly, the average 2008 to 2012 chum salmon escapement past the Crooked Creek weir represents 0.3 to 0.6 percent of the total escapement goal for the four Kuskokwim River stocks for which escapement goals have been established (Conitz et al. 2016). The average 2008 to 2012 coho salmon escapement past the Crooked Creek weir represents 2.9 to 3.9 percent of the total escapement goal for the three Kuskokwim River stocks for which escapement goals have been established (Conitz et al. 2016).

Evaluation of potential impacts to Crooked Creek salmon production, based on predicted flow reductions from the proposed project, in comparison to total salmon production in the Kuskokwim River drainage requires consideration of several factors. First, the escapement goals established for the Kuskokwim River drainage involve salmon stocks from a limited number of tributaries and do not reflect the total abundance from all salmon-bearing streams in the Kuskokwim system. Second, predicted reductions in surface flows, instream habitat quantity and quality, and over-wintering conditions in Crooked Creek due to the proposed project are predominately limited to the middle reaches of Crooked Creek in the vicinity of the Mine Site and well upstream of lower reaches of Crooked Creek where most spawning occurs. In recent years, spawning salmon densities within the middle reaches of Crooked Creek have been limited whereas most Chinook, coho, and chum salmon spawning has been observed downstream of Getmuna Creek and/or within the Getmuna and Bell creek drainages (Ottertail 2012b). Thus, any percentage comparison of total salmon escapement based on Crooked Creek weir counts versus total escapement goals for the Kuskokwim River system tends to reflect the relative contribution of Crooked Creek stocks which primarily spawn in the lower reaches of Crooked Creek.

Other Impacts of Streamflow Changes on Aquatic Habitat

American Creek has a catchment area of 6.9 mi^2 at the confluence with Crooked Creek. During Operations, runoff from this catchment would be captured and stored in the lower contact water pond for use in mine operations, thus reducing inflows to Crooked Creek. During Year 20 of operations, the annual average flow to Crooked Creek from American Creek and its adjoining area would be reduced as much as 100 percent due to mining activities (BGC 2011j). Following closure (and when the pit lake fills), flows released from this area could nearly double (due, in part, to discharges from the pit lake) but would annually average 18 percent greater than pre-mining conditions based on average (50th percentile) flow conditions (BGC 2013f).

To limit contact with waste rock, waters upstream of the WRF in American Creek would be diverted into Omega Gulch's relatively small catchment area of 0.9 mi^2 during the Construction and Operations phases of mining (BGC 2011j). These diversions may result in average flow increases as large as 287 percent. This likely would result in flow-increase impacts as previously described including bank erosion and channel down-cutting (also refer to section on Erosion and Stream Sedimentation). Increased flows in Omega Gulch may alter the distribution and extent of aquatic habitat within the creek channel and in the Crooked Creek mainstem downstream. Depending on the channel's response to increased flows, aquatic habitat and fish passage conditions in Omega Gulch could become altered potentially providing access to areas where fish have not been previously documented (Ottertail 2012b). Potential impacts of this would depend on the nature and extent of changes that could either encourage or deter access and use of instream habitats, particularly in the lower reach of the creek. Flow increases would be infrequent, however, as diverted waters would be redirected back to the American Creek drainage during the later years of proposed operations (BGC 2011j).

Construction of the TSF within Anaconda Creek would reduce the watershed area at the confluence of Crooked Creek from 7.7 mi^2 to 1.8 mi^2 (BGC 2011j). By Year 20 of mining operations, flows in Anaconda Creek are predicted to be reduced by 24 percent along its remaining segment due to TSF operations (BGC 2013f). Such flow reductions would adversely affect the extent of aquatic habitat as previously described.

During the Closure Phase, surface runoff and instream flows in the Anaconda Creek drainage upstream of the reclaimed TSF would be collected and diverted into Crevice Creek by diversion channels. While the average annual flow of Crevice Creek is currently 5.45 cfs, diversion of upper Anaconda Creek would increase the average annual flow in Crevice Creek to 7.79 cfs (by 43 percent) under normal conditions (BGC 2011j). An increase of this magnitude could alter the drainage's configuration to some extent from stream bank erosion and channel down-cutting, in addition to other impacts from flow increases as previously described. Energy dissipating structures would be used to control discharge velocities and streambank stabilization measures would be implemented at select locations where bank scour or excessive down-cutting is anticipated to control effects of erosion and sedimentation.

Lewis Gulch, Queen Gulch, Snow Gulch, and Grouse Creek also may experience flow decreases resulting from pit dewatering activities (BGC 2013f). The effect of these alterations on surface flow in these streams can be predicted based upon the expected drawdown of the water table (Figure 3.13-3). The decreased surface flows would be most pronounced in Lewis and Queen Gulch while flow reductions in Snow Gulch and Grouse Creek would be less.

In addition to flow changes from pit dewatering, Snow Gulch also may be subjected to flow changes based on the operation of the freshwater reservoir. When the process plant would require water withdrawals from the freshwater reservoir to meet its demand, discharges from the reservoir may temporarily cease. This would substantially reduce streamflow to the downstream portions of the creek (BGC 2011g). Depending on the extent of groundwater inflows to Snow Gulch, this could result in a complete diversion of upstream surface flows that would adversely affect Dolly Varden populations downstream of the freshwater reservoir. Establishment of minimum flow releases below the freshwater reservoir could help assure existing populations of Dolly Varden and other aquatic life are sustained.

Stream Temperature Changes

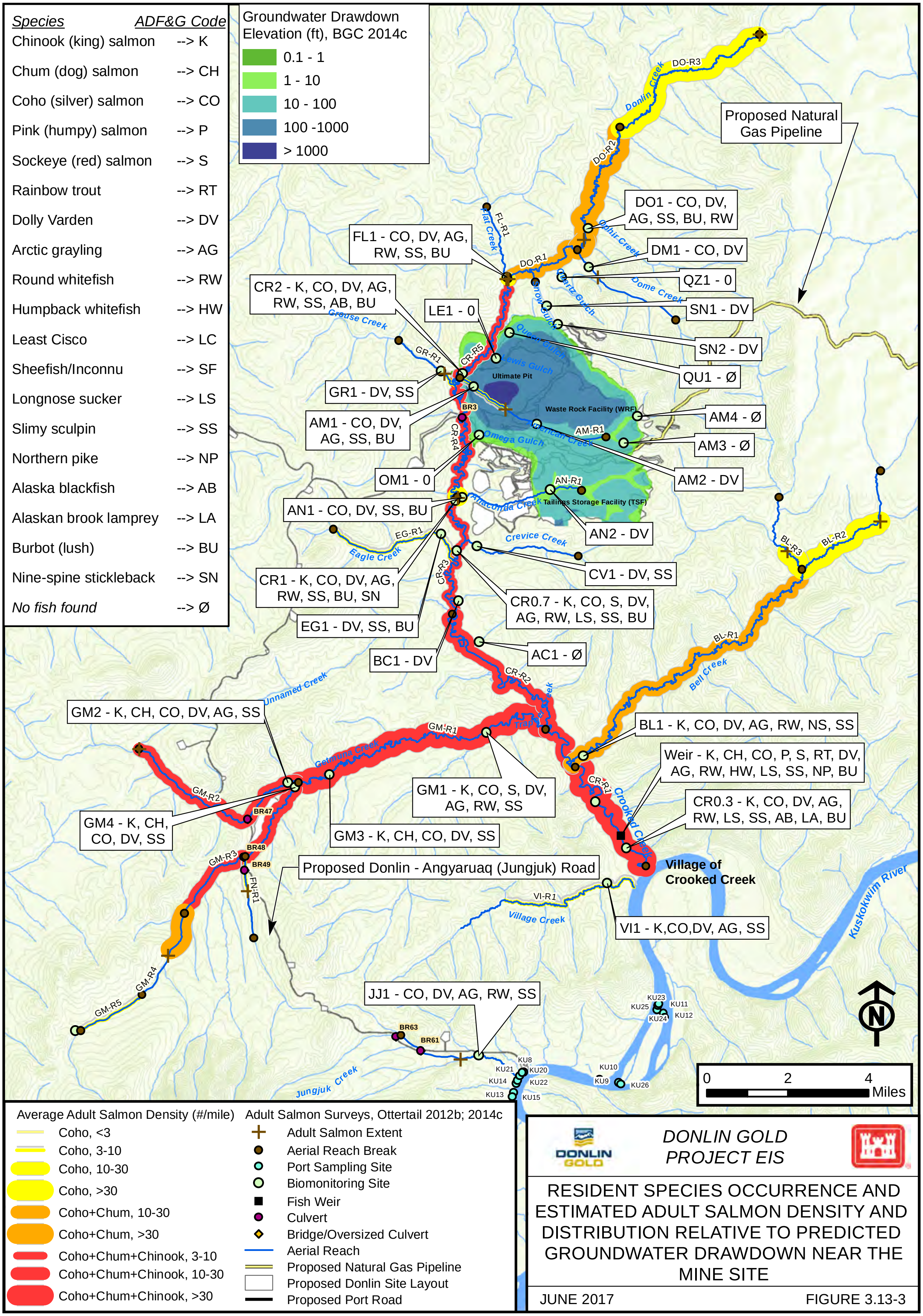
Stream temperature is a measure of the amount of heat energy per unit volume of water. While internal hydrologic processes within the stream system insulate and buffer water temperatures, external factors can alter the amount of heat energy delivered to the stream or the amount of water flowing in the channel. The combination of such internal and external factors can result in a change in a stream's temperature regime. For example, removal of riparian vegetation along stream corridors, human alteration of groundwater dynamics and stream channel morphology, or construction of upstream dams and impoundments with subsequent release of cold hypolimnetic water or warm surface waters to downstream reaches may detrimentally alter the temperature regime of streams (Poole and Berman 2001; Weber-Scannell 1992).

As a primary physical factor influencing the life history of coldwater fishes, temperature affects fish growth and overall survival; changes the timing and distribution of migrating adults as they seek spawning areas; can result in fish avoiding certain streams or stream reaches altogether; and alters the timing for juveniles to become smolts and migrate to salt water (Weber-Scannell 1992; Brett 1952; Jonsson and Ruud-Hansen 1985; Hokanson et al. 1977). Stream temperature directly influences the metabolic rates, physiology, and life-history traits of aquatic species and affects the rates of important community processes such as nutrient cycling and productivity (Allan 1995). Incubation temperatures in a stream above or below a suitable range also will lengthen or shorten the time for egg development, increase egg mortality, and increase the occurrence of deformed fry (Weber-Scannell 1992).

During the Construction and Operations Phases, stream temperatures in drainages downstream of the vicinity of the Mine Site are anticipated to remain relatively constant. Both surface water and groundwater from the American Creek and Snow Gulch drainages would be diverted to the mill processing circuit. While this would reduce the volume of flow ultimately reaching Crooked Creek, the amount of heat energy per unit volume of water would not be expected to appreciably change. The possible exception to this would involve a relatively small volume of surface water and pit dewatering well water that would be collected, treated, and discharged to Crooked Creek. The average (50th percentile) proposed surface water diversion and discharge into Crooked Creek would be 1,048 gpm (2.33 cfs) with a range of 2,001 gpm (4.46 cfs) during Year 2 of operations to 756 gpm (1.68 cfs) during Year 25 of operations (BGC 2013f). Based on an average (50th percentile) projection of groundwater pumping, discharge of treated well water to Crooked Creek would be 863 gpm (1.92 cfs). The annual average discharge of treated water from the pit perimeter and in-pit dewatering wells to Crooked Creek over the mine life would range from a high of 1,231 gpm (2.74 cfs) during Year 15 of operations to a low of 0 gpm (0 cfs) during Year 25 and later (BGC 2012b).

While it is likely that treated water from the pit perimeter and in-pit dewatering wells may have a slightly higher temperature than that of the initial untreated water from these sources, the larger contribution of diverted surface water would be mixed with treated water from the pit perimeter and in-pit dewatering wells before it is discharged to Crooked Creek is not expected to result in a measurable or noticeable change to the Crooked Creek water temperature regime. The average ratio of diverted surface water to treated pit perimeter and in-pit dewatering well water would be 1.21 to 1, with a range over the life of the mine of 0.85 to 1 in Year 15 of Operations to 100 percent of the flow originating from diverted surface runoff in Year 25 of Operations (BGC 2013f). Although Crooked Creek flows would be reduced due to flow diversions from the upper and lower contact water ponds and Snow Gulch for process water, the net heat energy per unit volume of water is expected to remain relatively unchanged.

Reduced flows in the Crooked Creek drainage during mine operations would affect the thermal mass on a localized basis. While the drainage is currently subject to natural seasonal flow changes and winter freeze, proposed mine operations could further alter the extent and locations in Crooked Creek near the vicinity of the Mine Site where winter freeze could occur affecting, to a limited extent, the volume and surface area of aquatic habitat available to overwintering fish, aquatic organisms, and their eggs incubating in gravels.



DONLIN GOLD PROJECT EIS

RESIDENT SPECIES OCCURRENCE AND ESTIMATED ADULT SALMON DENSITY AND DISTRIBUTION RELATIVE TO PREDICTED GROUNDWATER DRAWDOWN NEAR THE MINE SITE

JUNE 2017

FIGURE 3.13-3

Based on bathymetric contour mapping of the Crooked Creek mainstem between American Creek and Getmuna Creek, undisturbed winter average (50th percentile) flow conditions (typically lowest in January) result in a total surface area of 89.2 acres of aquatic habitat comprised of riffles, runs, and pools (Ottertail 2014a; BGC 2014c). Undisturbed winter low flow (10th percentile) conditions (typically lowest in March) results in a total surface area of 76.3 acres, or a 14.5 percent reduction between undisturbed winter average and low flow conditions. Disturbed winter (March) low flow conditions during Year-20 of proposed mine operations would result in a total surface area of 72.2 acres or a 5.4 percent reduction of aquatic habitat from undisturbed winter low flow conditions. Donlin Gold modified their proposed project design to include treating and discharging excess water using advanced water treatment. In September 2015, the modeled streamflow was updated and had a minor effect on the results. The analysis of resulting changes in fish habitat effects has not been updated, but the effects would be similar to the previous analysis.

The reach between American Creek and just below Omega Gulch consists of 2.7 acres of pool habitat under winter low flow undisturbed conditions or about 29 percent of the habitat in this reach. Flows under Year 20 of Operations would reduce pool area in this reach to 2.6 acres (by 3 percent) as a result of the water stage being reduced from 0.69 to 0.56 feet. As previously mentioned, Crooked Creek winter stream surveys have not documented substrate freezing in water depths greater than 1.6 feet. In addition, spawning surveys have determined that a small proportion of salmon spawn near or upstream of the vicinity of the Mine Site where incubating eggs would be at risk from lower flows and winter freeze conditions. From 2004 to 2010, an annual average of 40 adult salmon (12 percent of the total number observed in the mainstem channel) were documented either upstream of the Mine Site or in the middle reaches of Crooked Creek near the mine where they potentially would have been subject to flow reductions occurring during Operations.

During summer Construction and Operation Phases, pit de-watering would result in groundwater depressurization near Crooked Creek altering the volume and direction of groundwater flow to and from the creek. Groundwater inflows to a stream channel can moderate water temperature in the channel year-round (Holmes 2000). Reduced groundwater inflows to Crooked Creek could affect the water quality regime (i.e., stream temperatures, oxygen levels, and nutrient concentrations) which, to a certain extent, may locally affect populations of aquatic life (Poole and Berman 2001). Maximum recorded stream temperatures for Crooked Creek at Crevice Creek in June, July, and August are 45.8°F, 51.6°F, and 50.1°F, respectively[2]. Under summer low flow conditions during mining operations, reductions in groundwater inputs to Crooked Creek could cause stream temperatures in reaches near the mine to be close to or above the State of Alaska's water quality temperature standard of 55.4°F for egg / fry incubation and spawning and 59.0°F for migration and rearing. Currently, Crooked Creek's riparian corridor is completely intact providing shade to the stream channel which, to some extent, would help buffer potential mining-related changes to stream temperature. Increases in water temperatures may result in a cumulative increase in degree-day temperature units (TUs), the impacts of which are described below. Such impacts would be most substantial during low-flow events and likely would be localized near the middle reaches of Crooked

2 Unpublished Donlin Gold temperature sensor data provided by BGC Engineering, Inc., May 2009 (BGC 2009b)

Creek, between American and Crevice creeks, where riffle habitat and salmon spawning are limited (Ottertail 2012b; Ottertail 2014a).

Following Mine Site Closure, a post-Closure water treatment plant (WTP) would be constructed prior to the pit completely filling. Treatment would begin in Post-Closure Year 52 to maintain the operating level of the lake at elevation 316 feet. This would provide sufficient freeboard and storage for upset flood events and also would prevent a groundwater gradient from developing that might otherwise cause groundwater in the vicinity of the pit lake to migrate toward Crooked Creek. After the pit lake fills to the operating level, the warmer surface water would be treated and monitored to meet compliance standards and discharged directly into Crooked Creek during the April through September open water season.

The post-Closure Phase of the project likely would result in seasonal water temperature changes in Crooked Creek due to the transition of the American Creek drainage from a cold water stream environment to flows influenced by releases from the pit lake via the WTP (reservoir environment). Waters draining from the surface of reservoirs tend to have higher temperatures than nearby streams due to longer residence time and increased solar exposure. Downstream of dams and reservoirs, warming waters have been shown to cause shifts in macroinvertebrate communities, increased fish species richness, and reductions in population densities of certain coldwater fish species (Lessard and Hayes 2003).

Fish, macroinvertebrates, and other aquatic life would be potentially affected by a warmer water temperature regime in the Crooked Creek drainage during the post-Closure Phase. Section 3.7, Water Quality, provides additional information on anticipated water temperature changes. A direct effect on salmon would involve the cumulative increase in degree-day TUs experienced by incubating salmon eggs in response to warmer temperatures from treated discharges released from the pit lake.

The development of salmon eggs through egg hatch and egg sac absorption is temperature dependent and normally expressed in TUs. One TU represents 1 day that the mean daily water temperature exceeds freezing by one degree; 1 day with a mean water temperature of 36°F (2 degrees Celsius [°C]) represents 2 Celsius degree-day TUs. Salmon stocks have genetically evolved to maximize survival over a wide geographic area and climatic conditions. The dates of initial spawning and subsequent egg development and hatch reflect an adaptation to and synchronization with watershed-specific temperature regimes (Quinn 2005). The timing of seasonal spawning migration and other life-cycle stages in Pacific salmon populations is often highly adapted to local thermal conditions in freshwater rivers, streams and lakes, and the ocean. Adaptation and natural selection in response to water temperature changes can shape the timing of migration so it more favorably aligns with environmental conditions that avoid predictable periods when stressful, energetically demanding, or dangerous conditions occur (Kovach et. al. 2012; Hodgson and Quinn 2002).

Increasing water temperatures in a southeast Alaska stream, where yearly mean temperature anomalies were elevated by about 36°F (2°C) over a 40-year period, have been shown to result in the earlier timing of migration and spawning of a pink salmon population by nearly two weeks (Kovach et. al. 2012). Increasing water temperatures also have been shown to affect the timing of egg development, maturation, and emergence of freshwater fishes (Weber-Scannell 1992). Salmon stocks may be adversely affected if earlier egg hatch and alevin emergence does not coincide with favorable river or stream conditions. As a result, genetic selection would favor fish that adapt to the new temperature regime provided water temperatures do not exceed critical survival thresholds (Kovach et. al. 2012).

The median number of Celsius degree-day TUs typically required for Chinook salmon to hatch is 542 (range 485 to 569°C TUs) while 1,056 are required (range 912 to 1,201°C TUs) for emergence. For coho salmon, the median number of °C TUs required for eggs to hatch is 521 (range 425 to 577°C TUs) with 927 required (range 641 to 958°C TUs) for emergence. The median number of °C TUs required for chum salmon eggs to hatch is 538 (range 365 to 641°C TUs) with 888 (range 732 to 1,138°C TUs) for emergence (Weber-Scannell 1992).

Pit lake water surface temperatures were modeled for post-Closure discharges after the pit lake reaches its operating level. The average daily water surface temperatures (0 to 6.6 feet deep) for the pit lake during an average flow year (50th percentile) are predicted to be highest from mid-June to late July, peaking at approximately 63.7°F (17.6°C) on June 28th[3] Over this same period between 2005 and 2008, water in Crooked Creek downstream of Crevice Creek had an average daily temperature of 39.6°F (4.2°C)[4]. Based on water balance models, treated water from American Creek is predicted to contribute, on average, 13 percent of the Crooked Creek flow at its confluence with American Creek during the April through September open water season when discharge would occur. This percentage may be expected to fluctuate over time based on seasonal variations in precipitation and the water storage available in the pit lake. Predicted water temperatures and resultant TUs were calculated for the mixed maximum WTP pumping rate of 6,605 gpm (14.7 cfs) and the 10-year low flow (10th percentile) in Crooked Creek. The resultant water temperature of the blended flow was evaluated for its effect on the stream temperature in Crooked Creek immediately downstream from the American Creek and Crevice Creek confluences.

The predicted increase in TUs was evaluated using 1) modeled daily pit lake water temperatures; 2) measured daily water temperatures in Crooked Creek between 2005 and 2008; 3) anticipated dates of discharge from the pit lake; and 4) the median dates of salmon migration in Crooked Creek. Median dates of migration were determined based on the passage of salmon past the Crooked Creek weir located 1.5 miles upstream of the Crooked Creek confluence on the Kuskokwim River (Ottertail 2012b). In 2010, the median dates for salmon migration past the weir were July 13 for Chinook salmon; July 26 for chum salmon; and September 4 for coho salmon (Ottertail 2012b). The median date represents the period in time when 50 percent of the migration would have passed the weir; although actual egg deposition on the spawning grounds likely would have occurred at a later time.

Under this scenario, the predicted increase in Celsius degree-day TUs is 156.4°C TUs for Chinook salmon; 93°C TUs for chum salmon, and 18.5°C TUs for coho salmon following the median passage date at the downstream weir. As noted, this is a conservative estimate and would likely be lower because salmon passing through the downstream weir would not yet have begun spawning and depositing eggs. This represents approximately 14.8 percent of the total °C TUs required by Chinook salmon to emergence; 10.5 percent of the total °C TUs to emergence for chum salmon; and only two percent of the total °C TUs to emergence for coho salmon. These values are within the normal range presented above for chum and coho salmon and just slightly above the normal range for Chinook salmon.

3 Unpublished data provided by Lorax Environmental Inc., May 2009 (Lorax 2009)

4 Unpublished Donlin Gold temperature sensor data provided by BGC Engineering, Inc., May 2009 (BGC 2009b)

Most Chinook and chum salmon spawning in Crooked Creek occurs in the lower river downstream of Crevice Creek (Ottertail 2012b, 2012d) where additional tributary inflows would buffer potential impacts of discharges with elevated temperatures from the pit lake. Based on the modeled maximum pit lake discharge and 10-year low flow conditions in Crevice Creek, the predicted increase in °C TUs in Crooked Creek, downstream of Crevice Creek, would be 107.4 for Chinook salmon; 63.3 for chum salmon; and 12.6 for coho salmon. Such increases remain well within the documented normal range of TUs for Chinook, chum, and coho salmon. As a result, potential alterations to the temperature regime would have an overall effect on Chinook or chum salmon fry production that may not be measurable or noticeable. Under the 10-year (10^{th} percentile) low flow scenario, the maximum TUs increase in Crooked Creek downstream of Crevice Creek is 10.2 percent of the average amount required to reach emergence for Chinook salmon and 7.1 percent of that needed to reach emergence for chum salmon. Although coho salmon spawn in Crooked Creek immediately downstream of American Creek, the predicted temperature increase under this scenario is still likely to result in an adverse effect that may not be noticeable, because of the extremely limited number of additional TUs (1.4 percent of total needed to reach emergence) that might be accumulated during the anticipated discharge period.

Water temperatures within Crooked Creek would return to baseline levels when discharge from the pit lake ceases each year at the end of September. As such, no additional accumulation of TUs above natural background levels would be expected after discharge from the pit lake ceases. Average water temperature during the first two weeks of October 2006 was 35.4°F (1.91°C).[5]

Salmon that deposit their eggs in gravels in mid- to late summer / fall exhibit embryonic growth under a declining water temperature regime with emergent fry produced in early spring. The earliest stages of development at which embryos can tolerate low temperatures and grow normally reflect adaptive spawning times among salmon populations. The early blastula stage (128-cell development) is the first developmental stage that displays tolerance to temperatures below the optimal threshold 40.1 to 42.4°F (4.5 to 5.8°C) (Combs and Burrows 1957; Combs 1965). Fertilized eggs of Chinook salmon require 144 hours at 42.4°F (5.8°C) to develop to the blastula stage (Groot et al. 1995). This temperature corresponds favorably with the modeled average water temperature of 42.4°F (5.8°C) predicted to occur downstream of Crevice Creek between July 15 and July 31. In addition, some evidence indicates that a modest water temperature increase early in the egg incubation period (through early blastula or 128-cell stage) may increase subsequent egg survival during colder water periods (Combs 1965). As a result, the intensity of impacts of predicted stream temperature changes on fish and other aquatic biota may be noticeable, and the duration of impacts would not be anticipated to return to pre-disturbance levels. Incidents of injury or mortality to fish eggs may be detectable but populations would remain within normal variation. The extent or scope would be limited to waters in the vicinity of the project footprint and associated watershed. The context of these impacts would affect Crooked Creek and certain tributaries regulated as EFH.

5 Unpublished data provided by BGC Engineering, Inc., June 2009 (BGC 2009c)

Erosion, Stream Sedimentation, and Metals Emissions

Erosion and Stream Sedimentation

Mining activities have the potential to release particulates and sediment into local drainages and tributaries from a range of activities and sources including:

- Soil disturbance, compaction, and vegetation removal;
- Wetland in-filling that reduces sediment retention and exposes soils to erosive forces of wind and/or water;
- Stream erosion from increased flows released as a result of inter-basin diversions and transfers;
- Rock fracturing/processing activities; and
- Runoff from constructed roads, runways, and materials sites.

Sections 3.2, Soils; 3.5, Surface Water Hydrology; and 3.7, Water Quality provide additional information on soil disturbance, erosion risk, and related impacts on water quality at the Mine Site during all three phases.

All three phases of the Mine Site and its infrastructure can introduce additional particulates and sediment loads to local drainages. Increased sediment has been shown to degrade the quality and quantity of aquatic habitat by elevating suspended solids and increasing turbidity (Waters 1995). Sediment generated from natural, catastrophic, and anthropogenic sources can fill interstitial spaces of substrates within a stream channel which, in turn, can decrease habitat important to fish spawning, egg incubation, and rearing.

Excessive erosion and sedimentation can affect the survival of incubating fish eggs; reduce substrate cover and refugia habitat for fish rearing and migration; increase predation of fishes; cause a loss of winter carrying capacity; and decrease the availability of habitats that support an abundant and diverse macroinvertebrate community and sources of food for fish (Waters 1995; Bjornn and Reiser 1991; NMFS 2011a). Excessive sediment loads also can affect the morphology of stream channels and the availability, distribution, quality, and functions of habitats important to fish and other aquatic life. While sediment transport and deposition are natural stream processes, major disruptions of the stream system and its functions may occur when sediment delivery is substantially changed or when the ability or capacity of the stream to transport sediment is altered.

Erosion and sedimentation also may elevate turbidity which can adversely affect fish feeding behavior and growth and reduce tolerance to disease and toxic compounds (Waters 1995). While salmonids, at times, may avoid or delay migration in waters with high silt loads (Cordone and Kelley 1961; Bjornn and Reiser 1991), they also commonly migrate as adults or juveniles through the mainstems of the Kuskokwim, Copper, Tanana, and other rivers that are characteristically turbid throughout the open water season (Lloyd et al. 1987).

Elements of the Mine Site that could result in the release of varying amounts of particulates and sediment to Crooked Creek drainages include the WRF, overburden stockpiles, pits, TSF, stormwater management systems, mine access roads, culverts, runways, general construction practices, water diversions and conveyance systems, and gravel/material sites. Proposed project activities at the Mine Site will result in the disturbance of approximately 9,000 acres of surface soil. The potential amount of stream sedimentation that would result from such disturbance will depend on the effectiveness of BMPs ultimately implemented and maintained during all phases of the project.

Depending on the effectiveness of control measures implemented, weather conditions, and site issues encountered, potential unanticipated impacts could occur that generate increased sediment loads in Snow Gulch; Omega Gulch; and Crooked, American, Anaconda, and Crevice creeks. In the Snow Gulch drainage, construction and operation of the freshwater reservoir would alter sediment transport and stream sedimentation downstream of the proposed dam. The freshwater reservoir would act as a settling basin by intercepting fine sediments from the upper drainage and preventing the natural delivery of sediments to the lower reaches of the creek. While retention of fine sediments in the reservoir may reduce turbidity downstream and provide more efficient foraging for fish; the reduced sediment load may increase the stream's potential to erode its banks and down-cut the channel downstream.

An Erosion and Sediment Control Plan (ESCP) and SWPPP will be prepared during final design for specific elements of the Mine Site. Proposed BMPs described in these plans will be finalized in accordance with ADEC, Division of Water requirements. The plans will be prepared during the final design and permitting phase of the project to reflect construction and engineering design changes and potential regulatory comments from the NEPA review process.

Proposed BMPs include sediment and stormwater management and monitoring measures that would be implemented from initial construction of mine infrastructure through mine closure. Sediment control measures include silt fences, hay bales, sediment retention basins, cross bars and ditches, runoff interception and diversion, mulching and revegetating disturbed surfaces and soil stockpiles. Other BMPs included in these plans are designed to reduce the intensity of surface runoff, erosion, particulates, and sediment loads in downstream drainages. BMPs would be installed and monitored to ensure their effectiveness and minimize impacts to fish, other aquatic biota, and their related habitats. Post-Closure sediment controls would include site grading and capping of erodible material, revegetation, and rerouting of surface runoff to reestablish natural conditions.

For local drainages near the mine site directly affected by Construction and Operations, sedimentation could noticeably change the character and quantity of aquatic habitat within tributaries and in Crooked Creek. Noticeable changes in the behavior of fish may affect reproduction, feeding, or survival of individuals. The duration of impacts may be expected to last during and beyond the life of the project. Greater impacts are anticipated when extreme weather events coincide with ground disturbance activities, grading, and major excavations. The extent or scope would be limited to the vicinity of the project footprint and Crooked Creek watershed. The context of impacts would affect Crooked Creek, American Creek, and Anaconda Creek, all of which are regulated as EFH.

Metals Emissions

The potential for risk to fish and aquatic organisms from particulates released from Mine Site Operations on surrounding land and water was evaluated for mercury, arsenic, antimony, and other metals. Mercury is naturally present in the environment and associated with gold deposits such as those in the Kuskokwim Gold Belt where the Mine Site is located. Methylmercury, which is formed when mercury combines with carbon, is readily absorbed by living organisms, is persistent in the environment, and has high toxicity and bioaccumulation characteristics.

Gaseous mercury released from non-point sources could be transported from the processing facilities or TSF to local drainages. An analysis was conducted that evaluated potential impacts of mercury dispersion on the environment from proposed construction and operational activities (SRK 2014a; ARCADIS 2014). Based on the analysis, it was determined that:

- Most mercury from ore processing will be captured and contained;
- Mercury in ore processing air emissions would be the largest source of mercury;
- Mercury sediment concentrations could increase from 2.5 percent above current baseline concentrations at Donlin Gold Camp to 0.8 percent above baseline at Village Creek;
- Average surface water concentrations in Crooked Creek watershed could increase, but would remain below Alaska water quality criteria. When considering the 95% upper confidence limit, surface water concentrations of total mercury would, in some instances, exceed the applicable chronic criterion of 12 ng/L. However, as described in Section 3.7.2.1.1, existing concentrations of total mercury in surface water measured as part of the Donlin Gold water quality characterization program exceeded the 12 ng/L chronic criterion in about 80 of the 564 samples collected between 2005 and 2015, indicating that concentrations of mercury above the applicable chronic criterion are a widespread natural feature of surface water in the vicinity of the Mine Site; and
- Concentrations of mercury in fish in the Crooked Creek watershed could increase, but the changes would likely be low (up to 3 percent above current levels) and within the range of regional background fish tissue concentrations. The level of increase would depend, however, on whether the future bioavailability of mercury to fish would be similar to historic conditions.

Increases in sulfate concentrations in natural systems with low concentrations of sulfate (as within the project area) will increase concentrations of methylmercury. Reviewed literature in ERM (2017) indicated the factor increase in methylmercury is 0.5 to 1.0 times the factor increase in sulfate (i.e., increase in percent methylmercury would be of similar magnitude to the increase in sulfate concentrations) in systems where sulfate is initially at low concentrations.

An analysis of potential environmental effects of metals from dust deposition on wildlife resources (see Section 3.12.2.2, Wildlife) resulted in the conclusion that dust deposition would increase the concentrations of mercury, antimony, arsenic, and other metals but by very low percentages that would not be expected to pose an additional risk to biota beyond that occurring from existing baseline concentrations.

With respect to mercury, mining activities in the Crooked Creek drainage under Alternative 2 would contribute additional inputs of total mercury to surface waters and wetland systems from atmospheric and aqueous sources on a long-term basis extending from Construction through Closure. While aqueous sources of mercury could affect water quality in local streams and wetlands downgradient of mine construction and operations activities, atmospheric sources could distribute mercury to drainages up to 10 miles from the mine site area. Additional information on potential impacts of mercury and other selected metals from fugitive dust sources during proposed mining activities is described in Section 3.2, Soils; and Section 3.7.3.2.2, Surface Water Quality.

It is anticipated that only a small fraction of the inorganic mercury dispersed from the Mine Site would be available for methylation (Marvin-Dipasquale et al. 2009). Combined sources from mining activities, however, could result in measurable increases in total mercury that exceed the 12 ng/L chronic effects criterion for aquatic life. Non-migratory fish and aquatic prey species that reside in the Crooked Creek watershed, often found in area drainages, would be more subject to the bioaccumulation of methylmercury than non-resident migratory species such as salmon.

Anticipated increases for mercury and antimony from fugitive dust deposition are discussed in Section 3.12.2.5.3, Fugitive Dust Deposition, in Section 3.12, Wildlife. Antimony, arsenic, and mercury would exhibit slight increases over the life of the project. While baseline concentrations of arsenic are greater than ADEC levels, the additional sources of arsenic that could be mobilized by the mine would contribute a relatively small increase in soil concentrations over the life of the project. Anticipated effects would persist over the life of the mine, and would remain at similar or reduced levels following Closure. The context or scope of soil quality impacts include soils that are extensive throughout the project area, and it is unknown whether they would be subject to future ADEC oversight due to potential dust impacts.

In the Crooked Creek drainage, or other watersheds where elevated levels of mercury naturally occur, wetland disturbance or in-filling can result in the transfer of methylmercury from sediments to down-gradient receiving waters allowing it to be available for assimilation by prey and predatory species of fish and other aquatic life. Alterations to the rate of mercury methylation in wetland systems at the Mine Site during Construction and Operations would depend upon several factors including:

- The presence or expansion of environments with no or limited levels of oxygen;
- The presence of sulfate-reducing or iron-reducing bacteria;
- The availability of multi-modal transfers of mercury (from air, water, or soils);
- The nutrient status of wetland systems (e.g., the availability of organic carbon, inorganic nitrogen, and sulfur); and
- The pH of sediments and soils.

As described in Section 3.7, Water Quality, the methylation potential near the mine site was evaluated along with potential consequent changes in project-related mercury concentrations and methylation rates (ARCADIS 2014). The main conclusions from the analysis are that unmeasurable or unnoticeable methylation occurs in most rivers and streams where water is actively flowing. The intensity of methylation in area wetlands was also determined to be unmeasurable or unnoticeable and is not expected to increase from mine activities. The extent or scope of methylation would be limited to waters in the vicinity of the project footprint.

Estimated average methylmercury concentrations in surface waters, however, have been predicted to increase at noticeable levels, from 0.280 ng/L to 0.398 ng/L (42 percent increase over the baseline concentration), due to mining activities under Alternative 2 (ARCADIS 2014). The duration of increased methylmercury concentrations in surface waters and wetlands would persist for the life of the project, with concentrations expected to return to pre-activity levels after Closure. The extent or scope of this would extend beyond the Crooked Creek drainage, with the potential for aquatic habitats outside of the immediate project area to be affected from deposition of atmospheric mercury sources. The context of impacts would include streams and wetlands in the region regulated as EFH.

Because the applicable numeric water quality criterion for methylmercury is expressed as a fish and shellfish tissue concentration, rather than a surface water concentration (EPA 2010a), methylmercury concentrations in surface water predicted to result from proposed mining activities under Alternative 2 cannot be compared to regulatory limits. Site-specific bioaccumulation factors (BAFs) can be used to explain and predict the relationships between methylmercury concentrations in primary media, such as surface water or sediment, and the concentrations measured in fish tissue. Additional information on potential impacts on the environment from releases of mercury is presented in Section 3.24, Spill Risk.

Summary of Mine Site Impacts

At the Mine Site, direct and indirect impacts on fish and aquatic resources are anticipated in the middle reach of Crooked Creek as a result of altered flow regimes, reductions in instream habitat, and loss of off-channel habitat and connectivity between the mainstem and off-channel areas. Such impacts would result from flow diversions and other water management activities at the Mine Site, pit dewatering, and clearing, earth movement, and grading along certain Crooked Creek tributaries. Variable levels of effect would occur during all three phases of the project. During Construction and Operations, the intensity of adverse impacts from reductions in habitat and flow in the middle reaches of Crooked Crook would range from unmeasurable or unnoticeable to acute or obvious. This would primarily affect rearing Chinook and coho salmon and spawning coho salmon. The most substantial proportion of adult salmon escapement and production occurs in lower Crooked Creek, Getmuna Creek, and Bell Creek. Flows in Getmuna and Bell creeks would be unaffected by Mine Site activities. In lower Crooked Creek, the intensity of adverse impacts from flow reduction during Year 20 of Operations would be unmeasurable or unnoticeable during winter low flow periods for average and low-flow years. Potential impacts from anticipated flow reductions in Crooked Creek would likely not be perceptible relative to broader populations of fish in the Kuskokwim River.

A summary of potential impacts for the overall Mine Site involve the following:

- Water quality practices (as described on pages 3.13-78 to 3.13-81): All mine contact water will be retained and reused on site for mill processing throughout mine operations, thereby avoiding water quality impacts on aquatic resources in the Crooked Creek drainage. After Closure when the pit fills, water from the pit would be treated per APDES permit specifications and applicable ADEC water quality standards to ensure protection of aquatic life before being discharged to the Crooked Creek drainage. During and following Closure, water quality compliance monitoring would continue at all points of discharge based on requirements established during final design and permitting after the NEPA process is completed. Changes in the character or quantity of fish and aquatic habitat in the Crooked Creek drainage as a result of treated water discharges may not be measurable or noticeable. The context of these impacts involving the lower reaches of American and Anaconda creeks; the mainstem of Crooked Creek from its mouth to Donlin Creek; and Getmuna and Bell creeks would affect waters regulated as EFH supporting key life stages of salmon that play a role in the Kuskokwim subsistence community.
- Water management practices (as described on pages 3.13-78 to 3.13-81): During Construction and Operations, water pumped from the in-pit and perimeter wells (about 1,400 gpm) will be treated according to APDES permit requirements and ADEC water

quality standards with nearly one third of the flow conveyed to the mill processing plant and two thirds discharged to the Crooked Creek drainage. Collecting and diverting other up-gradient non-contact surface waters from local drainages in the vicinity of the Mine Site around mine operations and then to tributaries and Crooked Creek downstream would result in impacts to aquatic habitat and fish populations near the mine site that may not be measurable or noticeable. The extent or scope of these impacts would be limited to waters in the vicinity of the project footprint and Crooked Creek watershed. However, under a High K scenario, impacts from middle reaches of Crooked Creek to the Kuskokwim River could be acute or obvious.

Most of the tributaries directly affected by filling, flow diversions, and other water management practices would experience losses of aquatic habitats, fish, and other aquatic species often found in the Crooked Creek watershed. These losses would not be anticipated to return to pre-disturbance levels. The context of impacts involving the lower reaches of American and Anaconda creeks; the mainstem of Crooked Creek from its mouth to Donlin Creek; and Getmuna and Bell creeks include waters regulated as EFH supporting key life stages of salmon that play a role in the Kuskokwim subsistence community. Impacts in the affected tributaries and middle reaches of Crooked Creek would be noticeable, and may be acute or obvious. However, impacts in lower Crooked Creek may not be measurable or noticeable. Under a High K scenario, impacts from the middle reaches of Crooked Creek to the Kuskokwim River would be acute or obvious.

- Wetland and riparian buffer removal (as described on pages 3.13-81 to 3.13-82): Removal, grading, and filling of vegetation, wetland communities, and riparian buffers due to mine development would reduce or degrade aquatic habitat in the vicinity of the project footprint and within several drainages east of Crooked Creek. The anticipated direct impacts would include reduced surface water infiltration, retention, and groundwater flow; increased surface water runoff; and reduced water quality functions (e.g., binding of nutrients, metals, and sediments from surface runoff). These changes in the character of aquatic habitat would be noticeable, and may be acute or obvious. Such changes would be attenuated and may not be measurable or noticeable downstream from the Mine Site in the lower reaches of Crooked Creek due to tributary inflows. The context of Impacts involving the lower reaches of American and Anaconda creeks; the mainstem of Crooked Creek from its mouth to Donlin Creek; and Getmuna and Bell creeks would affect waters regulated as EFH supporting key life stages of salmon that play a role in the Kuskokwim subsistence community.
- Streamflow changes and overall aquatic habitat (as described on pages 3.13-82 to 3.13-86): The intensity of direct and indirect changes in flows and aquatic habitats in tributaries affected by mine operations and in Crooked Creek in the vicinity of the mine site is anticipated to range from unmeasurable or unnoticeable to acute or obvious. Predicted flow reductions would be greatest in winter months (November to April) in the middle reaches of Crooked Creek from American Creek to below Crevice Creek. During the winter of Year 20 of operations under 10-year low flow conditions, flows in this reach are predicted to be reduced from about 25 to 33 percent while, during closure, flows would be reduced by about 11 to 17 percent. Overall, during Year 10 of Operations, the maximum winter flow reductions in stream reaches near the mine site and in lower Crooked Creek would vary from 16 to 100 percent. During Year 20 of Operations, the maximum winter flow reductions in stream reaches near the mine site

and in lower Crooked Creek would vary from 18 to 100 percent. During mine Closure, maximum flow reductions would vary from 11 to 17 percent. Alterations of winter low-flow levels during Year 20 of Operations would affect riffle, pool, and run habitat by reducing the combined total area of these habitats by about 5 percent between American Creek and Omega Gulch and by about nine percent from below Anaconda Creek to below Crevice Creek. Under a High K scenario, flow reductions up to 100 percent could occur in the vicinity of the Mine Site, while farther downstream reductions of 40 percent are predicted below Getmuna Creek where a high proportion of the salmon spawning and rearing in the Crooked Creek drainage occurs.

Based on aerial surveys of spawning adult salmon conducted from 2004 to 2010, an annual average of about 350 salmon have been observed in the mainstem of Crooked Creek with 88 percent of the observations occurring between Crevice Creek and the Kuskokwim River where flow reductions from mine operations and closure may not be measurable or noticeable. Over this same period in the middle reaches of Crooked Creek upstream from Crevice Creek, an annual average of 40 adult salmon (12 percent of the total) were observed primarily consisting of coho and chum. This indicates that the relatively small proportion of redds annually produced in this reach over this period would have been subjected to reduced flows had the proposed mine been operating.

Changes in the character or quantity of aquatic habitat may not be measurable or noticeable in the lower reaches of Crooked Creek and in the Kuskokwim River due to substantial inflows from undisturbed Getmuna and Bell Creek drainages. Impacts on surface flows in the affected tributaries and in the middle reaches of Crooked Creek would extend beyond the life of the project and not be anticipated to return to pre-disturbance levels. The extent or scope of impacts associated with flow reductions and aquatic habitat alterations in the Crooked Creek mainstem would primarily extend from the confluence of Queen Gulch to below Anaconda Creek. The context of these impacts involving the lower reaches of American and Anaconda creeks; the mainstem of Crooked Creek from its mouth to Donlin Creek; and Getmuna and Bell creeks would affect waters regulated as EFH supporting key life stages of salmon that play a role in the Kuskokwim subsistence community. In the middle reaches of Crooked Creek, changes in the character or quantity of aquatic habitat resulting from streamflow changes would be noticeable, while unmeasurable or unnoticeable changes are expected downstream in lower Crooked Creek. Under a High K scenario, these changes would be acute or obvious in the middle and lower reaches of Crooked Creek.

- In-stream habitat removal and disturbance or loss of fish and benthic biota (as described on pages 3.13-74 to 3.13-78): Irreversible impacts would occur to about 8 total miles of stream habitat within five drainages along the eastside of the Crooked Creek watershed from all three phases of the Mine Site. Affected tributaries would include Snow Gulch, Lewis Gulch, American Creek, Omega Gulch, and Anaconda Creek. American Creek would experience the greatest loss of aquatic habitat (about 4 miles) where populations of about 4,300 fish, primarily consisting of Dolly Varden, have been estimated. Habitat alterations, surface flow diversions, behavioral disturbances, and fish mortalities within these drainages would be noticeable, and may be acute or obvious. Incidents of injury or mortality to fish would be detectable, and depending on the intensity of changes, populations would either remain within normal variation or local population-level effects could occur. For the most part, tributaries directly affected by filling, grading, and flow diversions or reductions contain aquatic habitats, fish, and other aquatic species often found in the Crooked Creek watershed. The context or scope of impacts associated with American and Anaconda creeks would include lower reaches of these drainages regulated as Anadromous Water for coho salmon rearing by ADF&G and as EFH supporting key life stages of salmon. As a result, noticeable impacts are anticipated for tributaries in the vicinity of the Mine Site that are directly affected by habitat loss and flow reduction while impacts in lower Crooked Creek downstream from Crevice Creek to the Kuskokwim River confluence where most Chinook, coho, and chum salmon spawning and production occurs may not be measurable or noticeable. The extent or scope of these impacts would be limited to waters in the vicinity of the project footprint and Crooked Creek watershed.

- Stream temperature changes (as described on pages 3.13-1-101 to 3.13-107): Reduced groundwater inflows to Crooked Creek resulting from in-pit and pit perimeter dewatering wells could affect the water quality regime (i.e., stream temperatures, oxygen levels, and nutrient concentrations) which, to a certain extent, may locally affect populations of fish and aquatic life (Poole and Berman 2001). Under summer low flow conditions during Operations, reductions in groundwater inputs to Crooked Creek could cause stream temperatures in reaches near the mine to be close to or above the State of Alaska's water quality temperature standard of 55.4°F for egg/fry incubation and spawning and 59.0°F for migration and rearing. In the middle reaches of Crooked Creek, this may result in a cumulative increase in degree-day temperature units (TUs), affecting the duration and timing of egg incubation and availability of prey species. Such impacts would be most noticeable during low-flow events and likely would be limited in extent or scope between American and Crevice creeks, where riffle habitat and salmon spawning is limited. The context of these impacts involving the lower reaches of American and Anaconda creeks; the mainstem of Crooked Creek from its mouth to Donlin Creek; and Getmuna and Bell creeks would affect waters regulated as EFH supporting key life stages of salmon that play a role in the Kuskokwim subsistence community. In the middle reaches of Crooked Creek, changes in the character or quantity of aquatic habitat from stream temperature changes may be noticeable, while changes downstream in lower Crooked Creek may not be measurable or noticeable.

- Erosion and stream sedimentation and metals emissions (as described on pages 3.13-107 to 3.13-111): Unless effectively controlled, sediment generated from several sources at the Mine Site could be released to tributaries and the mainstem channel of Crooked Creek in the vicinity of the mine site. The intensity and extent of stream sedimentation in these drainages will depend on the effectiveness of BMPs ultimately implemented and maintained during all phases of the project. BMPs and other environmental management procedures described in an ESCP and SWPPP will be finalized and implemented in accordance with ADEC, Division of Water requirements. These plans will be prepared in the final design phase to reflect construction and engineering changes and regulatory comments from the NEPA and permitting review processes.

  The performance of sediment control measures implemented from these plans would be monitored throughout the life of the project to ensure potential impacts to fish, other aquatic biota, and related habitats are avoided or minimized. Even with such controls, some stream sedimentation could be measureable particularly when extreme weather events coincide with ground disturbance activities, grading, and major excavations from construction through reclamation. Changes in the character or quantity of aquatic habitat from sedimentation may be noticeable in tributaries and receiving waters immediately downstream. The extent or scope of impacts associated with sedimentation would be limited to the vicinity of the project footprint and Crooked Creek drainage. The context of these impacts involving the lower reaches of American and Anaconda creeks; the mainstem of Crooked Creek from its mouth to Donlin Creek; and Getmuna and Bell creeks would affect waters regulated as EFH and support key life stages of salmon that play a role in the Kuskokwim subsistence community. In the affected tributaries and middle reaches of Crooked Creek, changes in the character or quantity of aquatic habitat may be noticeable, while unmeasurable or unnoticeable changes are expected farther downstream in lower Crooked Creek. The dispersion and deposition of metals and formation of methylmercury concentrations in aquatic habitats in the vicinity of the mine site would impact fish and aquatic resources compared to baseline concentrations. As a result, changes in the character or quantity of aquatic habitat may be noticeable near the mine site and in the Crooked Creek watershed.

3.13.3.2.2 TRANSPORTATION CORRIDOR

Potential impacts from the Transportation Corridor would result from construction of the airstrip and Angyaruaq (Jungjuk) Port site and periodic deliveries of cargo and fuel by tug and barge traffic on the Kuskokwim River and from Dutch Harbor to the Port of Bethel over the 110-day annual shipping season. Potential impacts also would result from construction and maintenance of the access road, bridges, and culverts for stream crossings between the Angyaruaq (Jungjuk) Port site and the Mine Site, and from the removal of rock and gravel from the materials sites. Any actions that would occur at Dutch Harbor or the Port of Bethel at the Bethel Yard Dock are not part of the proposed action, and are considered connected actions (see Section 1.2.1, Connected Actions, in Chapter 1, Project Introduction and Purpose and Need).

Water Transportation

As detailed in Section 2.3.2.2.1, general cargo and fuel required for all three phases of the Mine Site under Alternative 2 would be transported along the Kuskokwim River from offshore marine waters and Kuskokwim Bay to the Port of Bethel, then to the proposed Angyaruaq (Jungjuk) Port site. Additional shipments would continue upriver to barge landings located beyond Stony River to support construction of the gas pipeline crossings. The marine transportation fleet operating on these waters would be subject to all applicable state, federal, and international statutes and regulations administered and monitored by the U.S. Coast Guard and other regulators. Additional information and analysis related to barge operations is presented in Sections 3.23, Transportation and 3.5, Surface Water Hydrology.

While existing tug and barge combinations on the Kuskokwim River from Bethel to Crooked Creek consist of approximately 68 round trips per year (involving mostly medium-size tows comprised of a single tug pushing one- to two-barges), the majority of existing vessel traffic involves smaller, high-speed boats that often travel closer to the river bank than slower barge traffic.

In addition to existing vessel traffic, project-related barge traffic for cargo and fuel shipments would occur over the 110-day ice-free shipping season typically extending from June 1 to October 1. During the Construction Operations Phases, commercial barge traffic would travel from the Port of Bethel upriver approximately 168 miles to the Angyaruaq (Jungjuk) Port site averaging about 89 Construction and 122 Operations cargo and fuel barge tows (round trips) per season. River barge tow configurations and loading, which affect vessel maneuverability and draft, would be determined based on the average daily discharge and associated depths and widths of the river channel. Depending on the elevation (stage) of the river, fuel barge tows in this section of the river would involve two or four barges configured side to side with a draft of three to 7.5 feet. During the Closure Phase, project-related barging would be minimal with traffic returning to near baseline levels. In addition, the Angyaruaq (Jungjuk) Port facilities would be removed and reclaimed leaving only a limited barge landing to support long-term monitoring activities.

As described below, several mechanisms associated with increased tug and barge traffic could result in potential impacts on fish and aquatic resources. While the nature of cargo and fuel shipments transported by ocean and river vessels would be similar for the various action alternatives, the number of fuel barges and trips and the quantity of fuel delivered to the Angyaruaq (Jungjuk) Port site would vary. Refer to Chapter 2, Alternatives, and Section 3.23, Transportation, for additional information related to waterway transportation.

Expected Ocean and River Traffic

As described in the River Barge Fleet Design and Operation Plan (AMEC 2013, 2014) and Chapter 2, Alternatives, general cargo would be shipped by ocean tugs and barges from consolidation terminals in Seattle, Washington or Vancouver, BC to the region's main port in Bethel. The transportation plan has been designed for an annual volume of 115,000 short tons of cargo during operation of the mine. The cargo would be shipped from Pacific Northwest (Seattle, WA and Vancouver, BC) ports via ocean barges towed by ocean-going tugs to Bethel. Each ocean barge would be 360 feet long by 100 feet wide and would have a net cargo capacity of 10,040 tons at a maximum draft of 16 feet.

River barges can move upstream of Bethel once the river is free of ice, generally between April 24th and June 1st. The Kuskokwim River typically begins to freeze up in early October ending the shipping season. The Kuskokwim River shipping season of 110 days is assumed to occur from June 1st to October 1st, allowing for two weeks of downtime to allow for occasional low flows. Between Bethel and Angyaruaq (Jungjuk) Port, available draft on the river is limited by the depth of water in the shallower sections of the river, such as the section of river alongside Nelson Island, just upstream of Tuluksak.

At Bethel, fuel would be transferred directly to river barges for transport to Angyaruaq (Jungjuk) Port, or off-loaded for temporary storage and later transport to Angyaruaq (Jungjuk) Port. Fuel would be transported up the Kuskokwim River from Bethel to Angyaruaq (Jungjuk) Port by a fleet of two pusher-type fuel tows comprising a tug and four double-hull river barges. A tow of four fuel barges would have a capacity of 1.29 Mgal. Each fuel barge would be 165 feet long by 44 feet wide with a maximum operating draft of 7 feet. The tugs would be triple-screw 1,450 horsepower with a minimum draft of 3 feet. The fuel barges would have round-trip cycle times between Bethel and Angyaruaq (Jungjuk) Port of 81 hours for a total of 64 trips per shipping season during Operations. During Construction, there would be an estimated number of 19 river fuel round trips per season. During the first two years of Construction, there would be an additional estimated 20 barge trips transporting pipe and equipment from Bethel to a staging area near Devil's Elbow above Stony River on the Kuskokwim River. Any actions that would occur at Dutch Harbor or the Port of Bethel at the Bethel Yard Dock are not part of the proposed action, and are considered connected actions (see Section 1.2.1, Connected Actions, in Chapter 1, Project Introduction and Purpose and Need).

Direct and Indirect Impacts

Waterway shipments of fuel and cargo to the mine would increase Kuskokwim River barge traffic from baseline levels of about 68 round trips to approximately 190 round trips per season during Operations and a total of 157 during Construction (baseline round trips plus project-related round trips). Potential impacts related to the increased barge traffic on fish and aquatic resources primarily would result from vessel-induced wave energy, propeller turbulence, and possible temporary vessel groundings. In addition, incidental spills of fuel could occur at port facilities or along the waterway or roadway corridor to the Mine Site.

Depending on the water depth, channel geometry, and riverbed character at critical sections of the river and the timing, speed, and specific route of travel of barge traffic, potential direct and indirect impacts could result from:

- Bank erosion and riverbed scour that cause direct habitat disruption and increased suspended sediment concentrations and turbidity;
- Displacement or stranding of young-of-year fish along certain shallow-gradient riverbanks and bars;
- Behavioral disturbance to resident and anadromous fish life stages (migration, rearing/ feeding, and spawning); and
- Propeller strikes or shear forces causing fish injuries or mortalities or alteration of fish behavior and migration.

Note that in the Kuskokwim River, spawning habitat disruption from dislodging of eggs or sedimentation can result from natural flooding, ice break up, bank erosion, and riverbed scour (from both natural causes and existing boat/barge traffic).

To evaluate potential impacts, several mechanisms were considered based on peer-reviewed literature and field investigations. These included potential effects of:

- Vessel waves on bank failure, erosion, suspended sediments, and turbidity that could cause gill abrasion, respiratory stress, feeding and behavioral disturbance, and disease susceptibility in aquatic life;
- Vessel waves on river temperature regimes near the confluence of tributaries along the margins of the mainstem channel;
- Vessel waves on fish displacement and stranding along certain shallow-gradient river banks and gravel bars;
- Tug propeller forces on injury or mortality of fish life stages, river bed scouring, and critical habitat; and
- One or more of the above mechanisms in combination with past, existing, or reasonably foreseeable future impacts from other non-project origins (see cumulative impacts analysis in Chapter 4).

In addition to the above, potential impacts of vessel traffic on subsistence fisheries (net management and riverbank use/access) and the accidental release of transported fuel or chemicals are described in Section 3.21, Subsistence, and 3.24, Spill Risk, respectively.

The spatial and temporal distribution of resident and anadromous fish life stages were considered in this analysis relative to habitat conditions and use along the main navigation channel of the Kuskokwim River. For example, the location and timing of fish use, migrations, and movements were evaluated relative to potential areas of risk, particularly where barge traffic would pass through confined and shallow segments of the river channel and near the confluence of major tributaries (BGC 2013i, 2015m; AMEC 2014). At Nelson Island, near the confluence of the Tuluksak River, the available channel width of the Kuskokwim River would be only 129 feet when the low flow period approaches about 39,000 cfs and when the water depth would be about five feet (see Section 3.5.2.2.3, Surface Water Hydrology, Table 3.5-21).

The relative importance of tributaries for salmonid spawning and rearing also was considered since adults and juveniles are often distributed in these waters where potential effects from tug and barge traffic would be unmeasurable or unnoticeable. Geographically, potential effects of shallow-draft barge traffic on fish and their migrations in the Kuskokwim River primarily would involve certain segments of the main navigation channel between the Port of Bethel in the lower river and the proposed Angyaruaq (Jungjuk) Port site (168 nautical miles upriver).

Vessel Wave Energy

Vessel-generated waves (wakes), drawdown and surge (from water displaced by large vessels in transit), and propeller turbulence (prop wash) create hydraulic forces that can actively alter water quality and other physical, biological, and chemical attributes of the shore zone in lakes, rivers, and coastal ecosystems. In rivers, the extent of channel alteration by such vessel forces is largely influenced by the magnitude of flow, geometry of the channel relative to vessel geometry and draft, and character of the shore zone as defined by river bed substrates, shoreline profile, and in-water and upland vegetation and soils.

The height, speed, and frequency (period) of vessel waves are key parameters that affect the magnitude of erosive forces that encounter a shore zone (Corps 2000a). These parameters are primarily controlled by a vessel's speed, although the vessel's size, distance to shore from its sailing line, and hull design/geometry also are key factors affecting wave height (Gates and Herbich 1977). Hodek et al. (1986) concluded that controlling speed is the most effective way to reduce vessel-caused erosion along shorelines. Shore zones that are seasonally subjected to natural high-energy events including wind, flooding, and ice-out conditions may largely consist of coarse-textured substrates with limited ability to generate additional suspended sediment concentrations when subjected to vessel waves on a periodic but long-term basis (Corps 2000a).

Hydraulic forces generated from vessel waves and propulsion systems in confined and shallow channels can potentially affect the shore zone when vessels pass at relatively high speeds. Other factors that contribute to effects of wave forces on shore zones include the vessel's draft, hull geometry, and propulsion system; the channel's depth and configuration; and composition and character of streambed substrates and other instream structure. A vessel with a hull design/geometry that occupies a large proportion of the channel cross-section will cause wave heights to increase markedly. Frequent, short-term exposure to vessel waves in such areas can result in shore zone erosion and bed scouring, resuspension and transport of sediments, and failure of bluffs and riverbanks (Corps 2000a). According to Mazumder et al. (1993), navigation traffic on large waterways can generate wave energy and turbulence that cause substantial temporary changes in water velocity with the largest changes taking place in a zone that extends about 10 percent of the channel width from shore. An important aspect of a vessel's hull geometry that affects wave generation is the shape and dimensions of the bow and stern. Vessels of comparable bow and stern geometries but with different parallel mid-body lengths produce waves of the same magnitude (Helwig 1966). This suggests that barge tows with similar bow and stern geometry but different lengths should generate waves of a similar magnitude that would be subsequently altered by the character of the shore zone.

Sediments in river systems remain suspended in the water column in the case of fine-textured particles (i.e., suspended sediment) or, because of their larger size, settle out and become deposited along the river bed and banks. Settled sediments become temporarily resuspended and transported downriver when flow conditions mobilize medium to fine-textured materials along mid-channel and point bars and in backwater areas. The quantity and distribution of in-channel sediment sources that provide habitat for fish and other aquatic biota are strongly influenced by hydrologic forces that shape the character and stability of the riverbed and banks. Typical non-channel sources of sediments that may be transported to rivers include upland soils mobilized by runoff, bank failures and landslides, and development activities that cause shoreline disturbance.

On the Kuskokwim River, key factors affecting bank erosion and channel scour are natural flooding caused by spring breakup and intense precipitation during the open-water season. Compared to flooding, wave energy from wind or vessel traffic has less influence on river erosion rates largely due to the width of the river in most areas (BGC 2007c, 2013i). Most of the existing vessel traffic along the Kuskokwim River involves small, high-speed boats that often travel closer to shore than more infrequent, slower, and larger tug and barge combinations. Waves from small-boat traffic traveling close to shore have been observed to result in larger and more frequent waves along the shoreline than barge traffic (Camfield et al. 1980). This suggests that, at certain times and locations, small-boat traffic may create conditions that contribute to bank erosion more than large-vessel traffic.

Although barge-induced bank erosion could increase bank erosion above natural erosion rates, a study of the wave height and energy generated from barge traffic (BGC 2007c, 2015m, 2017g) indicates that the increase due to project barge traffic is likely to be small. Potential maximum wave heights from barge traffic were calculated using both the PIANC (1987) and Sorenson and Weggel (1984) equations (BGC 2015m and 2017g, Styles and Gailani 2016). Wave heights during upstream travel were calculated to be between 0.04 and 0.21 feet, and downstream travel wave heights were calculated to be between 0.29 and 0.67 feet (see Section 3.5 for details) due to increased barge speed. These wave heights were calculated with a distance to shore that ranged from 656 feet (Kwethluk) to 2,297 feet (Tulukskak). As a percentage of river tractive energy, which is the total power dissipated by the full wetted perimeter of the cross-section, barge-generated wave energy would vary between 3 and 10 percent. The greater the river energy (such as during higher water levels), the relative contribution of barge-generated wave energy reduces (Styles and Gailani 2016). Furthermore, the primary cause of bank erosion along the lower Kuskokwim River is related to the natural removal (from lateral dissipation of energy and ice-related impacts during breakup) of loose material at the base of the bank, making the bank more susceptible to mechanical erosion and thermoerosional niching associated with high water levels. Additionally, ice jams and moving ice floes during spring break-up is a significant cause of erosion of riverbed and banks.

Additional analysis was conducted to predict wave heights with a much closer distance to shore of 246 feet, with barges travelling under both maximum speed (conservative) and at 50% speed (BGC 2017g). For this scenario, the total barge-generated wave energy per season used was 3.3% of the total river tractive energy, a conservative percentage that assumes barges are empty and travelling at maximum speed (barges are more likely to slow down to navigate meander bends). Under maximum speed and upriver travel, wave heights were calculated to be between 0.06 and 0.28 feet, and for downriver travel, wave heights were calculated to be between 0.61 and 0.80 feet. Under 50% speed and upriver travel, wave heights were calculated to be between 0.00 and 0.05 feet, and for downriver travel, wave heights were calculated to be between 0.00 and 0.01 feet.

Wave-generated hydraulic forces from small boats and barge traffic traveling near the margins of the Kuskokwim River where high levels of fine-texture sediment have not been previously disturbed by natural flooding and ice-out conditions could cause riverbank erosion that reduces water quality by elevating suspended sediment concentrations and turbidity. The anticipated intensity of such impacts along the margins of the mainstem channel could vary, depending on such factors as speed of vessel transit and proximity to shore, width of the river, channel geometry, and the availability of fine-textured substrates that could be mobilized. Changes in the character or quantity of aquatic may be noticeable depending on the above factors.

Water quality degradation from increased levels of suspended sediment and turbidity has been shown to adversely affect the survival and growth of early life stages of fish and other aquatic life in rivers and streams (Barrett et al. 1992). This may be caused by impairing the ability of fish to capture prey and/or avoid predation along migration corridors or nursery areas. Reduced feeding efficiency and avoidance behavior have been documented by exposing juvenile coho salmon, accustomed to relatively clear waters, to elevated levels of turbidity exceeding 70 nephelometric turbidity units (NTU), well below sublethal stress levels (Bisson and Bilby 1982). Juvenile salmon and other prey species accustomed to waters with low turbidity have been shown to avoid areas with unacceptably high levels of turbidity (Servizi 1988). In contrast, fish have been shown to seek out waters having moderate levels of turbidity (10 to 80 NTU) that can provide visual protection and cover from predators (Cyrus and Blaber 1987a, 1987b). Although a reduced preference by adult salmon homing to spawning areas has been demonstrated where turbidities exceed 30 NTU (20 mg/L suspended sediments), Chinook salmon exposed to 650 mg/L of suspended volcanic ash have been able to locate their natal waters (Whitman et al. 1982).

Fish and benthic macroinvertebrates are generally tolerant of suspended sediments and turbidity up to the point of reaching relatively high levels that can cause abrasive injuries, clog gill tissues, impede respiratory functions, and cause mortalities to incubating eggs and larvae and benthic food sources (Robertson-Bryan, Inc. 2006). Pacific salmon and trout fingerlings exposed to suspended solids levels of 300-750 mg/L have been documented to survive 3-4 weeks even with short daily increases to 2,300-6,500 mg/L (Griffin 1938). Based on a literature review by Van Oosten (1945), average suspended solids concentrations of up to 200 mg/L were found to be tolerable to fish which were shown to thrive in waters with total suspended solids levels over 400 mg/L. While conducting surveys of rearing fish on the Kuskokwim River in July 2014, turbidities at Kalskag, BTC, and Holukuk were determined to average 84, 101, and 150 NTU, respectively (Owl Ridge 2014f). These and other studies suggest that effects of suspended sediments and turbidity on a given species of fish can vary widely, depending upon the texture of sediments and the intensity of exposure (Robertson-Bryan, Inc. 2006).

Potential effects of barge-generated waves, riverbank erosion, and turbidity on the quality of shallow-gradient nearshore nursery habitats used by larval and juvenile life phases of resident fish, seaward migrating salmon, and invertebrate prey species would depend on the location, intensity, frequency, and extent of wave exposure along margins of the river that are subject to erosion. Juvenile salmon in the Kuskokwim drainage predominantly rear in tributaries and, therefore, would largely be unaffected by turbidity generated from barge traffic until they travel downstream into mainstem river channel where they rear while migrating to sea.

Based on the level of riverbank erosion that occurs in the mainstem Kuskokwim River from natural flooding and ice-out conditions and considering naturally high background levels of turbidity that exist, the intensity of nearshore erosion and turbidity that could be attributed to vessel passages along the navigation route could range from unmeasurable to noticeable in response to intermittent episodes of small waves. The duration of impacts would extend from Construction through the Operations Phases. The extent or scope of potential wave exposure would be mostly limited to confined channel segments between the lower Kuskokwim River and the upriver port site. The context of such impacts would affect the river's mainstem, which is regulated as EFH.

Water temperature in the Kuskokwim River was evaluated relative to potential impacts from barge traffic in a study by Ottertail (2012e). Results of the study concluded that mixing of water by vessel passages does not cause notable changes in the water temperature profile in the main channel which was found to be generally well mixed and unstratified. While small changes in water temperature were observed before and after vessel passage, the differences were within the range of natural temperature variation measured in the water column. These findings are consistent with Wetzel (2001) who reports that thermal stratification is typically uncommon in river systems where water is constantly mixing.

Although not evaluated by Ottertail (2012e), tributary confluences or side channels with a different thermal character than the main river channel could contribute to localized variability in water temperature. During certain times of the year, shallow, shore zone margins and backwater areas that may be influenced by groundwater upwelling may be occupied by juvenile fish as they seek waters with low velocity and higher dissolved oxygen for feeding, refuge, or migration (Winkler et al. 1997; Keckeis et al. 1997). Water temperature in such areas, combined with prey availability and abundance, can determine the growth potential and mortality rates of juvenile chum salmon (Mason 1974; Healey 1982a; Salo 1991). Depending on the character and location of such areas relative to the Kuskokwim River navigation channel, vessel passages could generate wakes and turbulence sufficient to temporarily alter the local water temperature regime, particularly near tributary confluences or backwater areas during the June to September barge season.

Monitoring nearshore water temperature during barge passages in confined channel segments and near tributary confluences would provide an improved basis for determining whether local water temperature regimes in certain shore zone areas would be substantially altered whereby refuge or rearing functions for outmigrant salmon juveniles and other resident fishes would become degraded. These changes in the character or quantity of aquatic habitat are uncertain at this time but likely may not be measurable or noticeable. The duration of these changes would persist for the life of the project. The extent or scope of potential impacts would be limited to certain nearshore waters of confined river segments or downstream from tributary confluences between the lower Kuskokwim River and the upriver port site. The context of such impacts would affect the mainstem and its tributaries regulated as EFH since they provide conditions that support key life stages of five species of Pacific salmon.

Fish Displacement and Stranding

Studies involving the Lower Columbia, Mississippi, and other large rivers suggest that, under certain conditions, ship wakes produced by deep-draft vessels can displace and sometimes strand fish along shorelines (Pearson et al. 2006; Entrix 2008; FERC 2008; Corps 2000a; Kucera-Hirzinger et al. 2009; Ackerman 2002). Although not evaluated in association with smaller, shallow-draft vessels such as barge tows, fish stranding from passages of deep-draft vessels has been generally observed along shallow, low-gradient shorelines where young-of-year fish are swept to shore onto exposed beaches or shallow pools isolated from the main channel. The susceptibility of young-of-year fishes has been shown to be related to their inability to swim against strong currents, including those from wakes of deep-draft vessels (Wolter and Arlinghaus 2003). Stranding can result in mortality unless the fish are swept back into the water by a subsequent wake. Pearson et al. (2006) noted that fish stranding strictly occurred during nighttime vessel passages and that no stranding occurred at the same locations during daytime passages.

Fish stranding has been shown to be associated with a series of interconnected factors that are not fully understood (Pearson et al. 2006; FERC 2008). As a result, it is not possible to accurately predict whether a vessel of a particular size and hull configuration, traveling at a given speed, water depth, and distance from shore, through a channel of a certain width and geometry would cause fish stranding. Vessel speed of travel, however, is considered the key factor controlling the height of a wave produced from a passing ship while distance to shore from the sailing line and hull design also are important (Gates and Herbich 1977).

Young-of-year and older juvenile riverine fishes occupying shorelines can be subject to displacement from vessel-generated hydraulic forces (Kucera-Hirzinger et al. 2009; Wolter et al. 2004; Winkler et al. 1997; Keckeis et al. 1997). Such forces can be caused by drawdown and surge (from displacement of water by a vessel in transit), vessel wakes, and propeller turbulence. These forces can combine to increase water velocities to a level along the shoreline that may cause small-size, fish to be displaced to deeper waters or washed ashore (Arlinghaus et al. 2002; Hucksdorf et al. 2011). Pearson et al. (2006) found that only small, young-of-year Chinook fry were stranded by waves from deep-draft vessels on the lower Columbia River while larger and stronger age 1+ fish (with greater swimming ability) appeared capable of withstanding the stronger currents and were not stranded. Chronic, intermittent exposure of young-of-year fish to increased velocities and displacement, even at relatively moderate levels, has been found to adversely affect growth and increase physiological stress which may contribute to the decline of certain fish stocks (Kucera-Hirzinger et al. 2009; Flore et al. 2001). Although passing barge traffic could cause nearshore rearing fish to be subject to long-term chronic exposure to intermittent episodes of increased velocities from vessel wakes and propeller forces, recent Kuskokwim River studies have shown that juvenile salmon rearing primarily occurs in backwater areas and tributaries unaffected by barge traffic until these fish enter the main channel for seaward migration (Owl Ridge 2015b).

In 2010, a study was conducted on the Kuskokwim River to assess potential stranding mortalities of seaward migrating salmon smolts as a result of waves from local barge traffic (Ottertail 2010). Shorelines were monitored at select gravel bars in the lower Kuskokwim River.

Although the selected survey sites were known to be occupied by juvenile fish and subject to wave forces, they were not located in the more confined segments of the river above Aniak. In addition, the monitored shorelines were known to be periodically occupied by migrating smolts that travel near the water surface. Although the waters evaluated were subject to frequent waves from barge traffic, no evidence of fish stranding or mortality was observed. Results of the study showed that wakes, generated by the particular tug-barge configurations that were in transit during the study were less than 1.5 inches in height along the gravel bars surveyed. This suggests that comparably powered and configured upriver-bound barge tows with similar drafts, traveling at similar speeds and distances from gravel bars having a similar character and orientation, could generate wakes of a relatively low intensity that result in no or minimal risks to salmon smolt stranding. Larger barge tow configurations powered by tugs with a higher horsepower rating, deeper drafts, and traveling downriver at higher speeds, however, may generate wakes of magnitudes that could pose risks to juvenile salmon along river margins in certain areas.

As previously described, waves from unloaded barge tows returning downriver from the Angyaruaq (Jungjuk) Port site traveling at absolute speeds of up to 14.1 feet per second (fps, 8.4 knots or 9.6 mph) were calculated to be between 0.61 and 0.80 feet when the barge distance to shore is 246 feet, and between 0.04 and 0.21 feet when the distance to shore ranges from 656 to 2,297 feet (BGC 2017g). Wave heights of this magnitude that extend to the shore zone, particularly in confined channel segments with shallow-gradient shorelines, could produce currents capable of temporarily displacing small young-of-year salmon or small resident fishes rearing or migrating along the shore zone. In particular, chum and pink salmon begin their downriver migrations to estuaries at a small size and remain longer in brackish waters than other salmon species such as Chinook and coho salmon (Healey 1982b; Simenstad et al. 1982; Fukuwaka and Suzuki 2002). Their relative small size, limited swimming ability, and longer residence along river and estuarine shorelines during their seaward migration tend to make young-of-year chum and pink salmon vulnerable to wave forces, especially in critical river sections with confined channels and shallow nearshore waters. Five such critical sections of the Kuskokwim River have been identified where available channel widths would range from 129 to 576 feet, when average daily flows approach 39,000 cfs with minimum channel depths of five feet (AMEC 2014). Progressing upriver, these sections were located at Nelson Island (near the confluence of the Tuluksak River), BTC, Aniak, Holokuk, and Upper Oskawalik.

Between May 15 to June 1 and June 19 to 22, 2015, surveys were conducted at relatively confined channel segments of the Kuskokwim River near BTC and above Upper Kalskag to assess the timing and distribution of juvenile salmon during their seaward spring migrations. The survey sampled river habitats with seines (effort: 336 seine passes / 48,738 linear m / 1,297,792 m^3 of water). The catch, which was highest in mid-May through June 1 and decreased considerably by the third week of June, consisted of 21,752 small chum salmon, 428 coho, 196 sockeye, 81 pink, and 45 Chinook salmon. Most fish were collected along river margins consisting of shallow shoals and backwaters within a few feet of shore (Owl Ridge 2015b). While barge wakes were not present during the survey, fish that were collected occupied shallow waters that could be subject to wave forces from passing vessels. Sixty-eight percent of chum salmon smolt were captured in areas deemed susceptible to barge wake and 32 percent in areas not susceptible to barge wake. Furthermore, 39.5 percent of the chum smolt measured at potential barge wake areas were large enough to avoid stranding (>40 mm). Based on the length of the young-of-year salmon captured and the locations and patterns of habitat use observed, barge-wakes of sufficient magnitude could have displaced or possibly stranded young-of-year salmon, particularly those observed along shorelines with low-gradient shoal habitat. However, barge wakes of sufficient magnitude to cause stranding (>1 foot) are not expected. Depending on the location and channel configuration where barge wakes or tugs could encounter abundant distributions of juvenile salmon along river margins between ice break-up into late June, potential incidents of stranding or displacement could occur. These changes due to project activity may not be noticeable and fish populations would remain in the vicinity. Along confined channel segments, noticeable changes in behavior of fish may affect reproduction, feeding, or survival of individuals. The timing of such impacts would be seasonal and intermittent and would extend over the Construction and Operations Phases. The extent or scope of such impacts would occur along certain reaches of the river. The context would involve the mainstem Kuskokwim River that is regulated as EFH.

In late May of 2014, a survey of rainbow smelt migration and spawning was conducted where smelt were observed along the river margins in large concentrations within 20 feet of shore. Spawning was determined to occur in waters at a mean depth of 8.5 feet (range 5 to 10 feet) upstream from upper Kalskag (Owl Ridge 2014a). In similar studies conducted in 2015 and 2016, rainbow smelt also were observed migrating along shorelines where they spawned in late and mid-May, respectively. Unlike the 2014 survey, spawning in 2015 occurred at locations downriver from lower Kalskag in a narrower river segment and at a deeper mean depth of 14.5 feet with a range of 8.7 to 23.4 feet. In 2016, spawning occurred farther upriver ranging from below Lower Kalskag to Upper Kalskag and closer to 2014 spawning areas (Owl Ridge 2015a; 2016). Since adult rainbow smelt reach lengths of up to 12 inches, their swimming ability at this size would be sufficient to prevent them from being displaced or washed ashore by wake forces from barge traffic. Wake forces along shorelines that would be of sufficient magnitude to temporarily affect the success of the rainbow smelt subsistence fishery, which extends for less than a week between Bethel and Upper Kalskag, are not anticipated.

Between July and September 2014, studies were conducted along the mainstem Kuskokwim River and select tributaries to assess the distribution and use of shallow, nearshore habitats by rearing juvenile salmon and other resident fish species. The study was initiated after the spring seaward migration of juvenile salmon to assess the presence and potential vulnerability of fish to wave forces from barge traffic during summer periods (Owl Ridge 2014b). While high densities of Chinook and coho salmon (and to a lesser extent sockeye and pink salmon) were collected in the Holokuk and Aniak rivers (two of the main tributaries of the Kuskokwim River), few juvenile salmon were collected along the shoreline in the Kuskokwim River mainstem near the mouth of the Holokuk River, near Upper Kalskag, or at BTC. Instead, nearly 13,000 longnose sucker, about 600 each of arctic grayling and slimy sculpin, and about 50 each of broad whitefish and round whitefish were collected. Of the fish collected in the mainstem, catch per unit effort was higher from deeper-water habitats (sampled by a 20m long seine) compared to shallower areas closer to shore (sampled by a 9m long seine). This suggests that from July to early September, following the seaward migration period of salmon, juvenile salmon may rely more on rearing habitats in tributaries where they would not be subjected to potential wakes from barge traffic along the margins of the mainstem Kuskokwim River.

Regarding the potential displacement of spawning adult salmon in the main channel of the Kuskokwim River by barge traffic, such changes may not be noticeable and fish populations would remain in the vicinity since most spawning occurs in tributaries outside the main channel. An exception to this involves chum salmon that have been reported to spawn along freshwater tributary plumes near shore on the south side of the river near the seawall in Aniak (Cannon 2013). Based on the run timing shown in Table 3.13-10, the June through early September barge season would overlap the peak upriver spawning runs that extend from mid-June through August for the five species of salmon in the Kuskokwim River. The intensity of potential impacts from barge traffic on migrating adult salmon are expected to be unnoticeable since adult salmon have sufficient swimming and sensory ability that would generally allow them to sense and avoid approaching tug propeller flow fields as vessel traffic is encountered (Robertis and Handegard 2013; Xie et al. 2008). High levels of turbidity, which are customary in the Kuskokwim River, would tend to reduce visibility and, in theory, could compromise fish avoidance of tug propellers or their flow fields.

In summary, displacement and/or stranding of small young-of-year and possibly juvenile anadromous fishes may occur from ice breakup to late June during their out-migration, particularly in confined channel segments. Potential risks have been identified where shallow gradient shorelines are exposed to wave forces from downriver-bound barge traffic traveling in narrow channel segments at speeds of 14 fps (over 8 knots or 9 mph) and where wakes between 0.61 and 0.80 feet in height could extend to shore. Potential risks to seaward bound salmon migrations would be greatest each year from ice breakup to late June over the life of the project. Changes in behavior of fish would likely be unnoticeable and populations would remain in the vicinity. No noticeable incidents of injury or mortality to individual fish would likely occur. However, these changes may be intensified based on the character of confined channel segments with shallow-gradient shorelines; the location, timing, and density of schools of small, young-of-year outmigrant salmon encountered by barge traffic; and the frequency of barge-generated wakes up to 0.80 feet in height that reach the shore zone of these areas. Under intensified conditions, impacts of fish displacement and/or stranding from downriver barge traffic traveling at speeds over 8 knots (about 9 mph) would cause noticeable changes in the behavior of fish that may affect reproduction, feeding, or survival of individuals. In cases of injury or mortality, incidents to individual fish would be detectable but populations would remain within normal variation. The extent or scope of impacts would be limited to the vicinity of the project footprint and the affected watershed. Such impacts would affect the Kuskokwim mainstem and its tributaries regulated as EFH that play a role in the Kuskokwim subsistence community.

Prop Wash, Bed Scour, and Fish Injury/Mortality

Prop Wash and Bed Scour

Propellers of tugs and other vessels produce jets of water and hydraulic forces (prop wash) that diffuse through the water column which, if reaching the bottom of a river, can scour sediments along the riverbed and cause displacement and mortality of fish or other aquatic life (Verhey 1983, Holland 1986, Mazumber et al. 1993, Maynord 2000, Gutreuter et al. 2003, Corps 2005, Corps 2006c; Killgore et al. 2005, Killgore et al. 2011, Anchor QEA LLC 2009; CH2M Hill 2011e; Hayes et al. 2012). The bed and shore zone of a river can be subjected to scouring from excessive water velocities extending from the flow field of a propeller jet, particularly if the channel is shallow or the bank is close to a vessel's line of travel (see Section 3.5, Surface Water Hydrology, for additional analysis related to propeller scour).

The magnitude of shoreline erosion, bank failure, and bed scour that may be caused by prop wash from tugs, or other vessels, is controlled by several factors including propeller size and number, engine horsepower, propeller depth and orientation in the water, vessel speed, under keel water depth, distance to shore, and character of affected soils and bed substrates (CH2M Hill 2011e). Large changes in velocities and energy scour can occur in a zone within 10 percent of the channel width from shore as a result of the water turbulence from a vessel in transit (Mazumber et al. 1993). Turbulence can increase suspended sediment concentrations and turbidity, alter water quality, and affect ecological and physiological processes of biota at both the population and individual level. In riverine systems where naturally occurring turbidity and sediment do not exist at high levels, prop wash also can affect the distribution and productivity of benthos, aquatic plants, and fish and can impact the transport and dispersal of eggs and larval life stages of fish (Corps 2000a).

The ratio of water depth to a vessel's draft was determined to be the predominant factor affecting the movement of sediments by prop wash; little movement of sediment occurs when the ratio of water depth to vessel draft was greater than two (Liou and Herbich 1976, 1977). This implies that for a vessel with a three-foot draft, a six-foot water depth should result in minimal disturbance to the riverbed, depending on the substrate character. For the proposed project, a three-foot minimum operating draft was assumed for tugs and upriver bound cargo and fuel barges during low-water / shallow passage conditions. This included allowance for vessel squat or the additional draft caused by a vessel in motion. For downriver bound traffic, the draft for cargo and fuel barges was assumed to be 2.3 feet and 1.4 feet, respectively, although heavier loads may result in deeper drafts during periods of higher flows depending on river stage and water depth. When the river stage and depth increases during periods of high flow, the maximum operating draft of cargo and fuel barges was assumed to increase to 7.5 feet (AMEC 2014). To minimize potential impacts of bed scour, barge traffic would be tracked using GPS and real-time river stage and depth monitoring systems to ensure vessel passages are conducted through the deeper portions of the channel, especially in confined and shallow segments of the river.

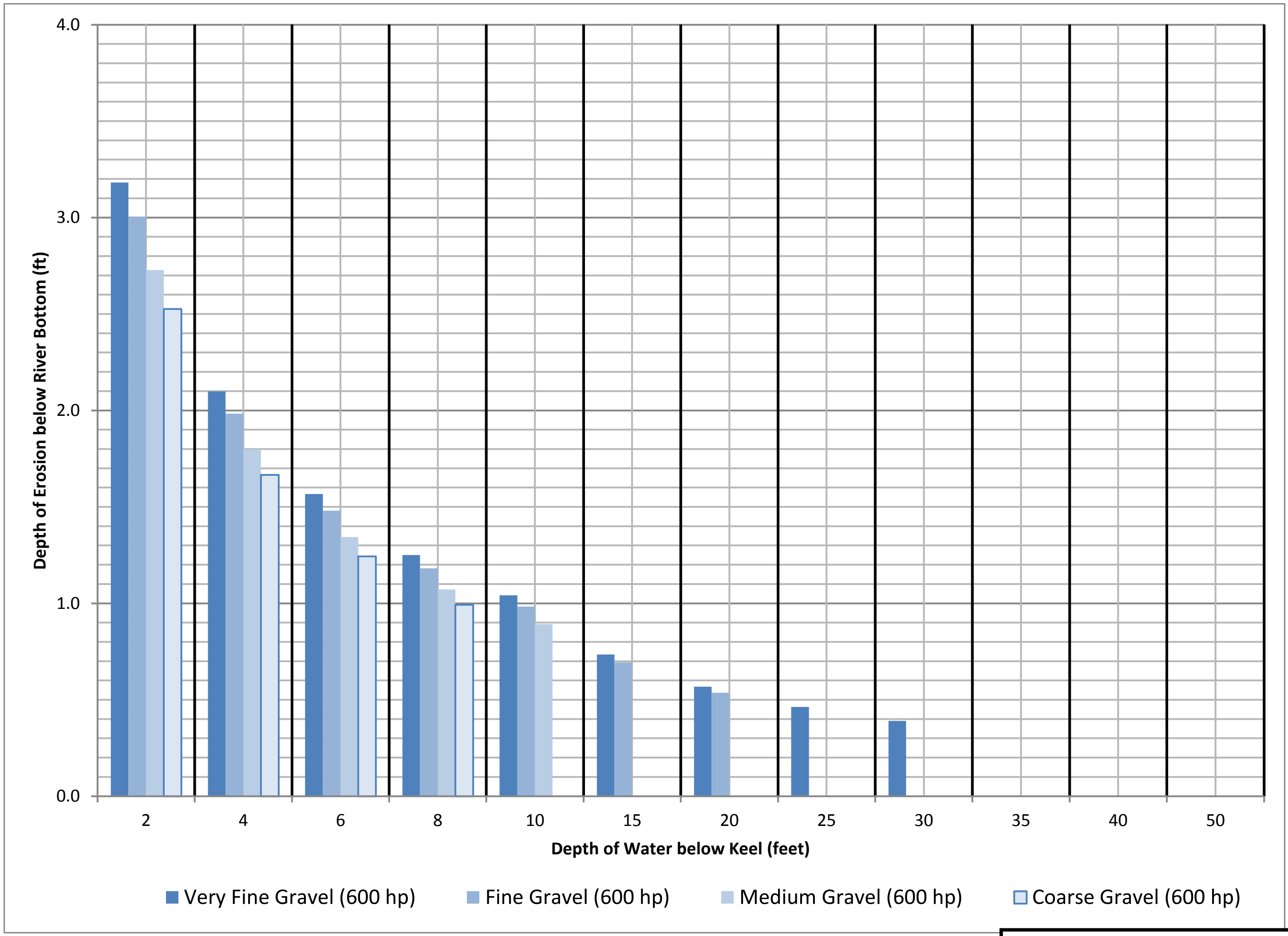
To evaluate the intensity and extent of bed scour that could result from the proposed project, an empirical model (Maynord 2000) was used to predict water velocities and related sediment scour along the bottom of a theoretical river channel based on variable under keel water depths and engine power ratings of 150 to 600 horsepower (hp) (AECOM 2015d). Calculations indicated that propeller forces from a tug with a 600 hp engine (most conservative case) moving slowly through shallow water with under keel water depths of two and six feet would generate bottom velocities of 11.9 and 3.5 fps, respectively. Velocities of this magnitude would be sufficient to scour large cobbles and coarse gravel greater in size than the materials measured at sampling stations in confined sections of the Kuskokwim River. Based on under keel water depths of 10 feet (13 feet total depth assuming a three foot vessel draft) or deeper, the model predicted that bottom velocities along the propeller flow path would be imperceptible and the depth of scour of medium to coarse gravel would be eliminated or substantially reduced depending on the horsepower rating of the tug (Figures 3.13-4 to 3.13-7).

Figure 3.13-4 presents a schematic view of a theoretical tug (propelled by a 600 hp engine) with a four-barge tow traveling in water with an under keel clearance of three feet. The area behind the tug that would correspond to the propeller flow field along the riverbed is shown by colors representing a gradient of velocities. As shown in the figure, velocities would range from up to 3.4 fps (yellow) for about the first 100 feet from the stern of the tug to less than one fps at about 250 feet from the stern. The horizontal extent of the flow field would closely approximate the 88-foot width of the two-by-four-barge tow. Wider and possibly deeper zones of scour would be expected where tugs are stationary or slowly maneuvering as when barges are being brought to berthing stations at the port site or when staging at confined channels to modify barge configurations.

As previously mentioned, the 2014 rainbow smelt survey determined that spawning occurred in late May upriver of Upper Kalskag at a mean depth of 8.5 feet along the sides of the mainstem channel. Spawning occurred at a similar time in 2015 but at locations downriver from Lower Kalskag in a narrower river segment at a mean depth of 14.5 feet. In 2016, spawning occurred during mid-May from just below Lower Kalskag to Upper Kalskag near 2014 spawning areas (Owl Ridge 2014a; 2015a; 2016). Depending on water depths and locations where rainbow smelt spawning occurs during the Construction and Operations Phases, hydraulic forces from propellers of passing tugs could scour substrates and dislodge or displace incubating eggs resulting in injuries or mortalities. Eggs spawned in mid- to late-May typically would incubate for about 21 days before larvae drift downstream to the estuary. The timing for this, however, depends on water temperatures during this period which may vary from year to year. Incubating eggs, therefore, could be at risk of potential displacement, injury, or mortality from barge traffic from about mid-May to mid-June.

Impacts from prop wash could be reduced if barge traffic between mid-May to mid-June travels along the deepest portions of the channel in reaches where rainbow smelt spawning has been previously documented. Disturbance to substrates (and incubating eggs) would be minimized if barges travel along depth contours that would allow the tug to maintain a gross under keel clearance greater than 15 to 20 feet. During the 2015 rainbow smelt spawning survey, spawning occurred as shallow as 8.7 feet along a relatively confined channel segment. The propeller scour of passing tug traffic in such locations could have resulted in detectable incidents of injury or mortality to incubating fish eggs or population-level effects depending on the tug's horsepower rating and engine speed. Because of the relatively shallow depth across this particular channel segment, it is unlikely that impacts to incubating rainbow smelt eggs could have been avoided by altering the line of travel of barge traffic. Similar impacts to other resident fish species that might spawn in shallow segments of the mainstem channel also would be at risk.

Based on this analysis, prop wash from a tug in passage is expected to cause noticeable and possibly acute or obvious scouring to gravel-size riverbed substrates at localized areas along the navigation route, particularly in waters with an under keel depth shallower than approximately eight to 10 feet. Such impacts would extend from the Construction through Operations Phases. Over time, the natural sediment load in the river would tend to refill the scoured substrates to an undetermined extent. While the zone of turbulence from tug propellers could extend laterally about as wide as two parallel barges in tow (about 88 feet), the width and depth of scour along the riverbed could vary, especially where tugs are stationary, maneuvering, or traveling through shallow waters. Scouring could displace, injure, or cause mortalities to eggs of anadromous rainbow smelt. Adult rainbow smelt have importance to subsistence fisheries between Bethel and Upper Kalskag and are a key forage fish species to predatory finfish in the Kuskokwim River system.



DONLIN GOLD
PROJECT EIS

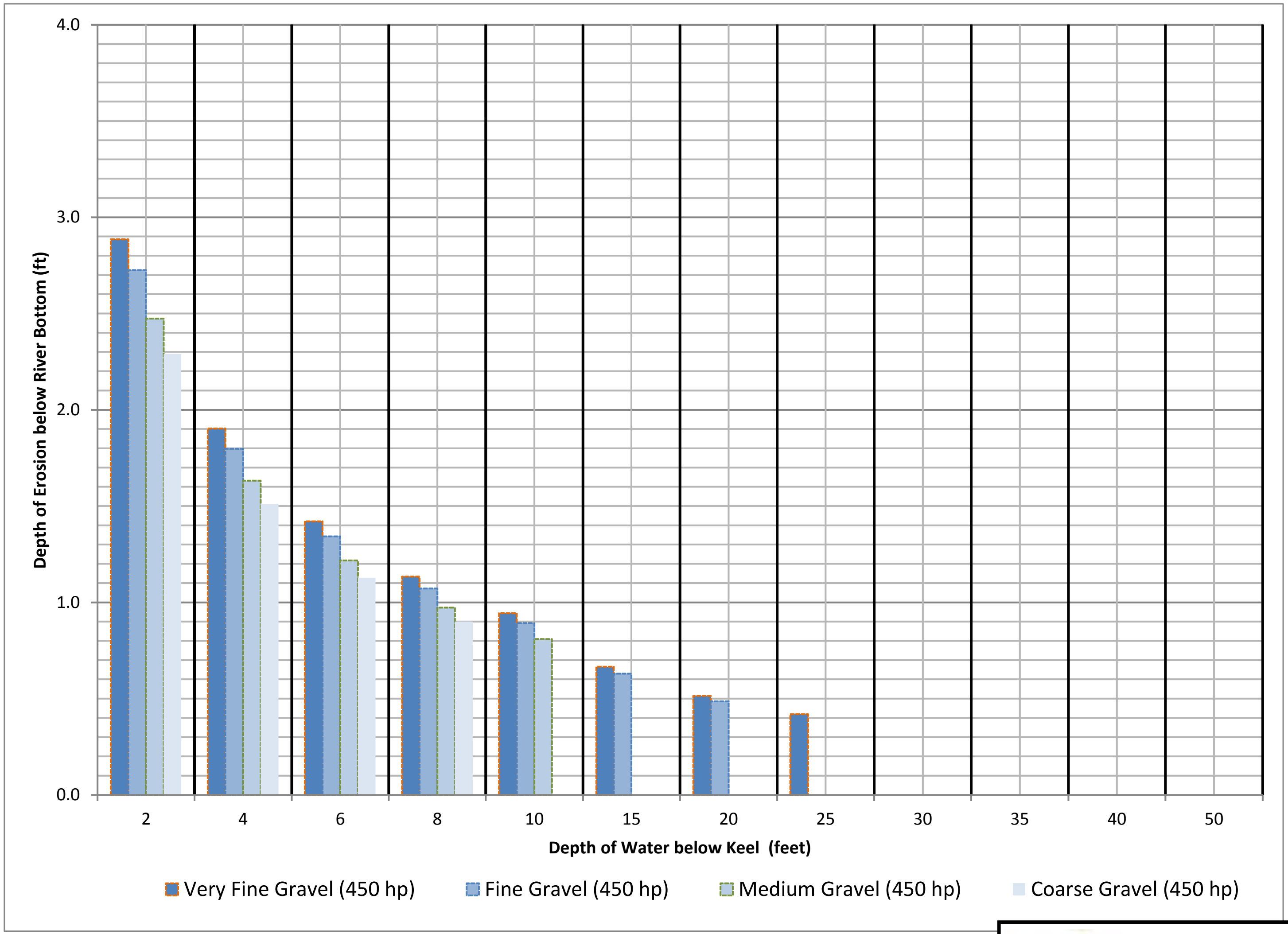
ESTIMATED SCOUR DEPTH BY GRAIN SIZE AND WATER DEPTH FOR A 600 HP TUG

JUNE 2017

FIGURE 3.13-4

Notes:
1. Results are based on Hong et al. (2012) and represent scour under a stationary tow after 1 minute. This provides a conservative estimate of scour since scour under a moving tow would be less and would be spread over a large distance due to the movement of the tow. For example a tow moving at 5 mph would move about 400 feet in 1 minute.
2. A typical upriver tow with a full barge load would be powered by a 450 hp tug operating at 75% of maximum throttle (Fernandez 2014d).

Assumptions:
Diameter of propeller - 40 inches
Distance from keel to propeller centerline - 22 inches
Minimum draft - 3 feet
Ducted propeller



DONLIN GOLD PROJECT EIS

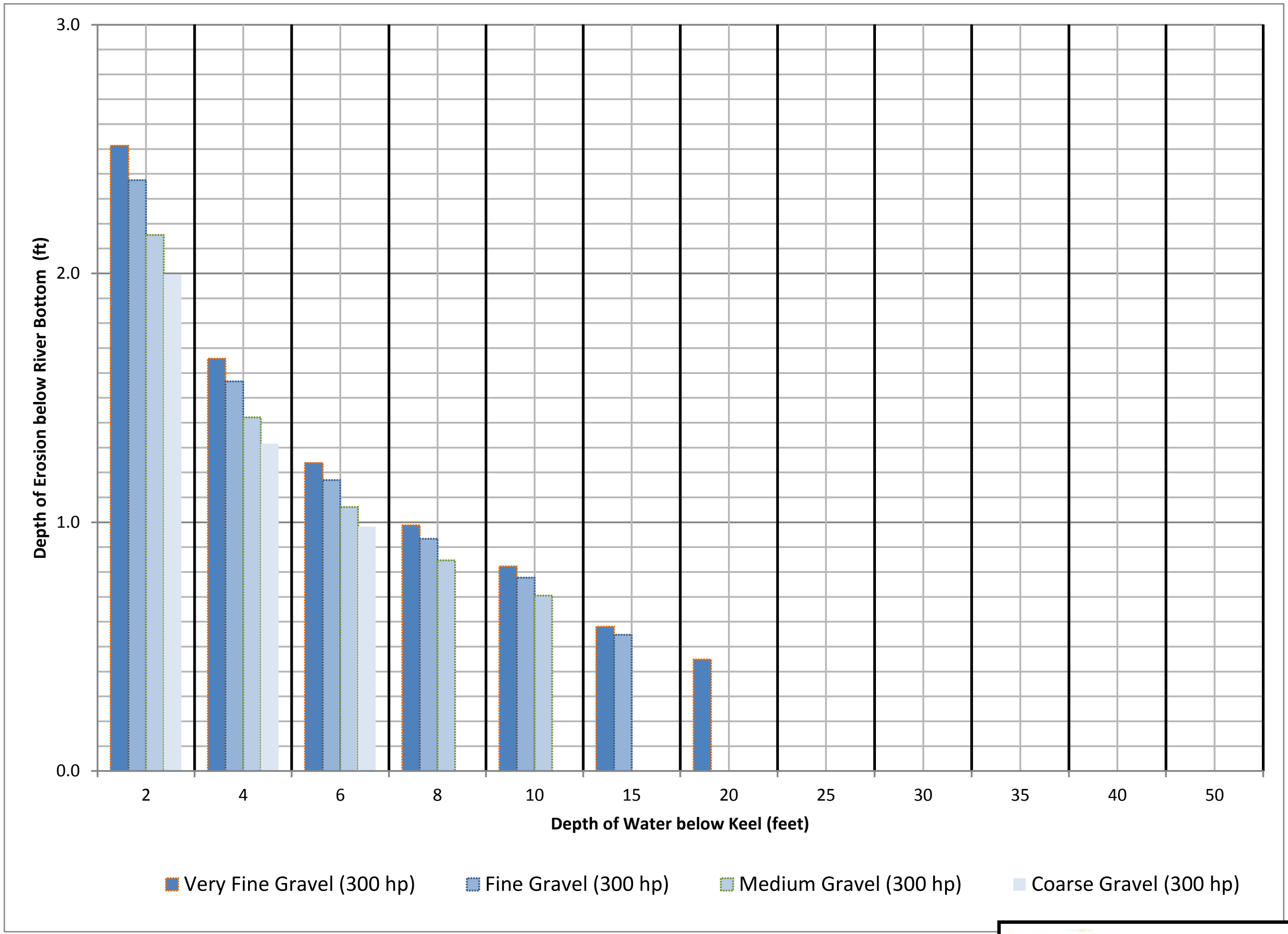
ESTIMATED SCOUR DEPTH BY GRAIN SIZE AND WATER DEPTH FOR A 450 HP TUG

JUNE 2017

FIGURE 3.13-5

Notes:
1. Results are based on Hong et al. (2012) and represent scour under a stationary tow after 1 minute. This provides a conservative estimate of scour since scour under a moving tow would be less and would be spread over a large distance due to the movement of the tow. For example a tow moving at 5 mph would move about 400 feet in 1 minute.
2. A typical upriver tow with a full barge load would be powered by a 450 hp tug operating at 75% of maximum throttle (Fernandez 2014d).

Assumptions:
Diameter of propeller - 40 inches
Distance from keel to propeller centerline - 22 inches
Minimum draft - 3 feet
Ducted propeller



Notes:
1. Results are based on Hong et al. (2012) and represent scour under a stationary tow after 1 minute. This provides a conservative estimate of scour since scour under a moving tow would be less and would be spread over a large distance due to the movement of the tow. For example a tow moving at 5 mph would move about 400 feet in 1 minute.
2. A typical upriver tow with a full barge load would be powered by a 450 hp tug operating at 75% of maximum throttle (Fernandez 2014d).

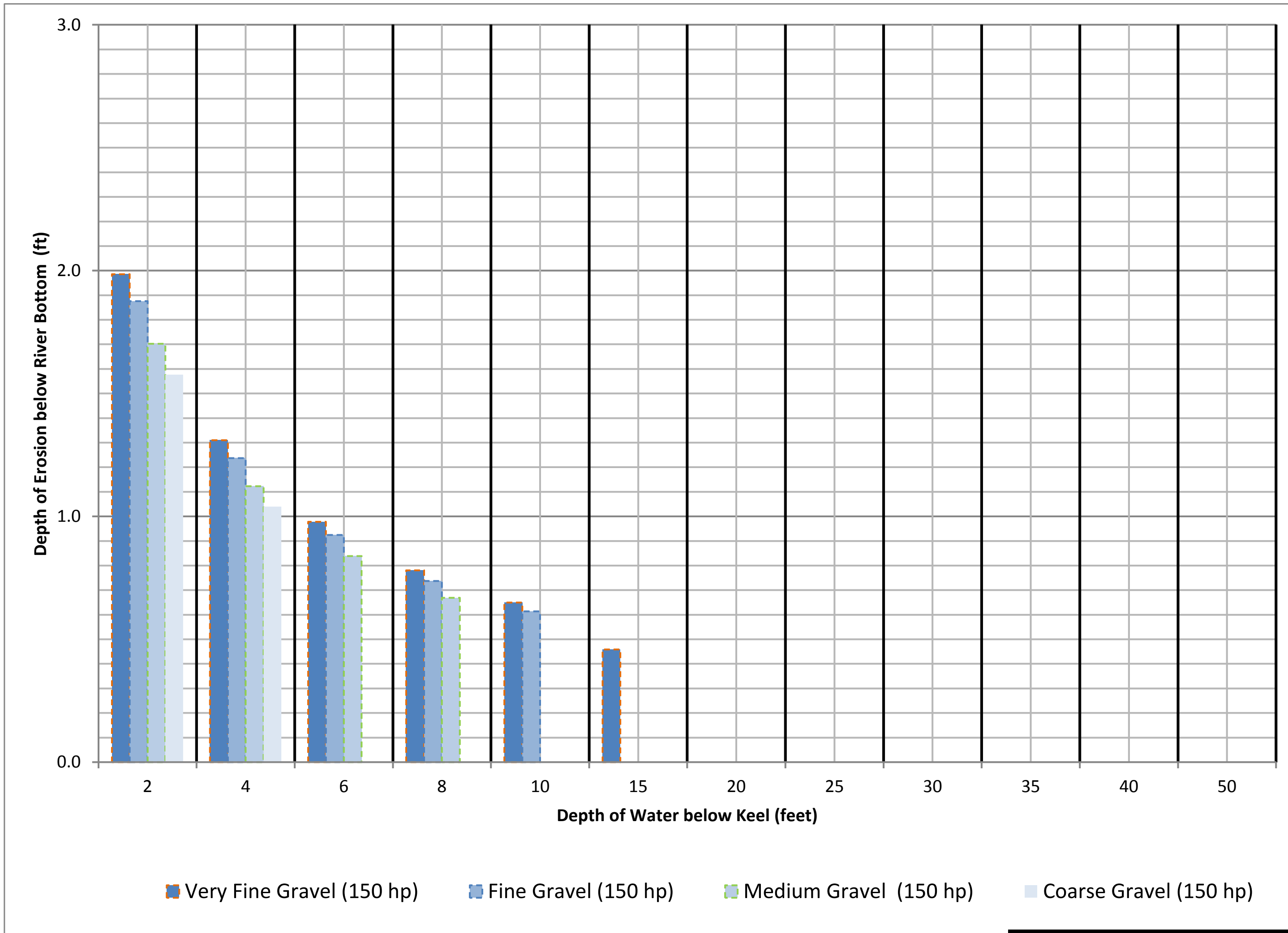
Assumptions:
Diameter of propeller - 40 inches
Distance from keel to propeller centerline - 22 inches
Minimum draft - 3 feet
Ducted propeller

DONLIN GOLD PROJECT EIS

ESTIMATED SCOUR DEPTH BY GRAIN SIZE AND WATER DEPTH FOR A 300 HP TUG

JUNE 2017

FIGURE 3.13-6



Notes:
1. Results are based on Hong et al. (2012) and represent scour under a stationary tow after 1 minute. This provides a conservative estimate of scour since scour under a moving tow would be less and would be spread over a large distance due to the movement of the tow. For example a tow moving at 5 mph would move about 400 feet in 1 minute.
2. A typical upriver tow with a full barge load would be powered by a 450 hp tug operating at 75% of maximum throttle (Fernandez 2014d).

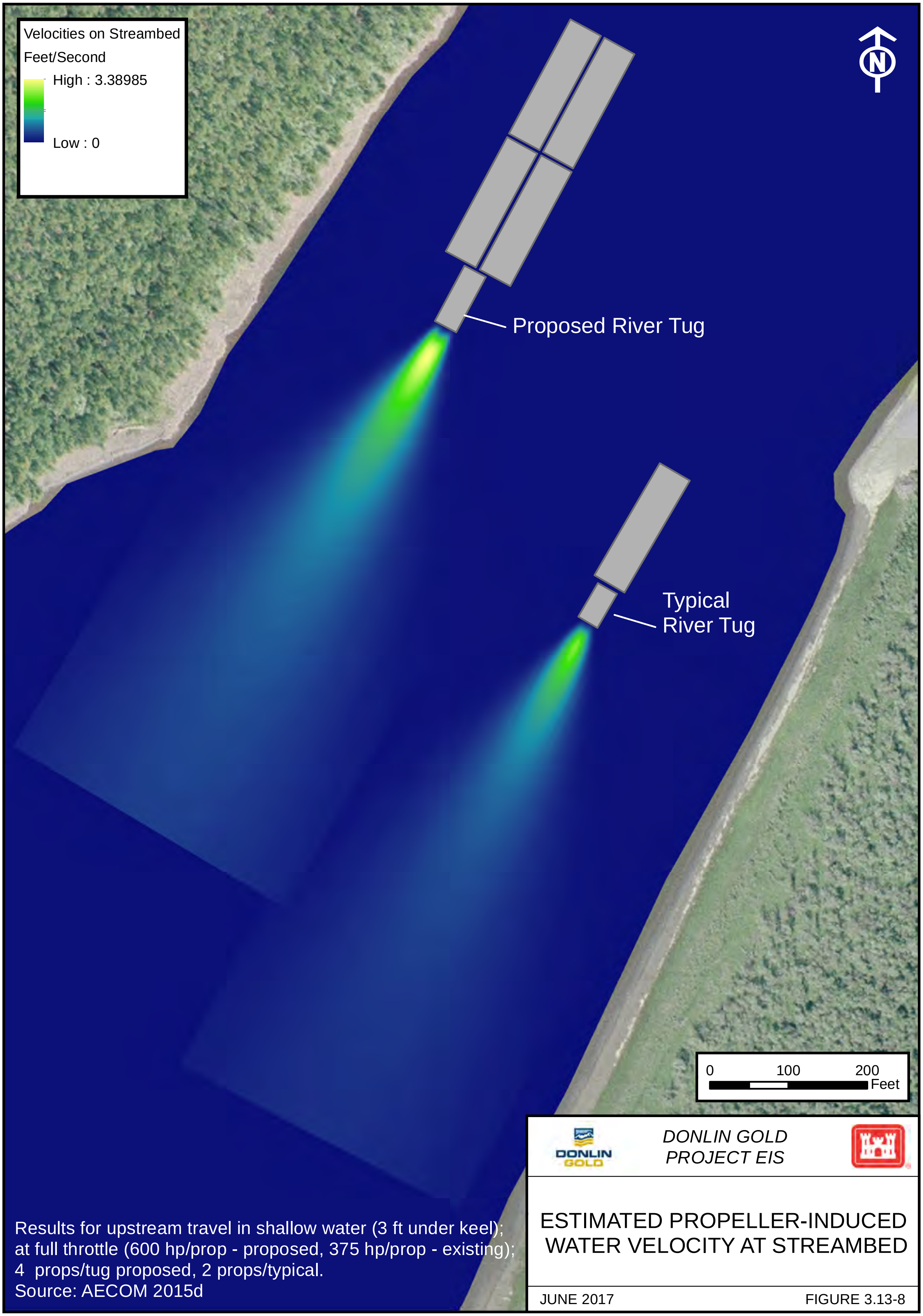
Assumptions:
Diameter of propeller - 40 inches
Distance from keel to propeller centerline - 22 inches
Minimum draft - 3 feet
Ducted propeller

DONLIN GOLD PROJECT EIS

ESTIMATED SCOUR DEPTH BY GRAIN SIZE AND WATER DEPTH FOR A 150 HP TUG

JUNE 2017

FIGURE 3.13-7



Results for upstream travel in shallow water (3 ft under keel); at full throttle (600 hp/prop - proposed, 375 hp/prop - existing); 4 props/tug proposed, 2 props/typical.
Source: AECOM 2015d

DONLIN GOLD
PROJECT EIS

ESTIMATED PROPELLER-INDUCED WATER VELOCITY AT STREAMBED

JUNE 2017

FIGURE 3.13-8

M:\Projects\26221089 - Donlin Gold EIS\Mxd\Ch_3\Biological_Figures_PFEIS\Fig_3_13_Fish\Fig_3_13_08_PropWash.mxd

Bed scour from existing barge traffic, flooding, and ice-out conditions also contribute to sediment resuspension and displacement of fish eggs and larvae and other aquatic biota. The additive effects of bed scouring from proposed barge traffic would persist for the life of the project and the extent or scope would involve shallower sections of the Kuskokwim River along the navigation channel. Since natural flooding and existing small boat and barge traffic already contribute to riverbed scouring within the navigation channel in certain locations, displacement of aquatic habitat and biota in areas previously disturbed may not be measurable or noticeable. As a result, impacts from prop wash scour on anadromous or resident fish and aquatic life that rely on mainstem channel areas for spawning that have not been previously subjected to natural flooding or existing small boat and barge traffic could cause either noticeable changes in behavior that may affect reproduction, feeding, or survival; or acute, obvious or abrupt changes in fish behavior that disrupt life functions and indirectly reduce populations in the EIS Analysis Area. These changes would depend on how and where tugs are operated, water depth, channel geometry, substrate character, and life stages of fish and aquatic species that encounter such hydraulic forces.

Fish Injury and Mortality

Specific impacts of propeller-induced injury or mortality to anadromous or resident fishes in the Kuskokwim River from barge traffic are not completely known. Evaluating impacts of barge traffic relative to potential fish injuries or mortalities on the Kuskokwim River requires consideration of the timing, distribution, and density of anadromous and resident fishes, particularly during the seaward migration of young-of-year salmon and larval life stages of resident fish, within confined segments of the main channel. Evaluation of impacts also requires consideration of potential injury caused by entrainment through propellers. Analysis of literature from other systems is assessed to provide a basis for impact assessment in the document analysis framework, as information from the Kuskokwim River system is limited.

To provide information on local populations to help evaluate impacts, surveys of fish populations were conducted in nearshore waters and the mid-channel of the Kuskokwim River during May and June of 2015 near BTC and above Upper Kalskag. The abundance of young-of-year chum and coho salmon smolts captured during the survey were highest in mid-May through June 1 and decreased substantially by June 19 to 22. Over 21,000 young-of-year chum, about 400 coho smolts, and lesser amounts of pink, sockeye, and Chinook salmon were collected during the survey (Owl Ridge 2015b).

To understand timing, distribution, and density of populations, literature from Pacific coast regions of anadromous species was investigated. The distribution and use of shoreline, mid-channel, and other river habitats by juvenile salmon during their downstream migration has been investigated by researchers who have described patterns that varied by species, river systems, and time of day. Studies by Neave (1955) noted that populations of pink and chum salmon in British Columbia have been observed migrating downstream exclusively at night. Individuals not reaching the estuary during their first night of migration moved temporarily back into streambed gravels during the day and resumed their migrations the next night. Radio tracking studies suggest that downstream juvenile salmon migrations are not continuous but interspersed with periods of holding. In addition, downstream migrating fish have been reported as typically swimming in the fastest water available (Quinn 2005). Downstream migration took place during daylight hours, but salmon temporarily held in back eddies and off-channel habitats containing woody debris and cover consistent with the findings of

McMahon and Holtby (1992). Others also have reported that seaward migrating salmon have been observed, at times, to utilize shallow waters of less than 3 feet in depth and within 33 feet of shore (Owl Ridge 2014b). Such shallow shoreline zones also have been reported to function as important nursery areas for non-migrating, rearing fishes (Winkler et al. 1997; Keckeis et al. 1997). Coho salmon in the Chehalis River in Washington were estimated to spend 40 percent of the time swimming downstream and 60 percent holding (Moser et al. 1991).

Investigations by Burril et al. (2009) determined that juvenile chum and other salmon species from the Kwethluk River (a tributary of the lower Kuskokwim River) migrate to sea from early May to mid-June. During the study, seaward migrations for all salmon species tended to be greatest when water levels, which are generally clearer in this tributary than in the mainstem Kuskokwim River, were rising and during the hours of low light (i.e., 02:00 to 08:00). Based on 2003 and 2004 studies in Kuskokwim Bay, the peak abundance of downstream migrating pink, coho, and sockeye salmon was greatest in late May, while chum and Chinook salmon had the greatest peak abundance in mid to late June (Hillgruber and Zimmerman 2009). Similar findings regarding the timing of out-migrating salmon in the Yukon Delta have been observed in other studies (Martin et al. 1986).

Besides young salmon, larval and juvenile life stages of other fish species may also be subject to injury from barge traffic. Between April and early September, juvenile life stages of rainbow smelt, least cisco, broad whitefish, humpback whitefish, inconnu (sheefish), and Arctic grayling (among others) migrate in the Kuskokwim River often during spring or early summer floods. Arctic and Pacific lamprey migrate to the estuary in August and September.

To assess barge passage impacts, various studies were examined to provide information on mean catch changes, and injuries or mortalities to fish eggs, larvae, or juvenile life stages caused by exposure to hydraulic shear forces, propeller strikes, or water pressure changes in a propeller's flow field, A study by Holland (1986) assessed short-term impacts of deep-draft commercial barge traffic on fish eggs, larvae, young-of-year fishes, and small adults in the upper Mississippi River based on net sampling prior to and 45 and 90 minutes after vessel passage. Results indicated that downstream (loaded) vessels caused an immediate reduction in mean catch that continued through the 90-minute sampling period while the mean catch increased in surface waters immediately after upstream (unloaded) passage. Gross damage to larval fish was rarely observed and no consistent pattern of injury from barge passages was apparent. Results of the study indicated that impacts of barge passages on the distribution of drifting eggs and larvae is primarily related to the physical effects of the vessel on the water column relative to wave forces and drawdown that alter water levels along the margins of the channel.

Killgore et al. (2005) reported that instantaneous mortality of fish collected in a specially designed net after being entrained through twin-screw towboat propellers was minimal in studies conducted on the Mississippi and lower Illinois river. Sampling, which consisted of 139, 10-minute trawls, was dominated (96 percent) by the herring family Clupeidae and gizzard shad (*Dorosoma cepedianum*). It should be noted that fish of the size and age sampled in the study have a greater swimming ability than larval, young-of-year, or larger-size juvenile salmon. When instantaneous mortality of fish entrained through towboat propellers was observed, it was found that only gizzard shad were susceptible to entrainment in any measurable number. All but one of the injured or killed fish also had visible net marks on their bodies which may have contributed to injuries. The mean entrainment mortality rate for upriver-bound tows was equivalent to 0.01 to 1.0 fish/km of towboat travel which also included net-induced injuries. Although not measured, additional delayed mortalities also may have occurred. Since the entrainment mortality was slightly higher in the Illinois River where the channel was narrower, the author suggests that pelagic fishes inhabiting the mid to upper water column of small or narrow navigation channels may be more susceptible to propeller entrainment where populations are confined and concentrated.

As described in the EFH Assessment (Owl Ridge 2017c), Killgore et al. (2011) reported that the magnitude of larval mortality due to shear stress caused by propellers would be size-dependent. Small larvae (<10 millimeters [mm]) would be the most susceptible. Juvenile chum and pink salmon exceed these sizes, with chum salmon out-migrating from the Kuskokwim River in 2015 averaging 38.0 mm (range: 27 to 50 mm) and pink salmon averaging 34.5 mm (range: 30 to 42 mm) (Morris et al. 2015). Outmigrating Chinook, coho and sockeye salmon are larger, with mean lengths of 83.6, 84.8, and 53.1 mm, respectively, so would be at less risk of injury.

According to Gutreuter et al. (2003), commercial vessels operating in confined channels of large rivers may cause injuries or mortalities to fish eggs, larvae, or juvenile life stages caused by exposure to hydraulic shear forces, propeller strikes, or water pressure changes in a propeller's flow field. The mean entrainment mortality of gizzard shad was estimated at 2.52 fish/km (80 percent confidence interval of 1.00 to 6.09 fish/km) (Gutreuter et al. 2003).

As described in the EFH Assessment (Owl Ridge 2017c), a study of entrainment rates though propellers conducted in the Mississippi River (Killgore et al. 2011) indicated that entrainment rate was low (<1 fish/km) in deep and wide sections of the river with swift water. However, it was pointed out in the study that entrainment could reach high rates (>30 fish/km) in shallow sections with slow velocity (Killgore et al. 2011). This study discusses how fish may avoid entrainment in wide or deep channels, escaping vertically or horizontally, and notes that other studies have documented transient avoidance responses to boats though radiotelemetry and hydroacoustics. It is noted that the Killgore et. al. study involved towboats with propellers 2.7 meters (9 feet) in diameter while the proposed design for Donlin Gold project tugs would be on the order of 1 meter (3.3 feet). Similarly, the draft of the towboats studied on the Mississippi and Illinois rivers was 2.4 meters (7.9 feet) while the draft of the tugs proposed for the Donlin Gold project is 0.9 meter (3 feet). For context, annual traffic in the Mississippi and Illinois river study area ranges from approximately 1,900 to 5,700 towboats while Donlin Gold would propose 122 barge two trips above the current baseline level of 68 trips for a total of 190 barge tow trips.

On the Kuskokwim, barge traffic navigating deeper and wider sections of the river typically would not pass close to shore, depending on the river channel width and the channel's geometry (Owl Ridge 2017c). Under such conditions, rearing or migrating salmon and other anadromous and resident fishes in shore zone areas would tend to experience low levels of risk relative to injury or mortality from tug propellers, vessel wakes, drawdown and surge, prop wash, and other associated hydraulic forces. In more confined segments of the channel, however, a relatively higher level of injury or mortality could occur to eggs, larvae, and possibly young-of-year resident or anadromous fishes that encounter shear forces from tug propellers, especially where these populations are concentrated.

The timing and locations when/where fish concentrations could be greatest and susceptible to potential injury or mortality at the population level, would generally depend on the life stages of fish that would be at risk. Fish eggs, larvae, and small young-of-year juvenile life stages moving downstream would be at higher risk compared to upstream migrating adult fish with stronger swimming ability. Adult and larger juvenile fish that tend to follow shallower shoreline areas with lower velocity would be less susceptible to shear forces from propellers and propwash in the middle of the river channel.

Based on field studies and available literature, out-migrating Chinook, coho, and sockeye salmon are large enough to avoid barge propeller strikes, while a portion of the pink and chum salmon may still be small enough to be affected. Fish injury or mortality from tug and barge traffic on the Kuskokwim River may be somewhat greater if shallow-draft tug and barge combinations would have propellers that are closer to the surface where portions of the seaward migrating salmon often travel in mid-channel, high-velocity waters.

Based on studies described earlier, the greatest concentrations of seaward migrating salmon in the Kuskokwim River (traveling from tributaries to Kuskokwim Bay) are likely to occur between early May and late June, and possibly during hours of low light and rising water levels. Fry-size and older juvenile salmon tend to occupy high-velocity portions of the river channel as they actively swim toward the estuary during their seaward migrations. Some species, such as chum and pink salmon, periodically hold in slower, shallow waters along shorelines, back eddies, and side channels during their seaward migration. Similar to seaward migrating salmon, early life stages of other resident and anadromous fishes, such as rainbow smelt, whitefish, sheefish, lamprey, and least cisco, that actively migrate or drift downriver would be subject to potential injury or mortality from tug propeller forces. The extent and intensity of impacts would depend on the timing and locations in the river channel where concentrations of these fishes would intersect with vessel traffic.

Where impacts could occur, they would persist over the life of the project and would be limited to the vicinity of the project footprint and affected watershed with greatest risk occurring in confined channel segments between Kuskokwim Bay and the Angyaruaq (Jungjuk) Port site (and to a lesser extent or scope, upriver to the pipeline crossing of the Kuskokwim). The context of such impacts would affect EFH and associated species protected under the Magnuson-Stevens Act. Therefore, anticipated fish injuries or mortalities from tug and barge traffic along the navigation channel would range from unnoticeable to detectable depending on the seasonal timing of fish migrations, life stages, time of day, and the concentration of fish encountered by barge traffic relative to confined and shallow channel segments. Incidents of injury or mortality may be detectable, but populations would remain within normal variation. Although fish species potentially at risk would be often found in the Kuskokwim River system, the mainstem and its tributaries are regulated as EFH since these waters provide habitat that supports key life stages of salmon which also play a role in the Kuskokwim subsistence community

Mine Access Road

Under Alternative 2, a new, 30-mile, two-lane, 30-foot-wide access road would be constructed to transport cargo and fuel from the barge landing at the Angyaruaq (Jungjuk) Port site to the mine. The all-season, gravel road would be used exclusively for mine-related traffic and would remain in service in perpetuity to support post-Closure compliance monitoring at the mine. Performance bonds would be established so the road and all bridges and culverts are regularly monitored and properly maintained and that all maintenance equipment would be available onsite to do so. Water trucks and BMPs for managing runoff would be used to control dust and the release of fine sediments to local streams. The road would cross approximately 51 streams or drainages using 45 culverts varying in size from 24 to 72 inches and six bridges. In addition, rock and gravel for construction of the road would be removed from about 13 material sites along the road corridor with a primary site that would be located between the confluence of the north and south forks of Getmuna Creek. Truck traffic, carrying fuel and cargo, would arrive at the Mine Site or Angyaruaq (Jungjuk) Port site about every half hour, on average, during the approximately 110-day shipping season. Daily traffic would typically consist of 20 trucks making 54 trips (half each for fuel and cargo) with a one-way trip requiring about 1.6 hours.

Historically, road construction and maintenance practices can result in potential risks to nearby streams and drainages from increased surface erosion and deposition of fine sediments; alteration of water temperature; delays or barriers to fish migration at culverts; changes in streamflow and hydrologic processes; and introduction of nonnative invasive plant species (NMFS 2011a). Surface erosion can result from clearing, grading, and excavation activities and from poorly surfaced or maintained roads with steep grades, high levels of traffic, and insufficient stormwater management facilities. Accumulations of fine sediments in streams have been associated with decreased fry emergence, reductions in winter carrying capacity and benthic production, and changes in species composition in benthic communities (NMFS 2011a; Bisson and Bilby 1982; Bilby et al. 1989).

Downgradient from the mine access road corridor and at material borrow sites near streams, potential construction impacts related to erosion and sedimentation and loss of shade from removal of trees and riparian plant communities could adversely affect fish communities and aquatic habitat particularly at bridges or culvert crossings. Such impacts would be managed and monitored by implementing specific construction and maintenance BMPs that will be finalized during the design and agency review processes including specifications required for the Title 16 Fish Habitat Permit. A range of BMPs, including silt fences, bale check dams, sediment retention basins, cross bars and ditches, runoff interception and diversions, gabions and sediment traps, mulching of disturbed surfaces and stockpiles, and other measures, would be installed and monitored along the road corridor and at all bridge and culvert crossings to ensure they effectively reduce the intensity of runoff, erosion, and sediment loads and minimize potential impacts to fish, other aquatic life, and their habitats. Periodic barriers to fish passage could occur over all phases from Construction through post-Closure monitoring. The intensity of impacts to fish populations may be detectable but populations would remain within normal variation, depending on the nature, location, and magnitude of potential blockage incidents and the timing required to restore fish passable conditions.

The main tributaries that would be crossed by the mine access road are the north and south forks of upper Getmuna Creek and Crooked Creek. These crossings would involve full-span bridges. Getmuna Creek represents some of the highest salmon and resident fish production in the drainage (Figure 3.13-1). Elsewhere along the roadway corridor, small creeks and drainages would be crossed by culverts. Culverts and bridges would be designed to allow fish passage. Culvert and bridge construction would be conducted consistent with specifications included in the Title 16 Fish Habitat Permit which would be implemented to protect in-water habitat, minimize impacts during construction, and assure long-term fish passage throughout post-Closure Phase monitoring. Inspection and maintenance of culverts, bridges, and roads would be regularly conducted and reported in compliance with permit conditions. Should culvert blockages occur, they could erode stream channels and contribute to sedimentation in waters downstream until water conveyance and fish passage are properly restored.

During Construction, rock blasting would periodically be conducted within or near streams along the road corridor, at materials sites, and elsewhere in at the Mine Site. All blasting would be conducted in compliance with the Title 16 Fish Habitat Permit and the Alaska Blasting Standard for the Proper Protection of Fish (Timothy 2013). This would include implementation of a suite of BMPs and alternative measures to avoid, minimize or mitigate impacts of blasting on all life stages of fish as determined during the final design and permitting processes. BMPs that would be developed during final design typically include:

- Identification of spawning beds, rearing areas, and migration corridors in the blast area;
- Scheduling of all blasting when fish and embryos are not present in the area to the extent practicable;
- Estimating number of blasts, maximum charge weight per day, distance between fish habitat and detonation sites;
- Predicting maximum overpressures in affected waters and peak particle velocities in spawning gravels;
- Use of alternatives to blasting;
- Displacing, removing, and blocking fish from the area prior to blasting activities; and
- Resloping, restoring, and revegetating disturbed streambanks based on methods presented in Walter et al. (2005).

By implementing blasting BMPs required in the Title 16 Fish Habitat Permit, pressure waves and vibrations that could otherwise jeopardize fish life phases (i.e., adults, juveniles, eggs, or larvae) would be monitored. This could include the use of hydrophones installed in appropriate locations near the point of detonation during all blasting activities. The instantaneous pressure rise in the water column in fish rearing and migration habitat would be limited to no more than 7.3 pounds per square inch (psi) where and when fish are present. Peak particle velocities in spawning gravels would be limited to no more than 2 inches per second during the early life stage of embryo incubation (Timothy 2013).

Bethel Cargo and Fuel Port Sites

The existing Bethel Port site may be expanded to include general cargo berths at the Knik Bethel Yard Dock (a connected action, see Chapter 1, Section 1.2.1, Connected Actions). Development may include construction of an 850-foot long open-cell sheetpile bulkhead to accommodate barges and prevent shoreline erosion. About 40,000 cubic yards (cy) of fill and 1,600 cy of riprap would be placed behind and at the ends of the sheetpile, respectively, resulting in the loss of about 3 acres of nearshore aquatic habitat. This would slightly decrease the cross-sectional area of the river and cause slightly greater river velocity that could realign the thalweg of the river (e.g., deepest portion of the channel) slightly closer to the dock. Construction of sheetpile infrastructure and fill activities also would result in a momentary increase in suspended sediment from disturbance of the channel bottom. Such changes, combined with increased nearshore velocity and localized scouring and eddies near the proposed rip rap at the upstream and downstream ends of the dock, would adversely affect shallow-water refugia for rearing and migrating fish. During Operations, tugs would maneuver barges along the bulkhead where prop wash would disturb riverbed substrates and local populations of fish and aquatic biota. Any actions that would occur at Dutch Harbor or the Port of Bethel at the Bethel Yard Dock are not part of the proposed action, and are considered connected actions (see Section 1.2.1, Connected Actions, in Chapter 1, Project Introduction and Purpose and Need).

At upland portions of the terminal, an area of about 16 acres would be constructed to receive and store cargo from ocean barge deliveries and from river barges returning from the upriver Angyaruaq (Jungjuk) Port site. In addition, 3.5 acres would be developed to accommodate buildings, access roads, equipment storage, plowed snow, spare pallets, chains and rope, damaged containers, dock surfaces, and area for equipment maneuvering. Since site development would be undertaken by a third party, potential impacts related to fish and aquatic resources are considered indirect effects of a connected action to the Donlin Gold Project. The proposed construction design, operations plan, and related BMPs for over / in-water construction and maintenance activities would be conducted in a manner that provides fish and aquatic resource protection in compliance with all regulatory requirements including the project's Title 16 Fish Habitat Permit.

The Bethel Fuel Terminal and Tank Farm may need to be reconfigured or expanded in order to accommodate an additional six Mgal in fuel storage in tanks with lined containment areas. Any actions that would occur at Dutch Harbor or the Port of Bethel at the Bethel Yard Dock are not part of the proposed action, and are considered connected actions (see Section 1.2.1, Connected Actions, in Chapter 1, Project Introduction and Purpose and Need). The tanks would be used to store fuel offloaded from ocean fuel barges berthed at the terminal. Fuels arriving at the terminal also would be transferred directly to river barges moored alongside the ocean barges and, therefore, would not require temporary onsite fuel storage at Bethel. Since the site is already equipped with tank pads, liners, and containment, it is not anticipated that additional storage capacity would require substantial expansion of the existing fuel terminal. Potential disturbance of fish and aquatic resources from Construction and Operations Phase activities, therefore, would likely be limited, and would be considered effects of a connected action. Similar to the cargo terminal, the extent of additional storage area at the fuel terminal and tank farm would be determined by a third party who would expand and operate the terminal. Based on the design standards and BMPs that would be implemented in compliance with the Title 16 Fish Habitat Permit, the number of stream crossings proposed, and the extent of the mine access road corridor, the intensity of anticipated changes to fish and aquatic resources and their associated habitat may be noticeable. The context of impacts would affect streams to be crossed by bridges and culverts that are regulated as EFH. Anticipated impacts would be limited to waters in the vicinity of the project footprint and associated watershed and occur for the life of the project. Acute or obvious impacts extending beyond the region would only be anticipated in the event of a catastrophic event such as a major landslide or release of fuel or chemicals from a truck having an accident near a major fish-bearing tributary, especially if it were to involve Getmuna or Crooked creek. The potential impact of such a scenario is described in Section 3.24, Spill Risk.

Angyaruaq (Jungjuk) Port Site

Shoreline infrastructure at the Angyaruaq (Jungjuk) Port site also would be developed and maintained consistent with design standards and BMP requirements stipulated in the project's Title 16 Fish Habitat Permit. Construction would involve 26 acres where about 10,000 cy of dredged material along the Kuskokwim River shoreline would be removed and placed on a 5-acre overburden stockpile for development of the sheetpile infrastructure and fuel barge berthing facilities. Construction of sheetpile infrastructure and fill activities would result in a momentary increase in suspended sediment from disturbance of the channel bottom. To manage such impacts, silt and sedimentation control BMPs would be installed and maintained throughout the in-water work window established in the Title 16 Fish Habitat Permit for protection of fish and aquatic life. Once constructed, potential impacts are anticipated from changes in velocities and flow patterns occurring upstream, downstream, and across the channel from the sheet pile wall. This could create scour and depositional conditions which, in turn, could lead to increased channel and bank erosion near the structure causing sediment deposition downstream. Based on hydraulic modeling and existing site conditions, the proposed sheet pile wall design is predicted to alter the Kuskokwim River morphology at an unnoticeable level of intensity relative to average annual peak flow and 100-year flood conditions. During 100-year flood events, however, potential eddy formation upstream from the sheet pile structure could occur that causes scour and bank erosion. During operations, tugs would maneuver barges into the constructed berths where prop wash would disturb riverbed substrates and local populations of fish and aquatic biota. The resulting alteration of the shoreline character, loss of aquatic habitat, and disturbance of local fish populations would result in noticeable impacts that would persist until site reclamation is completed during the Closure Phase. The extent or scope would be limited to waters in the vicinity of the project footprint. The context of such impacts would affect aquatic habitat in the Kuskokwim River regulated as EFH.

Summary of Transportation Corridor Impacts

From Construction to Closure, anticipated impacts associated with truck and barge traffic along the mine access road and on the Kuskokwim River would range in intensity depending on the type of impact causing factor. For example, changes in the character or quantity of aquatic habitat from erosion, turbidity, and water temperature may not be measurable or noticeable. However, habitat alterations from prop wash scour of riverbeds substrates and fish spawning gravels may be acute or obvious. Following Closure, the mine access road would remain in service, the port site would be reclaimed, and barge traffic would substantially diminish resulting in a reduced level of impacts to fish and aquatic resources in the Kuskokwim River and its tributaries. From Construction to Closure, impacts may extend beyond a local reach of stream and potentially throughout the EIS Analysis Area. Anticipated impacts would affect the Kuskokwim River and certain tributaries in the Crooked Creek drainage that are regulated as EFH which sustain life phases of several stocks of Pacific salmon under the Magnuson-Stevens Act. These fish stocks also play a role in the Kuskokwim subsistence communities.

Along the Kuskokwim River, anticipated impacts would be primarily associated with hydraulic forces from vessel-generated wakes and propeller wash in certain confined and shallow segments of the navigation channel. Four of the five narrowest river segments surveyed in a 2014 study were located between BTC and the Angyaruaq (Jungjuk) Port site (AMEC 2014). Depending on several considerations, hydraulic forces from barge traffic could result in:

- Shoreline erosion and water quality degradation;
- Fish displacement and stranding where channel segments at select shoreline locations having a low-gradient;
- Habitat degradation from riverbed scour; and

- Possible injury or mortality of egg, larval, or juvenile fish life stages that encounter propeller blades or shear forces in the propeller flow field in the water column or along the river bed.

Along the mine access road and at the port site, risks to fish and aquatic resources would be associated with construction and operation of roadways, bridges, culverts, and shoreline infrastructure. In the vicinity of these features, changes to the character of aquatic habitat and water quality would be noticeably altered resulting in impacts on anadromous and resident fish populations and invertebrate communities that would persist for the life of the project. At certain locations along the mine access road, constructed road culverts could become periodically blocked. This could result in infrequent barriers that obstruct fish passage until flows and fish passage conditions are properly restored.

3.13.3.2.3 PIPELINE

Alternative 2 would involve construction of a 14-inch-diameter pipeline for transmission of natural gas from an existing 20-inch pipeline tie-in near Beluga, Alaska to the Mine Site approximately 316 miles to the west (SRK 2013b). Pipe and other heavy construction equipment would be shipped by ocean barge from terminals in Seattle, Washington or Vancouver, British Columbia to the Port of Anchorage, then to the Beluga barge landing resulting in a slight increase in shipping activity at the terminals.

Stream Crossings

The pipeline route planning process was based on a series of engineering and environmental criteria including the minimization of the number of stream and river crossings; avoidance of hydrological hazards; and minimization of overall work activities where construction would be particularly challenging. During the Construction Phase, potential effects on fish and fish habitat would be minimized by using site-specific stream crossing methods; limiting work to prescribed in-water work windows; implementing construction BMPs and monitoring to ensure their effectiveness; and by using habitat restoration methods that provide an appropriate level of protection based on the species and habitat sensitivity that exists at each crossing (SRK 2013b). Specific BMPs would be developed during the final design and permitting process in cooperation with ADF&G (for the Title 16 Fish Habitat Permit) and other resource agencies having permitting authority.

The following subsections discuss the proposed methods used to cross streams along the pipeline and the impacts of those methods by drainage basin and river.

Stream Crossing Methods

Alternative methods evaluated for each river or stream crossing include horizontal directional drilling (HDD); open-cut dry flume; open-cut dam and pump; flowing water open-cut; non-flowing water open-cut; and small creek crossing. Where feasible, crossings would be constructed using appropriate open-cut methods for three different types of waterbodies:

1) smaller drainages, intermittent streams and ditches, and non-sensitive water bodies where potential impacts from sedimentation are not anticipated;
2) frozen rivers or streams in winter where there is no surface flow; and

3) rivers/streams that are so large that no isolation method is feasible.

The third method would depend on several factors including whether the crossing would occur in summer or winter, flow volume and velocity, type of bed material, and the width, depth, and amount of cover to be excavated/replaced.

Open-cut crossings of large rivers or streams would involve excavation of the trench through the waterbody using backhoes operated from the riverbank or within the waterbody if it is too wide. Braided rivers would require backhoe operators to install a channel diversion prior to excavating the pipeline trench. The selection of site-specific open-cut methods and BMPs would be determined during final design and confirmed at the time of construction consistent with permit approvals (SRK 2013b).

Open-cut pipeline construction would require crossing of streams inhabited by anadromous or resident fish populations during sensitive seasons, including winter. Construction at such crossings would be based on site-specific layout plans, design strategies, and measures developed for the purpose of avoiding or minimizing potential impacts to fish migration, rearing, and spawning activities and aquatic habitats. These protection measures would be confirmed in consultation with ADF&G for the Title 16 Fish Habitat Permits during final design but would include isolating the in-water work area from surrounding waters and, where practical, removing and transferring fish to downstream waters prior to construction. Alternative design approaches would be based on one or more of the following:

- Crossing beneath large rivers using HDD;
- Damming and pumping streams around crossing sites;
- Diverting streams to dewater crossing sites;
- Crossing streams when they are completely frozen;
- Fluming streams through temporary culverts while installing the pipeline beneath the culvert; and
- Surveying for fish overwintering areas in order to avoid direct and indirect impacts to these locations (SRK 2013b).

HDD methods would be implemented based on a site-specific HDD Plan that would include a Drilling Mud Disposal Plan for management and disposal of drilling cuttings and drill mud. All pipeline stream crossing activities would be subject to environmental monitoring inspections during construction. Following construction, performance monitoring would continue as stipulated in the Surveillance and Monitoring Plan (SRK 2013b). Entrance and exit bell hole locations at HDD crossings would each require 1.4 acres. Plan and profile views and construction entry site layouts for typical HDD crossings are shown in Figures 2.3-31 and 2.3-32 (Alternative 2 Typical HDD Crossing and Alternative 2 Typical HDD Entry Site Equipment Layout). Estimated quantities of water requirements, total solids/cuttings needing disposal, and drilling mud disposal for proposed HDD crossings are shown in Table 2.3-32 (HDD Estimated Water Use).

The selection process for proposed HDD crossings is based on:

- Whether the river was of substantial size that would present engineering or other challenges to conventional open cut trenching;

- Whether HDD would be technically feasible based on current technology;
- Whether substantial traffic would be expected on the river;
- Whether construction for HDD (or alternatively trenching) would occur in summer or winter;
- Whether there are any specific environmental, regulatory, or engineering considerations or constraints that would mandate evaluation of HDD; and
- Other potential environmental, engineering, schedule, or cost considerations for HDD (SRK 2013b).

Cook Inlet Drainage Crossings

Stream crossings in the Cook Inlet drainage include minor crossings at Beluga River, Theodore River, Lewis River, Alexander Creek, and associated tributaries. A summary of these crossings, associated fish species, and the potential effects of the crossings on those species are discussed below.

Major River Crossings

There are no major (> 100 ft wetted width) stream crossings proposed along the Cook Inlet Drainage.

Minor River Crossings

Minor crossings at Beluga River, Theodore River, Lewis River, Alexander Creek, and associated tributaries would be constructed using one of the open-cut previously mentioned with most of these constructed during winter. Subject to final design, additional stream crossings currently planned for open-cut methods may be constructed using HDD. Major fish species found in these rivers include all five species of Pacific salmon, Dolly Varden, rainbow trout, and humpback whitefish (Section 3.13.2.3; Table 3.13-20).

Salmon species accounted for approximately 17 percent of the total fish captured in sites surveyed along the pipeline route. Coho salmon constituted approximately 86 percent of the total salmon captured across all drainages, while Chinook salmon accounted for 10 percent. Captures of juvenile chum and sockeye salmon were rare (Ottertail 2012a). Dolly Varden was one of the top species found across all drainages along the Pipeline (Ottertail 2012a). Dolly Varden spawn in the fall between September and November in small headwater streams. Eggs typically hatch in March of the following year. After rearing in streams for up to 6 years, Dolly Varden may either migrate to sea or remain in freshwater (ADF&G 2008c; 2017). Rainbow trout spawn from late March through early July, depending on location and the severity of the winter. Fry emerge from redds from a few weeks to as much as four months after successfully spawning (ADF&G 2008d).

Spring and winter open-cut stream crossings that would occur in areas frequented by the above fish species could disturb spawning and/or overwintering activities. Fish may seek other suitable spawning habitat during pipeline stream crossings. Trenching during winter months when fish eggs are incubating could impact egg survival from direct disturbance or from sedimentation of the riverbed along the crossing or in waters immediately downstream. As discussed in Section 3.7.3.2.4, silt or sand resuspended as a result of pipeline construction activities could fill interstices in gravel and reduce water flow through substrate. Spring open-water trenching during periods when eggs are incubating could impact egg survival for these fishes from direct disturbance or from sedimentation of the riverbed along the crossing or in waters immediately downstream.

Skwentna Drainage Crossings

Stream crossings in the Skwentna drainage include major river crossings at Skwentna River and Happy River. Each of these major river crossings, a summary of minor crossings, associated fish species, and the potential effects of the crossings on those species are discussed below.

Major River Crossings

The Skwentna River crossing would be accomplished by HDD during the winter at MP 50. Major fish species found in Skwentna River include all five species of Pacific salmon, Dolly Varden, and rainbow trout. The Happy River crossing would be accomplished by HDD during the winter at approximately MP 86. Major fish species found in Happy River include Chinook and sockeye salmon, and Dolly Varden (Section 3.13.2.3; Table 3.13-20).

HDD could essentially avoid potential impacts to Pacific salmon and EFH at the Skwentna River and Happy River where this method is currently proposed. Should HDD prove unsuccessful at any of the major river crossings, the construction schedule would allow for a reattempt using the same method or one of the alternative methods discussed above (e.g. open-cut). HDD crossing methods could result in potential impacts from loss of drilling mud (fluid) through sub-surface fractures (referred to as a frac-out) or releases from coarse sand or unconsolidated gravels underlying the stream bed. This could cause non-toxic drilling mud to unintentionally seep into overlying waters. The HDD Operations Plan would require specific monitoring for any substantial fluid loss or drop in pressure that could indicate a frac-out has occurred. In such an event, drilling would be immediately halted until the situation has been resolved. Frac-out releases could result in momentary, local increases in turbidity and sedimentation from bentonite dispersed along the riverbed downstream of the crossing. Depending on the nature, location, and duration of the release, acute or obvious changes to streambed gravels, anadromous and resident fish populations, and other aquatic biota could occur. A frac-out during winter HDD operations could adversely affect over-wintering fish populations or incubating fish eggs. However, monitoring-specific BMPs as described below would reduce effects such that population-level impacts would not occur but noticeable changes in behavior of fish may affect reproduction, feeding, or survival of individuals.

Monitoring-specific BMPs at HDD construction sites would be conducted to prevent and assess potential frac-out incidents. This would include inspecting pressure levels on drilling fluids to ensure they are set as low as possible to match the formation being drilled in order to avoid or minimize potential frac-out occurrences. Further information on the prevention, detection, and response related to potential frac-out or drilling fluid release will be described in the HDD Plan and the SPCC Plan completed during final design and permitting. This would include procedures to be implemented in the event of potential HDD abandonment and use of alternative open-cut methods at locations where HDD was intended. Sections 3.5, Surface Water Hydrology; and 3.7, Water Quality, provide additional information regarding construction BMPs for water quality protection.

Minor River Crossings

Minor river crossings within the Skwentna drainage include Eightmile Creek, Shell Creek, and associated tributaries. These crossings would involve the use of open-cut methods with most of the construction occurring during winter. Subject to final design, additional stream crossings currently planned for open-cut methods may be constructed using HDD. Major fish species found within these creeks include coho, chum, sockeye, and pink salmon, Dolly Varden, and rainbow trout (Section 3.13.2.3; Table 3.13-20). Impacts to the above species at minor river crossings would be similar to that described for minor river crossings within the Cook Inlet drainage.

Yentna River Drainage Crossings

Stream crossings in the Yentna River drainage include a minor crossings within the Johnson Creek watershed and associated tributaries. A summary of these crossings, fish species, and the potential effects of the crossings on those species are discussed below.

Major River Crossings

There are no major stream crossings proposed along the Yentna River Drainage.

Minor River Crossings

Minor crossings within the Johnson Creek watershed would be constructed using open-cut methods with most of the construction occurring during winter. Subject to final design, additional stream crossings currently planned for open-cut methods may be constructed using HDD. Major fish species found within this drainage include coho salmon and rainbow trout (Section 3.13.2.3; Table 3.13-20). Impacts to these species would be similar to that described for minor river crossings within the Cook Inlet drainage and Skwentna drainage.

Kuskokwim River Drainage Crossings

Stream crossings in the Kuskokwim River drainage include major river crossings at Tatina River, South Fork Kuskokwim River, Windy Fork Kuskokwim River, Middle Fork Kuskokwim River, Big River, Tatlawiksuk River, Kuskokwim River, and George River. Each of these major river crossings, a summary of minor crossings, associated fish species, and the potential effects of the crossings on those species are discussed below.

Major River Crossings

The Tatina River crossing would be accomplished by open-cut methods during the summer at approximately MP 127.3. Major fish species found in Tatina River include coho salmon, Dolly Varden, and round whitefish. The South Fork Kuskokwim River crossing would be accomplished by open-cut methods during the winter at approximately MP 146.5. Major fish species found in South Fork Kuskokwim River include coho, Chinook, and chum salmon, Dolly Varden, round whitefish, sheefish, and Bering cisco. The Windy Fork Kuskokwim River crossing would be accomplished by open-cut methods during the winter at approximately MP 168. Major fish species found in Windy Fork Kuskokwim River include coho salmon, Dolly Varden, and sheefish. The South Fork Kuskokwim River crossing would be accomplished by open-cut methods during the winter at approximately MP 182.7. Major fish species found in Middle Fork Kuskokwim River include coho salmon, Dolly Varden, and sheefish. The Big River crossing would be accomplished by open-cut methods during the winter at approximately MP

191. Winter non-flowing open-cut methods are planned at the Big River crossing if, as anticipated, it is frozen solid in February. Otherwise, flowing-water open-cut methods (without a temporary diversion) would be used since channel isolation may not be feasible. As described in the Surface Water Hydrology section, typical burial depths of the 14-inch diameter pipeline into the riverbed would be 4-10 ft depending on the scour potential of the river at the crossing site. Major fish species found in Big River include coho, Chinook, and chum salmon, Dolly Varden, and humpback whitefish. The Tatlawiksuk River crossing would be accomplished by open-cut methods during the winter at approximately MP 217.5. Major fish species found in Tatlawiksuk River include coho, Chinook, and chum salmon, and round. The Kuskokwim River crossing would be accomplished by HDD during the winter at approximately MP 240. Major fish species found in Kuskokwim River include coho, Chinook, chum, and sockeye salmon, Arctic grayling, round, humpback, and broad whitefish, sheefish, least and Bering cisco, Alaska blackfish, burbot, and northern pike. The George River crossing would be accomplished by HDD during the summer at approximately MP 283 for the East Fork, MP 290 for the mainstem, and MP 298 for the North Fork. Major fish species found in George River include coho, Chinook, and chum salmon, Arctic grayling, Dolly Varden, round whitefish, and burbot (Section 3.13.2.3; Table 3.13-20). A summary of the life history and impacts to these major fish species found within the Kuskokwim River drainage are discussed below.

As described in Section 3.13.2.2.2 and Section 3.13.2.3.2, the Kuskokwim River serves as a migration corridor for resident and anadromous fish species and provides diverse, year-round habitat for various life stages of some of these species. Chinook salmon adults typically enter the Kuskokwim River system in June and July and primarily spawn in the main channel of tributaries from mid- to late summer. Fry emerge from redds the following spring and typically spend one year in tributaries and backwater rearing areas before their seaward migration. Chum salmon tend to be the most abundant salmon in the Kuskokwim River basin. Adults typically enter the Kuskokwim River in late June and July and spawn primarily in tributaries from July to August, depending on location. Chum salmon eggs typically hatch and emerge from redds in May. Coho salmon adults typically enter the Kuskokwim River in late July and spawn primarily in tributaries in September to early October. Fry emerge in May or June and typically spend one or two years in freshwater tributaries before migrating to the ocean in late spring or early summer. Sockeye salmon adults typically enter the Kuskokwim River in June and July and spawn primarily in tributaries in August and early September. Young emerge from redds the following April to June and typically spend one or two years in fresh water lakes before migrating to the ocean in late spring/early summer. Pink salmon are the least abundant salmon in the Kuskokwim River system. Adults enter the river in early to mid-summer and spawn primarily in tributaries in mid- to late summer. Fry emerge in May and immediately begin their seaward migration. Impacts these species would be similar to that described above for major river crossings using HDD within the Skwentna drainage and minor river crossings using open-cut methods within the Cook Inlet drainage.

Two other resident fish species that also can be important components of subsistence and sport fisheries in the Kuskokwim basin include northern pike and Arctic grayling. Northern pike often overwinter in deep, slow waters of the mainstem Kuskokwim and its major tributaries. Spawning occurs in spring, soon after ice-out occurs, when adults migrate to tributaries and subsequently return to warm, shallow, summer feeding areas in the same general area. During the summer of 2014, subadult northern pike were captured in nearshore waters of the mainstem Kuskokwim River and often were observed within off-channel backwaters and side channels of the mainstem channel (Owl Ridge 2014b). Arctic grayling spawn in spring and overwinters in deep pools in mainstem channels. It is a broadcast spawner that migrates upstream to spawn soon after ice-out. Eggs, which typically are spawned over pebbles and gravel substrates, incubate for about three weeks after which time fry migrate to nearshore waters for rearing in shoreline edge habitat. Juvenile grayling comprised the third most abundant species captured during nearshore fish surveys in the Kuskokwim River during the early summer of 2015 (Owl Ridge 2015b).

Burbot is a long-lived and slow growing resident fish that typically completes its life cycle in freshwater and requires five to seven years to reach sexual maturity. Within the Kuskokwim River drainage, burbot populations are considered robust where they are an important component of the local subsistence fishery. Dense concentrations of mature adults are often caught under the ice as they gather to spawn over fine gravel, sand, and fine silt in late winter in low-velocity waters in main channels and side channels. Spawning generally occurs over a brief 2 to 3-week period where milt and semi-buoyant eggs are broadcast into the water column and eventually settle into interstitial spaces of riverbed substrates to incubate. Egg incubation lasts 41 to 128 days depending on water temperatures (McPhail and Paragamian 2000). For relatively slow growing species such as burbot, potential impacts to adults or eggs from winter open-cut construction could require a long time for affected populations to recover.

Within the Kuskokwim River drainage, approximately 20 stream crossings would occur in permafrost terrain with potential vulnerability to erosion both during and after the Construction Phase. As detailed in Section 3.13.3.2.1, excessive erosion can affect the survival of incubating fish eggs; reduce substrate cover and refugia habitat for fish rearing and migration; increase predation of fishes; cause a loss of winter carrying capacity; and decrease the availability of habitats that support an abundant and diverse macroinvertebrate community and sources of food for fish (Waters 1995; Bjornn and Reiser 1991; NMFS 2011a). Erosion also may elevate turbidity which can adversely affect fish feeding behavior and growth and reduce tolerance to disease and toxic compounds (Waters 1995). These potential effects could occur during any season while stream crossing methods are taking place. To mitigate these effects, construction methods and BMPs to be implemented at anadromous and resident fish-bearing streams would be conducted consistent with requirements of the project's Title 16 Fish Habitat Permit. Where ephemeral waterways (with seasonal, intermittent flows) are crossed, the pipeline would be installed with a 4-foot depth of cover. This would be increased to 10 feet at perennial stream crossings with year around flow to provide scour protection. Within the Kuskokwim River drainage, Big River has been documented as a key spawning tributary for sheefish, broad whitefish, and humpback whitefish based on radio-tag tracking studies conducted from 2007 to 2011 (Stuby 2012; Harper et al. 2012). Results of these and others studies (Alt 1979) indicate historic spawning areas occur about 30 miles downstream of the proposed pipeline crossing but also may extend farther upstream. Based on these investigations, sheefish annually arrive at their spawning areas on the Big River from late July through mid-September and spawn between late September through early October. In June, local residents annually harvest sheefish from this area as these fish begin their upstream spawning migration from the Kuskokwim River. Since sheefish are one of the first species to return to the area in early spring, the fishery provides an initial source of fresh fish prior to the return of salmon runs. Potential momentary sediment loads downriver from the Big River pipeline crossing would be generated if flowing-water open cut methods are used. This could adversely affect incubating sheefish eggs in the event that spawning occurred near and downstream of the crossing the previous fall. Adult sheefish would not be overwintering in this area since they typically move downstream after fall spawning. Depending on the intensity and duration of potential sediment loads generated (which would depend on the depth of trench excavation ultimately required), the extent of impacts to incubating sheefish eggs (or those of other fish) would be limited to gravels in the immediate downstream vicinity of the crossing.

Potential momentary sediment loads downriver from the Big River pipeline crossing would be generated if flowing-water open cut methods are used. This could adversely affect incubating sheefish eggs in the event that spawning occurred near and downstream of the crossing the previous fall. Adult sheefish would not be overwintering in this area since they typically move downstream after fall spawning. Depending on the intensity and duration of potential sediment loads generated (which would depend on the depth of trench excavation ultimately required), the extent of impacts to incubating sheefish eggs (or those of other fish) would be limited to gravels in the immediate downstream vicinity of the crossing. To minimize such potential impacts, Donlin Gold would incorporate appropriate timing, site-specific crossing methods, BMPs, and monitoring to control sediment loads would be specified in the Title 16 Fish Habitat Permit developed in consultation with ADF&G.

Within the Kuskokwim River, broad whitefish were found to spawn in late October to early November while humpback whitefish spawned in early October with both species returning downstream where they overwintered in the mainstem Kuskokwim River. This suggests that proposed stream crossing activities that are scheduled to occur in winter, outside the period of July to early November would avoid disturbance of spawning activities although eggs would remain in the gravels for several months thereafter.

Two other resident fish species that also can be important components of subsistence and sport fisheries in the Kuskokwim basin include northern pike and Arctic grayling. Northern pike often overwinter in deep, slow waters of the mainstem Kuskokwim and its major tributaries. Spawning occurs in spring, soon after ice-out occurs, when adults migrate to tributaries and subsequently return to warm, shallow, summer feeding areas in the same general area. During the summer of 2014, subadult northern pike were captured in nearshore waters of the mainstem Kuskokwim River and often were observed within off-channel backwaters and side channels of the mainstem channel (Owl Ridge 2014b).

Arctic grayling, a common resident species within the Kuskokwim basin, also spawns in spring. Like burbot, Arctic grayling is a long-lived species that overwinters in deep pools in mainstem channels. It is a broadcast spawner that migrates upstream to spawn soon after ice-out. Eggs, which typically are spawned over pebbles and gravel substrates, incubate for about three weeks after which time fry migrate to nearshore waters for rearing in shoreline edge habitat. Juvenile grayling comprised the third most abundant species captured during nearshore fish surveys in the Kuskokwim River during the early summer of 2015 (Owl Ridge 2015b).

Streams along the Pipeline also provide habitat to other economic and traditionally important species such as Dolly Varden and rainbow trout. Dolly Varden was one of the top species found across all drainages along the Pipeline (Ottertail 2012a). Dolly Varden spawn in the fall between September and November in small headwater streams. Eggs typically hatch in March of the following year. After rearing in streams for up to six years, Dolly Varden may either migrate to sea or remain in freshwater (ADF&G 2008c; 2017). Rainbow trout spawn from late March through early July, depending on location and the severity of the winter. Fry emerge from redds from a few weeks to as much as four months after successfully spawning (ADF&G 2008d).

Open-cut stream crossings that would occur in areas frequented by Dolly Varden and rainbow trout could affect suitable spawning and overwintering habitat. Impacts to these two species would be similar to those described above for HDD and open-cut methods.

The Alternative 2-North Option route would cross a total of 42 streams, all of which are in the Happy River watershed and comprise of 1st and 2nd order tributaries of the Happy River. A total of 35 streams are expected to be dry or frozen during winter construction yielding 35 open cut crossings. A total of three crossings would be crossed using HDD methods, and the remaining four crossings would be isolated open cut crossings. Out of these 35 streams, a total of 13 stream crossings were evaluated by Michael Baker (2017c; 2017d) for fish presence and absence and habitat quality from July 5 to July 8, 2017. Of the Happy River tributaries to be crossed by the proposed pipeline corridor under the North Option, those highest in the drainage have the best potential for overwinter use by fish. While these may provide the best potential for overwinter use by fish, the fish habitat potential was rated from poor to fair (Michael Baker 2017c). Happy River tributaries lower in the drainage are characterized by high gradient cascades and waterfalls that constitute fish barriers rendering the habitat non-viable although the potential for isolated, above-barrier populations exists. The ADF&G AWC lists Happy River (of which two tributaries are crossed with the North Option), Threemile Creek, and Moose Creek as anadromous streams containing Dolly Varden, Chinook, and sockeye salmon. However, no evidence of spawning fish was observed at any of the proposed crossing locations and no salmon were observed. The only fish species caught or observed during field surveys were Dolly Varden and Arctic grayling (Michael Baker 2017c). Given the marginal habitat conditions at these sites, low potential for overwintering habitat, and minimally observed species, the changes in the character or quantity of aquatic habitat from the North Option stream crossings may not be measurable or noticeable.

Public Access

As discussed in Section 3.12, Wildlife, and Section 3.21, Subsistence, the possibility of increased fishing pressure exists for the area due to: 1) improved public access to previously difficult-to-reach areas along the construction roads and pipeline corridor, and 2) the influx of workers and new residents attracted to the employment opportunities.

During Construction, a controlled access policy would be implemented along the pipeline ROW to manage public access and safety and avoid construction hazards. Notices and warning signs, flagging, barricades, and other safety measures would be used to coordinate and manage public access during Construction through Closure phases to protect the public, sensitive environments, and fish and wildlife populations from potential impacts. The Donlin Gold Public Outreach Plan would inform the public regarding the nature and extent of such measures. Throughout all phases of the project, employees and contractors of Donlin Gold would be prohibited from operating project-related equipment off the pipeline ROW or any other temporary use areas or material borrow sites. In addition, Donlin Gold would prohibit its employees and contractors from hunting, fishing, trapping, shooting, and camping within or adjacent to the pipeline ROW or using equipment for those purposes while in the project area for work-related purposes (SRK 2013b).

Although limited potential exists for general public access to the pipeline corridor due to the remoteness of the area and seasonal transportation constraints, temporary construction roads, maintenance road improvements, and ATV use near rivers and streams along the gas pipeline could increase fishing access to area streams beyond existing conditions. As described in Section 3.2, Soils, ATV use could also result in increased erosion, sedimentation, and disturbance to streambed gravels in the immediate area of ATV stream crossing locations. Such access improvements could benefit the local subsistence community but also could increase competition from the sport fishing community from within and outside the area for salmon and non-salmon species including whitefish, burbot, rainbow trout, Dolly Varden, Arctic grayling, and northern pike. Table 3.13-20 provides a summary of fish species that exist in affected drainages along the gas pipeline ROW. Additional information on public access relative to fishing and hunting and potential water quality impacts is provided in Sections 3.21, Subsistence; 3.16, Recreation; and 3.7, Water Quality.

Water Withdrawals and Releases

Potential impacts during construction of the pipeline also could result from the withdrawal of water from local ponds, tributaries, rivers, and streams for development of temporary ice roads, general water use, and for pipeline hydrotesting. Volumes of water required for hydrotesting would vary depending on the segment length tested but could require up to 15 Mgal. As described in Section 2.3.2.3.5, discharges of water and sediment to local drainages also would occur during pipeline hydrotesting. All water used for hydrotest purposes would be tested before discharge, as required by applicable project permits. An APDES permit would be acquired for the discharge of hydrostatic testing water. In addition, energy dissipating devices and/or filter bags would be used to prevent scour, erosion, suspension of sediment, and damage to vegetation. Tables 8-12 and 8-12a in the Donlin Gold Natural Gas Pipeline Plan of Development provide a preliminary list of potential water extraction sites relative to construction milepost, season of use, waterbody type, years of use, and extraction rate and quantity (SRK 2013b).

While water withdrawals and discharges of test water have the potential to affect local water levels, streamflows, water quality, and fish habitat. Impacts to fish from these water withdrawal activities would be similar to those described for the Mine Site and include changes to streamflow and spawning habitat, changes to salmon production, and changes to overall aquatic habitat. These water withdrawal activities would be conducted consistent with requirements specified in ADNR water withdrawal permits, ADF&G Title 16 Fish Habitat Permits, and ADEC water discharge permits. These permits would establish fish-protection measures relative to screening of pump intakes, the locations and amounts/rates of water that could be withdrawn from various sources, and water quality discharge requirements. These requirements also would be incorporated into the detailed Pressure Test Plan developed during final design.

The rate and volume of water withdrawals and discharges would be monitored for permit compliance at each approved supply source and discharge point to ensure aquatic habitat and fish populations in the affected streams are protected, particularly for reaches identified as having habitat important for egg incubation and overwintering. These and other considerations could restrict water withdrawals from certain streams or stream reaches for ice road construction as determined by future agency consultations during the water withdrawal and discharge permit application review processes. Supplemental baseline surveys of the affected stream reaches where water withdrawals or discharges are proposed also may be required to identify and evaluate potential site-specific impacts that could require alternative locations to reduce impacts to fish populations and their habitat.

Construction

Details on the effects to hydrology and erosion from the construction of the pipeline are discussed in Section 3.2, Soils, and Section 3.5, Surface Water Hydrology. Based on proposed design measures, BMPs, and compliance monitoring, potential impacts from pipeline construction on surface waters, aquatic habitats, and anadromous and/or resident fish populations may be noticeable with a potential for acute or obvious changes to the character and quantity of aquatic habitat. Activities involving pipeline installation, stream crossings, construction access roads, and water withdrawals and discharges for ice roads and pipeline hydrotesting would extend through the Construction Phase, and involve direct impacts limited to the vicinity of the project footprint. Indirect impacts to fish and aquatic resources could extend throughout the EIS Analysis Area. The context of impacts would affect waters regulated as EFH in many locations. The duration of construction at any single point along the 316-mile pipeline ROW would last about three to four months until final grading is completed. Over 68 percent of the pipeline construction would be scheduled during frozen winter conditions to reduce impacts of disturbance to soils and surface waters.

Along the pipeline route, a compressor station would be constructed at MP 0.4. With the exception of two aboveground fault crossings that would extend over a distance of about 1,300 feet, the rest of the pipeline would be installed below ground. Construction would take place within an operational ROW about 50 feet wide along most of the route. The operational ROW would be slightly wider in certain locations to accommodate the compressor station and other related facilities. As compared to the operational ROW, the construction ROW would require clearing that typically would be up to 150 feet wide with additional width in certain areas for staging of equipment and supplies.

Operations

During Pipeline Operations, all temporary construction access roads, storage yards, airstrips, and related facilities would be reclaimed. The portion of the construction ROW outside the operational ROW also would be reclaimed. Limited soil disturbance would occur periodically over the 30 years of the pipeline's use as a result of maintenance access and related activities, operations at material borrow sites, ATV access, vegetation management, equipment removal and replacements, pipeline inspections, and ROW mitigation activities. Until disturbed soils are stabilized and reclamation has been completed with fully restored plant communities, runoff and stream sedimentation could result in noticeable adverse effects to aquatic habitat and anadromous or resident fish populations. The context of impacts would affect streams regulated as EFH.

Closure

During Closure, in-place abandonment of the pipeline following purging would result in no effects on runoff, stream sedimentation, instream flows, or aquatic habitats along most of the ROW. Some soil disturbance and runoff could occur where above grade facilities are dismantled and removed. Nearby streams in such areas would be subject to potential runoff from disturbed soils until the areas of disturbance are stabilized, however, potential impacts would be minimized by established BMPs. Depending on the effectiveness of BMPs implemented where above grade facilities are removed, such activities could result in noticeable adverse changes to nearby aquatic habitat and anadromous or resident fish populations. The character or quantity of aquatic habitat would be reduced infrequently but not longer than the span of one year and would be expected to return soon to pre-activity levels. The context of impacts would affect waters regulated as EFH.

Summary of Pipeline Impacts

Anticipated effects from Alternative 2 would involve anadromous and resident fish populations and associated aquatic habitats downstream of certain pipeline crossings not crossed using HDD methods and along the construction ROW where it is aligned near and upgradient from local streams. Potential direct and indirect impacts related to habitat degradation could result from stormwater runoff, suspended solids, and altered flows caused by disturbed soils; water withdrawals for ice-road construction and pipeline hydrotesting; construction of stream crossings using open-trench methods; and water releases from pipeline hydrotesting.

Such impacts would be lessened based on implementation of construction BMPs and permit requirements including those to be specified in the Title 16 Fish Habitat Permit once final design is completed. Potential Construction impacts would be no longer than the span of one year, while those extending through Operations and Closure would occur for up to 30 years. Because of the 316-mile length of the Pipeline, the extent or scope of potential impacts along the ROW would extend throughout the EIS Analysis Area. Potential impacts would affect reaches of streams at crossings or along the pipeline ROW that are classified as EFH under the Magnuson-Stevens Act.

3.13.3.2.4 CLIMATE CHANGE SUMMARY FOR ALTERNATIVE 2

Predicted overall increases in temperatures and precipitation and changes in the patterns of their distribution (McGuire 2015; Chapin et al. 2010; 2006; Walsh et al. 2005) have the potential to influence the projected effects of the Donlin Gold Project on wetland and water body habitats. Expected changes include species range shifts to fish tolerant of warmer waters; temporal shifts in prey and predators; food web alterations due to temperature and acidification changes; habitat changes such as turbidity increase; or shifts in run timing (ADF&G 2010b, IUCN 2009). Higher water temperatures increasing metabolic stress for fish species could result in lower tolerance thresholds to land-use impacts. A positive effect may be that an increase in water temperature could contribute to a more productive feeding season and enable fish to better survive the winter and additional stress. See Section 3.26, Climate Change, for further details on climate change and resources.

3.13.3.2.5 SUMMARY OF IMPACTS FOR ALTERNATIVE 2

Applying the methodology defined in Table 3.13-22 to the information and data presented in this section, Alternative 2 has potential direct and indirect impacts to fish and aquatic resources. Table 3.13-26 provides a summary of impacts by the four assessment factors.

Under Alternative 2, impacts to fish and aquatic resources that may not be noticeable could result from:

- Limited riverbed scour and aquatic habitat degradation from tugs traveling along the wide sections of the Kuskokwim River navigation channel in depths greater than 10 feet;

- Potential fish displacement or stranding along shorelines where the river channel is relatively wide or where the line of travel by barges is a relatively long distance from shore;
- Tug propeller shear force-related fish injuries or mortalities when small young-of-year fish are widely dispersed and not concentrated near barge traffic in confined channel segments along the navigation route;
- Water management and water quality effects in lower reaches of Crooked Creek below the Crevice Creek confluence, well downstream from the Mine Site area; and
- Habitat degradation along the mine access road and most of the natural gas pipeline alignment.

Under Alternative 2, noticeable impacts that may cause acute or obvious changes could result from:

- Streamflow reduction and sedimentation that cause local effects to fish populations and aquatic habitat in Crooked Creek and its tributaries in the vicinity of the Mine Site area;
- Barge traffic waves and turbulence that could displace or strand young-of year salmon or degrade shoreline water quality along shorelines of confined segments of the Kuskokwim River navigation channel (four of five of the narrowest channel segments are located at or upriver from BTC);
- Riverbed scour and degradation of aquatic habitat, in areas utilized for rainbow smelt spawning and egg-incubation in late May and June as a result of tug propeller forces along the navigation channel where depths are shallow and generally less than about 8-10 feet; and
- Potential injuries or mortalities from tug propeller shear forces when small young-of-year salmon or resident fishes are migrating in dense concentrations, particularly where barge traffic is passing through constricted channel segments of the river.

Table 3.13-26: Alternative 2 Impacts by Project Component

Impacts	Magnitude or Intensity	Duration	Extent or Scope	Context
Mine Site				
Habitat alterations, injury, and mortality from in-stream habitat removal and fish loss	Lewis, Snow, and Omega Gulch – Changes in the character and quantity of aquatic habitat would be noticeable. Incidents of injury or mortality to individual fish or other aquatic biota are detectable but populations remain within normal variation. American and Anaconda Creek – Changes to the character and quantity of aquatic habitat would be acute or obvious. Incidents of mortality or injury to individual fish or other aquatic biota create population-level effects.	All affected Creeks -The character or quantity of aquatic habitat would not be anticipated to return to its pre-disturbance character or levels. Potential for mortality or injury to fish or other aquatic biota would persist after actions that caused the disturbance have ceased.	All affected Creeks -Impacts to aquatic habitat would be limited geographically to waters in the vicinity of the project footprint and the associated watersheds.	Lewis, Snow, and Omega Gulch – Impacts would affect aquatic habitat that is regulated as EFH; such habitat would not be depleted in the locality. American and Anaconda Creek – Impacts would affect aquatic habitat that is regulated as EFH.
Habitat alterations from water management practices	Mine Site Tributaries — Changes in the character and quantity of aquatic habitat would be noticeable. Crooked Creek- Changes in the character or quantity of aquatic habitat may not be measurable or noticeable.	Mine Site Tributaries and Crooked Creek - The character or quantity of aquatic habitat would not be anticipated to return to its pre-disturbance character or levels.	Mine Site Tributaries and Crooked Creek - Impacts to aquatic habitat would be limited geographically to waters in the vicinity of the project footprint and the associated watershed(s).	Mine Site Tributaries and Crooked Creek - Impacts would affect aquatic habitat that is regulated as EFH.

Table 3.13-26: Alternative 2 Impacts by Project Component

Impacts	Magnitude or Intensity	Duration	Extent or Scope	Context
Habitat alterations from water quality practices	Changes in the character or quantity of aquatic habitat may not be measurable or noticeable.	The character or quantity of aquatic habitat would not be anticipated to return to its pre-disturbance character or levels.	Impacts to aquatic habitat would be limited geographically to waters in the vicinity of the project footprint and the associated watershed(s).	Impacts would affect aquatic habitat that is regulated as EFH.
Habitat alterations from wetland and riparian buffer removal	Changes in the character and quantity of aquatic habitat would be noticeable, and may be acute or obvious.	The character or quantity of aquatic habitat may not be anticipated to return to its pre-disturbance character or levels.	Impacts to aquatic habitat would be limited geographically to waters in the vicinity of the project footprint and the associated watershed(s).	Impacts would affect aquatic habitat that is regulated as EFH.
Habitat alterations from streamflows changes and overall aquatic habitat	Mid Reaches – Changes in the character and quantity of aquatic habitat would be noticeable. Lower Reaches – Changes in the character or quantity of aquatic habitat may not be measurable or noticeable. Mid and Lower Reaches Under *High K* Scenario - Changes to the character and quantity of aquatic habitat would be acute or obvious.	All stream reaches - the character or quantity of aquatic habitat would be reduced during and beyond the life of the project.	All stream reaches - impacts to aquatic habitat would be limited geographically to waters in the vicinity of the project footprint and the associated watershed(s).	All stream reaches - impacts would affect aquatic habitat that is regulated as EFH.

Table 3.13-26: Alternative 2 Impacts by Project Component

Impacts	Magnitude or Intensity	Duration	Extent or Scope	Context
Habitat alterations from streamflows changes to off-channel aquatic habitat	Mid Reaches – Changes in the character and quantity of aquatic habitat would be noticeable. Lower Reaches – Changes in the character or quantity of aquatic habitat may not be measurable or noticeable. Mid/Lower Reaches *High K* Scenario - Changes to the character and quantity of aquatic habitat would be acute or obvious.	All stream reaches - the character or quantity of aquatic habitat would be expected to last during and beyond the life of the project.	All stream reaches - impacts to aquatic habitat would be limited geographically to waters in the vicinity of the project footprint and the associated watershed(s).	All stream reaches - impacts would affect aquatic habitat that is regulated as EFH.
Habitat alterations from streamflows changes, spawning habitat, and mainstem aquatic habitat	Changes in the character and quantity of aquatic habitat would be noticeable. *High K* scenario - Changes to the character and quantity of aquatic habitat would be acute or obvious.	All stream reaches - the character or quantity of aquatic habitat would be reduced during and beyond the life of the project.	All stream reaches - impacts to aquatic habitat would be limited geographically to waters in the vicinity of the project footprint and the associated watershed(s).	All stream reaches - impacts would affect aquatic habitat that is regulated as EFH.
Habitat alterations from streamflows changes and freezing of salmon spawning substrate	Middle Reaches – Changes in the character or quantity of aquatic habitat may not be measurable or noticeable. Lower Reaches - Changes in the character or quantity of aquatic habitat may not be measurable or noticeable. Mid/Lower Reaches *High K* scenario - Changes to the character and quantity of aquatic habitat would be acute or obvious.	All stream reaches - the character or quantity of aquatic habitat would be reduced during and beyond the life of the project.	All stream reaches - impacts to aquatic habitat would be limited geographically to waters in the vicinity of the project footprint and the associated watershed(s).	All stream reaches - impacts would affect aquatic habitat that is regulated as EFH.

Table 3.13-26: Alternative 2 Impacts by Project Component

Impacts	Magnitude or Intensity	Duration	Extent or Scope	Context
Habitat alterations from streamflows changes and Crooked Creek salmon production	Middle Reaches – Changes in the character or quantity of aquatic habitat may be noticeable relative to salmon production. Lower Reaches - Changes in the character or quantity of aquatic habitat may not be measurable or noticeable. Mid/Lower Reaches *High K* scenario - Changes to the character and quantity of aquatic habitat would be acute or obvious relative to salmon production.	All stream reaches - the character or quantity of aquatic habitat would be reduced during and beyond the life of the project.	All stream reaches - impacts to aquatic habitat would be limited geographically to waters in the vicinity of the project footprint and the associated watershed(s).	All stream reaches - impacts would affect aquatic habitat that is regulated as EFH.
Injury and mortality from streams temperature changes in Crooked Creek	Near the Mine Site - Incidents of injury or mortality to fish eggs may be detectable but populations would remain within normal variation. Lower Crooked Creek – No noticeable incidents of injury or mortality to individual fish or other aquatic biota; population level effects are not detectable.	Potential for mortality or injury to fish or other aquatic biota would persist after actions that caused the disturbance have ceased.	Impacts to aquatic habitat would be limited geographically to waters in the vicinity of the project footprint and the associated watershed(s).	Impacts would affect individuals or populations of fish in Crooked and certain tributaries regulated as EFH.
Behavioral disturbance and habitat alterations from erosion & sedimentation	Changes in the character and quantity of aquatic habitat could be noticeable. Noticeable changes in the behavior of fish may affect reproduction, feeding, or survival of individuals.	The character or quantity of aquatic habitat would be reduced during and beyond the life of the project. Behavior patterns of fish or other aquatic biota are altered by ongoing activity and would return to pre-activity levels after actions causing impacts cease.	Impacts to aquatic habitat would be limited geographically to waters in the vicinity of the project footprint and the associated watershed(s).	Impacts would affect individuals or populations of fish in Crooked Creek, American Creek, and Anaconda Creek, all of which are regulated as EFH.

Table 3.13-26: Alternative 2 Impacts by Project Component

Impacts	Magnitude or Intensity	Duration	Extent or Scope	Context
Habitat alterations from methylmercury emissions	Changes in the character or quantity of habitat from mercury methylation in area wetlands would not be measurable or noticeable and is not expected to increase from mine activities. Changes in the character or quantity of habitat from mercury methylation in surface waters would not be measurable or noticeable and is not expected to increase from mine activities.	The character or quantity of aquatic habitat would be reduced beyond the life of the project.	Impacts to aquatic habitat would extend beyond a local reach of stream or watershed and potentially throughout the EIS Analysis Area.	Impacts would affect aquatic habitat that is regulated as EFH.
Transportation Corridor				
Habitat alterations from vessel wave energy impacts on nearshore erosion, turbidity, and water temperature	Changes in the character or quantity of aquatic habitat from erosion, turbidity, and water temperature may not be measurable or noticeable.	The character or quantity of aquatic habitat would be reduced during and beyond the life of the project.	Impacts to aquatic habitat would be limited geographically to waters in the vicinity of the project footprint and the associated watershed(s).	Impacts would affect aquatic habitat that is regulated as EFH.
Behavioral disturbance and habitat alterations from fish displacement and stranding	Changes in behavior of fish and aquatic biota may not be noticeable and fish populations would remain in the vicinity. Along confined channel segments, noticeable changes in behavior of fish may affect reproduction, feeding, or survival of individuals.	Behavioral patterns of fish or other aquatic biota are altered by ongoing activity and would return to pre-activity levels after actions causing impacts cease.	Impacts to aquatic habitat would be limited geographically to waters in the vicinity of the project footprint and the associated watershed(s).	Impacts would affect the mainstem Kuskokwim River that is regulated as EFH.

Table 3.13-26: Alternative 2 Impacts by Project Component

Impacts	Magnitude or Intensity	Duration	Extent or Scope	Context
Habitat alterations from prop wash scour of riverbed substrates and fish spawning gravels	Changes to the character or quantity of aquatic habitat would be noticeable and possibly acute or obvious, particularly in waters with an under keel depth shallower than approximately 8 to 10 feet.	The character or quantity of aquatic habitat would be reduced during and beyond the life of the project.	Impacts to aquatic habitat would be limited geographically to waters in the vicinity of the project footprint and the associated watershed(s).	Impacts would affect the mainstem Kuskokwim River that is regulated as EFH.
Propeller-induced fish injury and mortality	Varies with the life stage of fish that would be at risk. Fish eggs, larvae, and small young-of-year juvenile life stages moving downstream may experience population-level effects.	Events with potential for causing mortality or injury to fish or other aquatic biota would continue for up to the life of the project.	Impacts to fish or other aquatic biota would be limited to the vicinity of the project footprint and affected watershed.	Impacts would affect individuals or populations of fish or other aquatic biota that are regulated as EFH.
Behavioral disturbance and habitat alterations from mine access road Construction and Operations	Road work and stream crossings - Impacts to fish populations may be detectable but populations would remain within normal variation. Rock blasting – Changes in behavior of fish or other aquatic biota may not be noticeable; fish populations remain in the vicinity.	Road work and stream crossings - Behavioral patterns of fish and other aquatic biota are altered by ongoing activity and would return to pre-activity levels after road work and stream crossings are complete. Rock Blasting - Behavior patterns of fish and other aquatic biota are infrequently altered, but not longer than the span of Construction and would be expected to return to pre-activity levels after rock blasting has ceased.	Impacts to fish or other aquatic biota would be limited to the vicinity of the project footprint and affected watershed.	Impacts would affect populations of fish or other aquatic biota that are regulated as EFH.
Habitat alterations from port site Construction and Operations	Changes in the character and quantity of aquatic habitat would be noticeable.	The character or quantity of aquatic habitat would be reduced during and beyond the life of the project.	Impacts to aquatic habitat would be limited to waters in the vicinity of the project footprint and associated watersheds.	Impacts would affect aquatic habitat that is regulated as EFH.

Table 3.13-26: Alternative 2 Impacts by Project Component

Impacts	Magnitude or Intensity	Duration	Extent or Scope	Context
Pipeline				
Behavioral disturbance and habitat alterations from streams crossings, water withdrawals and discharges from ice road construction and pipeline testing	Varies on nature, location, and duration of a potential frac-out release. Noticeable changes may occur in behavior of fish or other aquatic biota due to pipeline-related project activities that may affect reproduction, feeding, or survival of individuals.	Behavior patterns and habitat of fish and other aquatic biota and are infrequently altered, but not longer than the span of Construction and would be expected to return to pre-activity levels after stream crossings are complete.	Impacts to aquatic habitat would be limited to waters in the vicinity of the project footprint and associated watersheds.	Impacts would affect aquatic habitat that is regulated as EFH.
Behavior disturbance and habitat alterations during Construction and Operations of pipeline and related infrastructure	Varies with proposed design measures, BMPs, and compliance monitoring. Changes to aquatic habitats and/or resident fish populations may be noticeable with a potential for acute or obvious changes.	Behavioral patterns and habitat of fish and other aquatic biota are altered by ongoing activity and would return to pre-activity levels after actions causing impacts cease.	Impacts to fish and aquatic habitat would extend beyond a local reach of stream or watershed and potentially throughout the EIS Analysis Area.	Impacts would affect aquatic habitat that is regulated as EFH.
Behavioral disturbance and habitat alteration during Closure	Depending on the effectiveness of BMPs implemented where above grade facilities are removed, impacts could result in noticeable adverse changes to nearby aquatic habitat and anadromous or resident fish populations.	Behavior patterns and habitat of fish and other aquatic biota and are infrequently altered, but not longer than the span of Construction and would be expected to return to pre-activity levels after stream crossings are complete.	Impacts to fish and aquatic habitat would extend beyond a local reach of stream or watershed and potentially throughout the EIS Analysis Area.	Impacts would affect aquatic habitat that is regulated as EFH.

3.13.3.2.6 MITIGATION AND MONITORING FOR ALTERNATIVE 2

Effects determinations take into account impact reducing design features (Table 5.2-1 in Chapter 5, Impact Avoidance, Minimization, and Mitigation) proposed by Donlin Gold and also the Standard Permit Conditions and BMPs (Section 5.3) that would be implemented.

Design features important in reducing impacts to fish and aquatic resources include:

- The project design includes, where practicable, crossing drainages at right angles and use of bridges to reduce impacts and minimize footprint in riparian areas;
- Surfaces would be progressively reclaimed throughout Operations; sediment controls would include site grading and capping of erodible material, revegetation, and re-routing of surface runoff to reestablish natural conditions;
- A Crooked Creek aquatic resources monitoring plan would be developed in conjunction with ADF&G and ADNR through habitat and water rights permitting processes. The objectives of the plan are to: 1) monitor for major changes to aquatic communities, 2) monitor for smaller scale and incremental changes to aquatic communities, and 3) guide results-based refinement to the monitoring program. The plan would build on the existing baseline dataset and include both biological and flow components, including: fish presence/abundance, invertebrate and periphyton sampling, and fish metals analysis; flow monitoring and winter surface water sampling to characterize fish habitat/passage and freezedown patterns; sediment sampling; and collection of additional geology and hydrology data to refine understanding of dewatering and groundwater/surface water flow dynamics (Donlin Gold 2018a,b; Owl Ridge 2017c). The ongoing data collection would be used in an adaptive management approach to refine the understanding of the dynamics surrounding Crooked Creek flow in winter as well as the open water seasons and to identify the most effective measures that can be used to ensure that minimum flows in Crooked Creek are maintained. If the project results in minimal losses to Crooked Creek flows, adaptive management measures may be unnecessary. If flow losses warrant a response, a range of measures could be considered that include but would not limited to: lining or relocating portions of the stream channel; augmenting flows from the Snow Gulch Reservoir; pumping water from the Kuskokwim River, or grouting areas of bedrock demonstrating high flow rates. (Donlin Gold 2018a);
- Numerous locations and combinations of locations were analyzed for TSF and WRF layouts during the alternatives development process. These are summarized in Appendix C. The layout of major mine facilities was designed to minimize wetland impacts and limit effects on water quality to the American and Anaconda Creek watersheds. The 404(b)(1) analysis will document the steps taken to minimize wetlands impacts;
- Donlin Gold's monitoring program would include monitoring and inspection of stream banks on Crooked Creek and tributaries, where water would be discharged, and corrective action plans for appropriate streambank protection in order to ensure erosion of stream banks does not occur;

- The Alaska Pollutant Discharge Elimination (APDES) five-year permit would be reevaluated, as required, including water flow models and/or pit lake modeling as appropriate. The adequacy of post-Closure Water Treatment Plant (WTP) technology would also be reevaluated as pit lake water monitoring is conducted; and treatment technologies would be adjusted, as necessary, as a result of this evaluation;
- Ocean and river fuel barges would be double hulled and have multiple isolated compartments for transporting fuel to reduce the risk of a spill;
- The barge operations system was designed to avoid the need for dredging the navigation channel in the river;
- Donlin would implement barge guidelines for operating at certain river flow rates, and conduct ongoing surveys of the Kuskokwim River navigation channel to identify locations that should be avoided to minimize effects on bed scour and the potential for barge groundings. As part of the proposed operation, equipment will be available to free or unload/lighter barges in the event of groundings. The equipment will be available as part of ongoing operations, it will not all be dedicated standby equipment;
- The project design includes a communication program, managed under purview of the DATROC Barge Subcommittee, to keep local communities informed of the schedules and current status of barge traffic as well as minimize displacement of subsistence fishing by barges (see Appendix W for Donlin Gold's Barge Communication Plan). Donlin Gold would consult with people experienced with navigation on Kuskokwim River to incorporate local knowledge as they are designing their barging operations and guidelines;
- To reduce impacts on existing river traffic and potential for groundings and accidents, Donlin would establish navigational aids and develop procedures for queuing in narrow channels. Donlin Gold vessels would use state-of-the-art navigation and communication equipment;
- Donlin would implement barge guidelines for operating at certain river flow rates, and conduct ongoing surveys of the Kuskokwim River navigation channel to identify locations that should be avoided to minimize effects on bed scour and the potential for barge groundings. As part of the proposed operation, equipment will be available to free or unload/lighter barges in the event of groundings. The equipment will be available as part of ongoing operations, it will not all be dedicated standby equipment;
- Culverts and bridges on transportation routes would be designed for fish passage;
- Monitoring of bank erosion immediately upstream and downstream of Angyaruaq (Jungjuk) port would continue, with measures applied, as warranted, for streambank protection as part of adaptive management (as a Standard Operating Procedure). If warranted, this may include installation of geotextile matting, riprap armoring or methods from the ADF&G Streambank Revegetation and Protection Manual (Walter et al. 2005), such as willow staking, to reduce the effects of eddy formation, scour, and bank erosion during flood events (BGC 2014e); and
- Donlin Gold would develop and implement a rainbow smelt monitoring program to establish additional baseline data for a better understanding of the species' occurrence and the character, use, and distribution of spawning habitat along the Kuskokwim

River. Survey methodology would likely include documenting sex ratio and age structure of the population and if possible, fecundity of females. Initially, surveys would be conducted annually to document the age structure of the rainbow smelt population and further document spawning patterns. Once an adequate baseline is established, regular sampling would be used to monitor for changes to existing patterns. The frequency of surveys over the long-term would depend on previous results and whether the data indicate a potential shift. If rainbow smelt population changes are observed over a defined time period, additional work would need to be undertaken to investigate the reason for those changes. If observed changes were attributed to project-related activities, Donlin Gold would implement an assessment of measures available to address or mitigate those activities. Such activities would be coordinated with the DATROC Subsistence Subcommittee. (Donlin Gold 2018a).

Standard Permit Conditions and BMPs important in reducing impacts to fish and aquatic resources include:

- Designing and installing culverts and bridges on transportation routes for fish passage;
- Implementation of Stormwater Pollution Prevention Plans (SWPPPs) and/or Erosion and Sediment Control Plans (ESCPs) and use of industry standard BMPs for sediment and erosion control;
- Development and maintenance of ODPCPs, SPCC Plans, and FRPs;
- Preparation and implementation of a Reclamation and Closure Plan (SRK 2017f);
- Using secondary containment for the storage of all fuel and hazardous or dangerous materials at the shipping terminals, Mine Site area, and gas pipeline alignment during all phases of the proposed project to prevent potential releases from fuel handling, tank failures, or contaminated stormwater from reaching the aquatic environment;
- Compliance with ADNR Temporary Water Use Authorization conditions for water withdrawal, such as screening requirements to avoid fish entrainment or injury, establishing water withdrawal rates and volumes, and as appropriate timing of water withdrawal to avoid fish migration, spawning, and incubating eggs;
- Monitoring of water withdrawals to ensure permitted limits are not exceeded;
- Monitoring Mine Site facilities and associated surface water and groundwater, water in Crooked Creek, and discharge water from WTPs during all project phases; as established in State of Alaska permits to ensure the proper reclamation is completed for the protection of aquatic resources in Crooked Creek;
- Compliance with permit provisions established by the State of Alaska to ensure the proper protection of aquatic resources in Crooked Creek pursuant to the Appropriation and Use of Water (11 AAC 90.035-147), Anadromous Fish Act (AS 16.05.871-901), and Fish Passage Act (AS 16.05.841);
- Potable well siting, construction, treatment, monitoring, and decommissioning in accordance with ADEC source water assessment and drinking water protection programs; and use of waste management BMPs under RCRA and ADNR solid waste programs (SRK 2016b) to minimize potential wellhead sources of contamination to drinking water wells; and

- Development and implementation of an Invasive Species Prevention and Management Plans (ISPMP) and application of industry-standard BMPs relating to nonnative invasive species (NNIS) prevention and management.

Additional measures are being considered by the Corps and Cooperating agencies and are further assessed in Chapter 5, Impact Avoidance, Minimization, and Mitigation (Section 5.5 and Section 5.7). Examples of additional measures being considered that are applicable to this resource include:

- Restore riparian areas at stream crossings along the pipeline;
- Establish minimum flows in Crooked Creek;
- Install well field on west side of Crooked Creek to supplement flow loss from dewatering;
- Reclaim lower portions of Snow and Ruby gulches, which have been disturbed by placer mining, to provide stable habitats for fish passage and shallow productive rearing (Owl Ridge 2017c; Donlin Gold 2018a);
- Modify fish migration barriers in the south fork of Getmuna Creek (cascades/falls in incised gorge) by providing resting pools at appropriate locations to encourage passage to upper reaches with extensive spawning and rearing habitat (Owl Ridge 2017c; Donlin Gold 2018a);
- For marine barging in the Bearing Sea - implement measures to minimize the risk of spills, including: avoiding operation of watercraft in fall and winter and in the presence of sea ice to the extent practicable; using double-hull tanks for fuel transport to reduce tank rupture risk; and using fully-operated vessel navigation systems composed of radar, chartplotter, sonar, marine communications systems, and satellite navigation receivers, as well as automatic identification system (AIS) for vessel tracking;
- Add an upstream monitoring site on Donlin Creek as a control point for monitoring water quality and discharge to enhance understanding of dewatering impacts on Crooked Creek habitat (monitoring site DCBO was specifically suggested as a location for background monitoring);
- Conduct water quality monitoring during Operations in the sedimentation ponds downgradient of the North and South overburden stockpiles, as well as in Lewis Gulch for the North overburden pile. Monitoring results would form the basis for additional adaptive management measures (such as increased pumping or pond size) to reduce potential water quality effects;
- Conduct Crooked Creek monitoring that may incorporate adaptive management elements, including:
    - Conduct further analysis of alternative WTP discharge points higher in the drainage (e.g., Queen, Lewis or American) or use of Snow Gulch Reservoir to supplement flow to reduce impacts to aquatic species;
    - Implement low flow requirements in Crooked Creek in the event that, based on streamflow monitoring, flow losses from pit dewatering are outside the magnitude of historical seasonal variations; and

  - o Monitor for adequate winter discharge measurements at the Crooked Creek gauging stations;

- If warranted, install a slurry wall or grout curtain between Crooked Creek and the pit (recommended placement at the margin of the alluvium) to minimize stream flow loss due to pit dewatering. This measure would require monitoring during dewatering and further evaluation to assess effectiveness in reducing vertical flow;
- If warranted, divert water in Crooked Creek that is subject to streambed loss from dewatering through a culvert or lined open-flow channel (flume), which could be seasonally controlled by a floodgate or similar structure;
- Monitor riparian crossing sites to identify areas that need additional restoration to prevent bank erosion which would be implemented after construction; and
- Conduct monitoring and analysis for mercury-related concerns, including:
  - o Include methylmercury fish tissue (e.g., pike and burbot) monitoring. If mercury levels exceed standards, develop and define contingency measures through adaptive management elements if impacts occur, and define objectives in an adaptive management plan;
  - o Building on the biomonitoring program to date (e.g., Ottertail 2014c) and fish tissue metals testing proposed as part of the aquatics monitoring plan, conduct a baseline survey and monitoring of mercury levels in macroinvertebrates and fish within the Project Area, larger HHRA Study Area, and a control site to monitor potential mercury deposition from the mine; and
  - o Conduct a periodic re-evaluation of the HIA / HHRA during and after mining activities (adaptive management), including periodic literature reviews or surveys, to confirm that the exposure assumptions and consumption assumptions made in the HHRA remain valid.

3.13.3.3 ALTERNATIVE 3A – REDUCED DIESEL BARGING: LNG-POWERED ROCK TRUCKS

3.13.3.3.1 MINE SITE

Under Alternative 3A, direct and indirect effects to fish and aquatic resources from all three phases of the Mine Site based on the use of LNG-powered rock trucks would be similar to that described for Alternative 2.

3.13.3.3.2 TRANSPORTATION CORRIDOR

Due to the proposed use of LNG-powered rock trucks under this alternative, less diesel fuel would be required at the Mine Site. This would reduce by about two-thirds (from 64 to 19 trips) the number of fuel barge trips from Bethel to the Angyaruaq (Jungjuk) Port site on the Kuskokwim River. Fewer barge trips would result in a proportionate reduction in the amount of tug and barge-generated wakes, prop wash, and riverbed scour that could adversely affect water quality, aquatic habitats, and anadromous and resident fish populations in the mainstem of the Kuskokwim River. The reduction in the number of trips by tug and barge combinations would nearly eliminate requirements for travel during low flow conditions. As a result, effects described above from barge traffic on migrating and rearing fish in confined and shallow sections of the navigation channel would be reduced. While the range of intensity, duration, extent or scope, and context of impacts would be similar to that described for Alternative 2, the probability of such impacts occurring would be proportionately reduced.

3.13.3.3.3 PIPELINE

Under Alternative 3A, direct and indirect effects to fish and aquatic resources from all three phases of the Pipeline would be the same as described for Alternative 2.

3.13.3.3.4 SUMMARY OF IMPACTS FOR ALTERNATIVE 3A

Since the amount of fuel barge trips on the Kuskokwim River would be reduced by two-thirds under Alternative 3A, the anticipated level of impacts from barge traffic and accidental releases of fuel would be less than Alternative 2. Impacts from the Mine Site and Transportation Corridor would be the same as Alternative 2. Impacts associated with climate change would also be the same as those discussed for Alternative 2.

Design features, Standard Permit Conditions and BMPs related to fish and aquatic resources are described in Alternative 2. Examples of additional measures being considered that are applicable to this resource are listed under Alternative 2.

3.13.3.4 ALTERNATIVE 3B – REDUCED DIESEL BARGING: DIESEL PIPELINE

Two options to Alternative 3B have been added based on Draft EIS comments from agencies and the public:

- Port MacKenzie Option: The Port MacKenzie Option would utilize the existing Port MacKenzie facility to receive and unload diesel tankers instead of the Tyonek facility considered under Alternative 3B. A pumping station and tank farm of similar size to the Tyonek conceptual design would be provided at Port MacKenzie. A pipeline would extend northwest from Port MacKenzie, route around the Susitna Flats State Game Refuge, cross the Little Susitna and Susitna rivers, and connect with the Alternative 3B alignment at approximately MP 28. In this option, there would be no improvements to the existing Tyonek dock; a pumping station and tank farm would not be constructed near Tyonek; and the pipeline from the Tyonek tank farm considered under Alternative 3B to MP 28 would not be constructed.
- Collocated Natural Gas and Diesel Pipeline Option: The Collocated Natural Gas and Diesel Pipeline Option (Collocated Pipeline Option) would add the 14-inch-diameter natural gas pipeline proposed under Alternative 2 to Alternative 3B. Under this option, the power plant would operate primarily on natural gas instead of diesel as proposed under Alternative 3B. The diesel pipeline would deliver the diesel that would be supplied using river barges under Alternative 2 and because it would not be supplying the power plant, could be reduced to an 8-inch-diameter pipeline. The two pipelines would be constructed in a single trench that would be slightly wider than proposed under either Alternative 2 or Alternative 3B and the work space would be five feet

wider. The permanent pipeline ROW would be approximately two feet wider. This option could be configured with either the Tyonek or Port MacKenzie dock options.

3.13.3.4.1 MINE SITE

Under Alternative 3B, direct and indirect effects to fish and aquatic resources from all three phases of the Mine Site based on delivery of fuel from a diesel pipeline would be similar to that described for Alternative 2.

3.13.3.4.2 TRANSPORTATION CORRIDOR

Under Alternative 3B, diesel fuel would be shipped via ocean barges to Tyonek at the eastern terminus of the diesel pipeline while cargo would be transported to the Mine Site, as described under Alternative 2, via the Kuskokwim River and mine access road. This would reduce or eliminate the need for additional diesel fuel storage described under Alternative 2 at the ports of Dutch Harbor, Bethel, and Angyaruaq (Jungjuk). During Construction of the Angyaruaq (Jungjuk) port site, mine access road, and Mine Site, diesel fuel would need to be transported by barge to the Angyaruaq (Jungjuk) port site. This would reduce barging on the Kuskokwim River from 122 annual barge trips during Operations in Alternative 2 to 64 annual barge trips in Alternative 3B. Any actions that would occur at Dutch Harbor or the Port of Bethel at the Bethel Yard Dock are not part of the proposed action, and are considered connected actions (see Section 1.2.1, Connected Actions, in Chapter 1, Project Introduction and Purpose and Need).

Similar to Alternative 3A, fewer barge trips on the Kuskokwim River would result in a proportionate reduction in the amount of tug and barge-generated wakes and prop wash that could adversely affect water quality, aquatic habitats, and anadromous and resident fish populations. The reduction in the number of trips would nearly eliminate requirements for travel during low flow conditions. As a result, effects of prop wash scour from barge traffic on migrating and rearing fish in confined and shallow sections of the navigation channel would be reduced. While the range of the intensity, duration, extent or scope, and context of impacts would be similar to that described for Alternative 2, the probability of such impacts occurring would be proportionately reduced.

3.13.3.4.3 PIPELINE

An 18-inch (vs. 14-inch under Alternative 2) diameter pipeline would be buried in a 334-mile (vs. 316-mile for Alternative 2) corridor along a similar alignment as Alternative 2. An additional segment, however, would be constructed between the improvements at the Tyonek North Foreland Facility or Pt. MacKenzie and the start of the corridor at Beluga as described under Alternative 2. Because there would be a small incremental increase in additional ROW and off-ROW disturbed areas under Alternative 3B compared to Alternative 2 (from 14,100 to 15,000 acres or 6 percent), there would be a larger, but similar level of effects from erosion and runoff that would vary substantially in intensity. Increased disturbance would include an additional 700 acres for construction of ROW from Tyonek to Beluga. Associated impacts to local streams and drainages from erosion and runoff would be limited, to the extent possible, by erosion and sediment control BMPs. Potential effects to anadromous and resident fish and aquatic resources along the pipeline ROW and in off-ROW areas due to Construction and Closure, therefore, also would be similar to Alternative 2. Additional cargo and fuel, however, would need to be delivered to the Tyonek Forelands terminal for construction of the proposed fuel terminal and pipeline that would extend from Tyonek to Beluga. During Operations, an additional 12 round trip barge trips would arrive at the terminal annually. Potential impacts on fish and aquatic resources near the terminal from the additional barge arrivals are anticipated to be unmeasurable or unnoticeable, unless there was an accidental discharge of diesel fuel to local streams which is evaluated under Section 3.24, Spill Risk.

The route in Alternative 3B-Port MacKenzie Option would include an additional major river crossing at the Susitna River and one intermediate river crossing at the Little Susitna River. The overall length of the pipeline would be roughly equivalent to that proposed for Alternative 3B.

The route in Alternative 3B-Collocated Natural Gas and Diesel Pipeline Option would add an additional five feet of ROW along the alignment. The additional ROW width would not change the overall intensity, duration, extent, or context of impacts of this Option compared to Alternative 3B.

3.13.3.4.4 SUMMARY OF IMPACTS FOR ALTERNATIVE 3B

While fuel barge trips on the Kuskokwim River during Operations would be eliminated under Alternative 3B, the sources and level of impacts during Construction would be similar to Alternative 2, and the impacts associated with the access roads would be longer lasting. Impacts for the Mine Site and Transportation Corridor would be the same as Alternative 2. Impacts associated with climate change would also be the same as those discussed for Alternative 2.

Design features, Standard Permit Conditions and BMPs related to fish and aquatic resources are described in Alternative 2. Examples of additional measures being considered that are applicable to this resource are listed under Alternative 2.

3.13.3.5 ALTERNATIVE 4 – BIRCH TREE CROSSING PORT

3.13.3.5.1 MINE SITE

Under Alternative 4, direct and indirect effects to fish and aquatic resources from all three phases of the Mine Site based on delivery of fuel and cargo from BTC Port site would be similar to that described for Alternative 2.

3.13.3.5.2 TRANSPORTATION CORRIDOR

Under Alternative 4, barge traffic from Bethel would travel about 124 miles upriver to the BTC Port site but would not be required to travel the additional 75 miles to the Angyaruaq (Jungjuk) Port site as proposed under Alternative 2. While this would involve a shorter over-water travel route, it would require the same number of tows, but over fewer days of traffic, since the same amount of cargo and fuel still would be required at the Mine Site during all three phases under both alternatives. Since the Kuskokwim River channel is more confined upriver of the BTC Port site (four of five of the narrowest channel segments are located at or above BTC), the intensity of impacts resulting from barge traffic relative to hydraulic forces from vessel wakes and prop wash on shorelines would be reduced in intensity. In addition, communities upriver of the BTC Port site including Aniak, Chuathbaluk, Napaimute, would not experience an incremental increase in barge traffic from the proposed project as otherwise would occur under Alternative

2. Therefore, potential impacts of vessel wave energy on water quality and fish displacement/stranding during all three phases would be reduced to an unmeasurable or unnoticeable level; potential impacts from tug propeller forces on bed scouring and aquatic habitat that could affect rainbow smelt spawning areas would be the same as Alternative 2, and tug propeller forces on fish injury or mortality would be reduced to an unmeasurable or unnoticeable level. Overall, water transportation impacts on fish and aquatic habitat would range considerably, and may cause acute or obvious changes to the character or quantity of aquatic habitat under a worst case scenario. The duration of impacts would persist for the life of the project and extend throughout the EIS Analysis Area from BTC to Kuskokwim Bay. The context of such impacts would affect waters along the Kuskokwim River navigation channel, from Kuskokwim Bay to BTC and farther upriver, which are regulated as EFH under the Magnuson-Stevens Act.

A single-season 12-mile ice road would be developed during Construction from Crooked Creek Village to the mine site vicinity along Crooked Creek valley as a temporary late-winter access to material borrow sites for road construction. The ice road would be constructed to minimize impacts to underlying vegetation, soils, and drainages by implementing guidelines and management practices that have been established for state and federal lands. Recent improvements in BMPs have shown that construction and use of single-season ice roads can minimize vegetation and soil impacts when routes are properly selected and appropriate construction methods are used by equipment operators (ADNR 2010). Subject to the Title 16 Fish Habitat Permit, water for ice road construction would be withdrawn from approved stream segments using screened pump intakes to prevent injury or death to fish. Water withdrawals would be prohibited in areas where streams freeze completely to the bottom to avoid draining isolated unfrozen pools in the area that may hold overwintering fish. Because vegetation types associated with soils along the anticipated route are not ideal for ice road construction, the landscape and local drainages could be noticeably adversely affected. Degradation of soils and drainages could temporarily affect water quality and in-stream habitat, resulting in adverse effects to fish and aquatic resources until the routes are sufficiently stabilized. The context of potential impacts to Crooked Creek would affect waters regulated as EFH. The single-season use of the ice road should minimize potential effects that might otherwise occur from multi-season use.

A new two-lane, 30-foot-wide, all-season gravel-surfaced mine access road would be constructed from the BTC Port site to the Mine Site. This 76-mile long road would be about 46 miles (1.5 times) longer than the 30-mile long road proposed under Alternative 2 that would connect the Angyaruaq (Jungjuk) Port site with the mine. The longer mine access road from the BTC Port site would require about 900 acres of soil disturbance versus 400 acres required under Alternative 2. The transport of materials on the longer road would require roughly twice as many truck trips to deliver materials because of the longer transit time.

The nature of potential impacts from erosion and sedimentation that could affect local streams crossed or downgradient from the ROW in the Owhat River drainage during Construction and long-term maintenance of the access road, bridges, and culverts would be similar to Alternative 2. Also similar to Alternative 2 are that Construction and Operations activities would be managed and monitored by implementing a suite of BMPs that would be installed and monitored along the road corridor and at all stream crossings to ensure they reduce the intensity of runoff, erosion, and sediment loads and minimize potential impacts to fish, other aquatic life, and their habitats.

Periodic, infrequent barriers to fish passage could occur over all phases of the project continuing through post-Closure monitoring. The intensity of impacts to fish populations may be detectable but populations would remain within normal variation. The intensity would depend on the nature and magnitude of potential blockage incidents and the timing required to properly restore flows and fish passable conditions. Although 43 miles longer than the access road proposed under Alternative 2, preliminary field reconnaissance indicates the route between the BTC Port site and the mine would cross 40 streams, 10 fewer than the number crossed for Alternative 2. Of the streams crossed, 8 would involve bridges while 32 would involve culverts (Alternative 2 would require 6 bridges and 51 culverts). The Owhat River and the lower reaches of several of its tributaries are classified as EFH under the Magnuson-Stevens Act. Similar to Alternative 2, potential impacts to anadromous and resident fish populations and EFH would be noticeable at certain times and locations, affecting sections of drainages downgradient of stream crossings within the vicinity of the project footprint. The duration of impacts may be expected to last during and beyond the life of the project. The access road, bridges, and culverts all would need to be maintained in perpetuity to support ongoing post-Closure monitoring.

In addition to construction of the mine access road, development of the BTC Port site would require disturbance of about 65 acres or nearly twice as much area as would be required for the Angyaruaq (Jungjuk) Port site under Alternative 2. Similar to Alternative 2, port construction at BTC would result in aquatic habitat loss related to removal and upland disposal of about 10,000 cubic yards of dredge material from the Kuskokwim River for construction of shoreline infrastructure including sheetpile walls and berthing features. Impacts associated with the mine access road and port site, therefore, would likely result in noticeable impacts on fish and aquatic resources, however, there would have a higher probability of such impacts occurring due to the road distance being twice as long as Alternative 2. Similar to Alternative 2 bedscour from tug propeller forces could adversely affect rainbow smelt eggs incubating in spawning gravels along the navigation channel near Kalskag (downriver from BTC).

3.13.3.5.3 PIPELINE

Under Alternative 4, direct and indirect effects to fish and aquatic resources from construction, operation, and abandonment/closure of the natural gas pipeline would be the same as described for Alternative 3A.

3.13.3.5.4 SUMMARY OF IMPACTS FOR ALTERNATIVE 4

Under Alternative 4, the upriver extent of barge traffic on the Kuskokwim River would be reduced by about 75 miles. This would eliminate the need for barge traffic in some areas where the river channel tends to be more confined. Although potential impacts from tug propeller forces on rainbow smelt eggs incubating in spawning areas near Kalskag would be similar to Alternative 2, some of the potential impacts on fish and aquatic habitat along shoreline areas would occur at a lower intensity. This is because the channel between Kuskokwim Bay and BTC Port Site is generally wider than it is farther upriver to the Angyaruaq (Jungjuk) Port site under Alternative 2. Also, compared to Alternative 2 there would be 11 fewer stream crossings along the mine access road under this alternative reducing the potential risks of stream sedimentation and water quality impacts from road construction and maintenance as well as fewer culverts to maintain. This would be offset, however, from proportionately greater risks of erosion, runoff, and sedimentation from construction and operation of a roadway that would be 46 miles longer than Alternative 2. The combined effects of Construction and Operations of the roadway would result in a proportionately greater increase in potential water quality and habitat degradation that could adversely affect anadromous and resident fish populations in the Owhat River drainage as compared to Alternative 2. Therefore, the net overall direct and indirect impacts for Alternative 4 also would be similar to Alternative 2. The summary impacts for the Mine Site and Transportation Corridor would be the same as Alternative 2. Impacts associated with climate change would also be the same as those discussed for Alternative 2.

Design features, Standard Permit Conditions and BMPs related to fish and aquatic resources are described in Alternative 2. Examples of additional measures being considered that are applicable to this resource are listed under Alternative 2.

3.13.3.6 ALTERNATIVE 5A – DRY STACK TAILINGS

This alternative includes two options:

- Unlined Option: The TSF would not be lined with a linear low-density polyethylene (LLDPE) liner. The area would be cleared and grubbed and an underdrain system placed in the major tributaries under the TSF and operating pond to intercept groundwater base flows and infiltration through the dry stack tailings (DST) and convey it to a Seepage Recovery System (SRS). Water collecting in the SRS pond would be pumped to the operating pond, lower Contact Water Dam (CWD), or directly to the processing plant for use in process.
- Lined Option: The DST would be underlain by a pumped overdrain layer throughout the footprint, with an impermeable LLDPE liner below. The rock underdrain and foundation preparation would be completed in the same manner as the Unlined Option.

3.13.3.6.1 MINE SITE

Under Alternative 5A, direct and indirect effects to fish and aquatic resources from all three phases of the Mine Site based on the use of a DST method would be similar to what has been described for Alternative 2 where the subaqueous tailings storage method would be used. The reduced storage requirements within the TSF, however, would lessen the risk of potential dam failure and downstream release of slurry materials to Anaconda and Crooked creeks.

3.13.3.6.2 TRANSPORTATION CORRIDOR

Under Alternative 5A, direct and indirect effects to fish and aquatic resources from all three phases of the Transportation Corridor based on mining operations using a DST method would be similar to what has been described for Alternative 2. Although there would be an increased demand for diesel fuel and consumables under this alternative, this would result in a minimal increase in barge traffic and associated effects on fish and aquatic resources over that described under Alternative 2.

3.13.3.6.3 PIPELINE

Under Alternative 5A, direct and indirect effects to fish and aquatic resources from all three phases of the Pipeline based on the use of a DST method would be similar to what has been described for Alternative 2.

3.13.3.6.4 SUMMARY OF IMPACTS FOR ALTERNATIVE 5A

Under Alternative 5A, direct and indirect effects to fish and aquatic resources from all three phases of the Mine Site, Transportation Corridor, and Pipeline based on the use of a DST method would be similar to what has been described for Alternative 2. The effects determinations take into account applicable impact reducing design features and BMPs, as discussed in Alternative 2. The summary impacts for the Mine Site Transportation Corridor would be the same as Alternative 2. Impacts associated with climate change would also be the same as those discussed for Alternative 2.

Design features, Standard Permit Conditions and BMPs related to fish and aquatic resources are described in Alternative 2. Examples of additional measures being considered that are applicable to this resource are listed under Alternative 2.

3.13.3.7 ALTERNATIVE 6A – MODIFIED NATURAL GAS PIPELINE ALIGNMENT: DALZELL GORGE ROUTE

3.13.3.7.1 MINE SITE

Under Alternative 6A, direct and indirect effects to fish and aquatic resources at the Mine Site would be similar to what has been described for Alternative 2.

3.13.3.7.2 TRANSPORTATION CORRIDOR

Under Alternative 6A, direct and indirect effects to fish and aquatic resources associated with the Transportation Corridor would be similar to what has been described for Alternative 2.

3.13.3.7.3 PIPELINE

Under Alternative 6A, the pipeline route would depart to the northwest from the Alternative 2 alignment at about MP 106.5. Overall, ground disturbance impacts would be similar to Alternative 2. This route would cross Happy River and the South Fork of the Kuskokwim River using HDD to minimize soil and streambed disturbance. There would be slightly fewer (22 compared to 28) stream crossings at sites with permafrost/erodible soils and confirmed or potential fish presence under this alternative compared to Alternative 2. Potential direct and indirect effects on fish and aquatic resources would be similar to Alternative 2 and would involve potential habitat degradation from stormwater runoff, suspended solids, and reduced flows caused by disturbed soils and water withdrawals for ice-road construction. Changes in the character or quantity of aquatic habitat may be noticeable. The duration of impacts may be expected to last during and beyond the life of the project. The extent or scope would be limited to waters in the vicinity of the project footprint and associated watershed. The context of these impacts would affect stream reaches crossed by the pipeline ROW that are classified as EFH under the Magnuson-Stevens Act.

3.13.3.7.4 SUMMARY OF IMPACTS FOR ALTERNATIVE 6A

Under Alternative 6A, direct and indirect impacts affecting fish and aquatic resources as a result of all three phases of the Pipeline aligned through the Dalzell Gorge Route would be similar to Alternative 2. The summary impacts for the Mine Site and Transportation Corridor would be the same as Alternative 2. Impacts associated with climate change would also be the same as those discussed for Alternative 2.

Design features, Standard Permit Conditions and BMPs related to fish and aquatic resources are described in Alternative 2. Examples of additional measures being considered that are applicable to this resource are listed under Alternative 2.

3.13.3.8 ALTERNATIVES IMPACT COMPARISON

A comparison of potential impacts among alternatives is presented in Table 3.13-27 below.

Table 3.13-27: Comparison by Alternative for Fish and Aquatic Resources*

	Alternative 2 – Proposed Action	Alternative 3A – LNG-Powered Haul Trucks	Alternative 3B –Diesel Pipeline	Alternative 4 – BTC Port	Alternative 5A – Dry Stack Tailings	Alternative 6A –Dalzell Gorge Route
Impact-causing Project Component						
Mine Site – construction of mine infrastructure, access roads, and related facilities	Construction, Operations, and Closure of open pit, WRF, TSF, and freshwater reservoir: • Tailings storage and operating pond footprint – 2,394 acres Tailings stored in combined tailings and operating pond facility contained by one dam.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Construction, Operations, and Closure of open pit, WRF, TSF, and freshwater reservoir: • Tailings storage and operating pond footprint – 2,463 acres Tailings stored as dry stack upstream of an operating pond; operating pond contained by a main dam and two upper dams	Same as Alternative 2.
Transportation Corridor – increased barge traffic from baseline levels	River and ocean barge traffic: • 50 river cargo trips per year to Angyaruaq (Jungjuk) Port Site (Construction Phase) • 64 river cargo trips per year to Angyaruaq (Jungjuk) Port Site (Operations Phase) • 19 river fuel trips per year to Angyaruaq (Jungjuk) Port Site (Construction Phase) • 64 river fuel trips per year to Angyaruaq (Jungjuk) Port Site (Operations Phase) • 20 pipe and equipment barges to staging area near Devil's Elbow, above Stony River (during first two years of pipeline construction - Construction Phase) • 16 ocean cargo trips per year to Bethel (Construction Phase) • 12 ocean cargo trips per year to Bethel (Operations Phase) • 14 ocean fuel trips per year to Bethel (both Construction and Operations Phases) **Totals:** • 89 river trips per year (Construction Phase) • 122 river trips per year (Operations Phase) • 30 ocean trips per year to Bethel (Construction Phase) • 26 ocean trips per year to Bethel (Operations Phase)	**Differences from Alternative 2:** • 19 river fuel trips per year to Angyaruaq (Jungjuk) Port Site (Operations Phase) • 5 ocean barge fuel trips per year to Bethel (Operations Phase) **Summary Differences:** • 83 river trips per year (Operations Phase) • 17 ocean trips per year to Bethel (Operations Phase)	**Differences from Alternative 2:** • No river fuel trips per year to Angyaruaq (Jungjuk) Port Site (Operations Phase) • No ocean barge fuel trips per year to Bethel (Operations Phase) **Summary Differences:** • 64 river trips per year (Operations Phase) • 12 ocean trips per year to Bethel (Operations Phase)	**Differences from Alternative 2:** • River trips would only go as far as BTC Port Site, rather than Angyaruaq (Jungjuk) Port Site	**Differences from Alternative 2:** • 71 river cargo trips per year to Angyaruaq (Jungjuk) Port Site (Operations Phase) **Summary Differences:** • 129 river trips per year (Operations Phase)	Same as Alternative 2.

Table 3.13-27: Comparison by Alternative for Fish and Aquatic Resources*

	Alternative 2 – Proposed Action	Alternative 3A – LNG-Powered Haul Trucks	Alternative 3B –Diesel Pipeline	Alternative 4 – BTC Port	Alternative 5A – Dry Stack Tailings	Alternative 6A –Dalzell Gorge Route
Pipeline - increased barge traffic from baseline levels	River and ocean barge traffic: • 20 ocean barges during the first year of pipeline construction from Anchorage to Beluga Landing	Same as Alternative 2.	River and ocean barge traffic: • 12 ocean trips per year to Tyonek (Operations Phase)	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.
Pipeline – stream crossings	Pipeline: • Length of 316 miles (North Option would be less than a mile shorter). • 28 stream crossings using HDD and open-cut methods (3 would be along the North Option route specifically).	Same as Alternative 2.	Pipeline: • Length of 334 miles (additional 19-mile segment between Tyonek and the start of the proposed corridor for Alt. 2 • 29 stream/river crossings using open-cut and HDD methods; additional segment would cross the Beluga River using HDD. • Port MacKenzie Option would add additional HDD crossing at the Susitna River and crossing at Little Susitna River. • Collocated Natural Gas and Diesel Pipeline Option would extend ROW by 5 feet.	Same as Alternative 2.	Same as Alternative 2.	Pipeline: • Length of 313 miles • 22 stream crossings using HDD and open-cut methods.
Direct or Indirect Impacts						
Mine Site						
Habitat alterations, injury, and mortality from in-stream habitat removal and fish loss	Direct loss of 8 miles of instream habitat in five Crooked Creek drainages near the mine site. • 5.6 miles of aquatic habitat in American and Anaconda Creeks • 0.66 mile of EFH • 2.36 miles of perennial stream habitat	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.
Habitat alterations from water management and water quality practices	Impacts in five tributaries in the vicinity of the mine site and in the middle and lower reaches of Crooked Creek. Reduced surface flows in nearby tributaries and in the middle reaches of Crooked Creek.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Reduced storage requirements within TSF would lessen risk of potential dam failure and downstream release of slurry materials.	Same as Alternative 2.
Habitat alterations from wetland and riparian buffer removal	Impacts involving about 100 acres of riverine wetlands or river channel including about 5 miles of perennial streams and about 1 mile of intermittent streams.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.

Table 3.13-27: Comparison by Alternative for Fish and Aquatic Resources*

	Alternative 2 – Proposed Action	Alternative 3A – LNG-Powered Haul Trucks	Alternative 3B –Diesel Pipeline	Alternative 4 – BTC Port	Alternative 5A – Dry Stack Tailings	Alternative 6A –Dalzell Gorge Route
Habitat alterations from streamflows changes to off-channel aquatic habitat along Crooked Creek	Reduction of connected off-channel habitat surface area from 15.3 to 11.3 acres. These impacts would be elevated and may be acute or obvious under a *High K* scenario where flow reductions could reach a maximum of 85 to 100 percent.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.
Habitat alterations from streamflows changes to aquatic habitat in the mainstem channel of Crooked Creek	Streamflow reductions up to 33 percent in winter between American Creek and Omega Gulch based on a 10-year flow scenario. These impacts would be elevated and may be acute or obvious under a *High K* scenario.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.
Habitat alterations from streamflows changes and salmon spawning habitat in Crooked Creek	Based on flow depletion model, 21 of 519 salmon redds in Crooked Creek below American Creek would be outside the wetted channel during winter low flow conditions during Mine Site Operations. These impacts would be elevated and may be acute or obvious under a *High K* scenario where flow reductions could reach a maximum of 85 to 100 percent.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.
Habitat alterations from streamflows changes and salmon spawning substrate freezing in Crooked Creek	Impacts may not be measurable or noticeable relative to dewatering or freezing because the majority of observed spawning habitat has been documented in lower Crooked Creek, where streamflow changes are reduced relative to areas in the vicinity of the mine site. These impacts would be elevated and may be acute or obvious under a *High K* scenario where flow reductions could reach a maximum of 85 to 100 percent.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.
Habitat alterations from streamflows changes and Crooked Creek salmon production	Streamflow reductions would affect an estimated 40 adult salmon near the mine site upstream of Crevice Creek. These impacts would be elevated and may be acute or obvious under a *High K* scenario where flow reductions could reach a maximum of 85 to 100 percent.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.

Table 3.13-27: Comparison by Alternative for Fish and Aquatic Resources*

	Alternative 2 – Proposed Action	Alternative 3A – LNG-Powered Haul Trucks	Alternative 3B –Diesel Pipeline	Alternative 4 – BTC Port	Alternative 5A – Dry Stack Tailings	Alternative 6A –Dalzell Gorge Route
Injury and mortality from streams temperature changes in Crooked Creek	1.5 miles upstream of the Crooked Creek confluence on the Kuskokwim River, predicted increase in Celsius degree-day TUs is 156.4, 93, and 18.5 for Chinook, chum, and coho salmon, respectively. These values are within the normal range for chum and coho salmon and just slightly above for Chinook salmon. Just downstream of Crevice Creek, predicted increases in Celsius degree-day TUs is 107.4, 63.3, and 12.6 for Chinook, chum, and coho salmon, respectively. These values are well within the documented normal range of TUs for Chinook, chum, and coho salmon.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.
Behavioral disturbance and habitat alterations from erosion and sedimentation	Disturbance of approximately 9,000 acres of surface soil. Stream sedimentation would depend on effective implementation of BMPs.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.
Habitat alterations from metals and mercury emissions	Depending on future bioavailability, concentrations of mercury in fish in Crooked Creek watershed would be up to 3 percent above current levels and within the range of regional background fish tissue concentrations.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.
Transportation Corridor						
Habitat alterations from vessel wave energy impacts on nearshore erosion, turbidity, and water temperature	Impacts along narrow segments of the Kuskokwim River from predicted wave heights up to 0.80 feet in height. Wave heights of this magnitude could temporarily displace small young-of-year salmon or small resident fishes rearing or migrating along the shore zone.	Compared to Alternative 2, this Alternative reduces total trips in the Transportation Corridor from 122 to 83 river trips and from 26 to 17 ocean trips during the Operations Phase. This would result in a proportionate reduction in the probability of tug and barge-generated wakes, prop wash, and riverbed scour that could adversely affect water quality, aquatic habitats, and anadromous and resident fish populations in the mainstem of the Kuskokwim River.	Compared to Alternative 2, this Alternative reduces total trips in the Transportation Corridor from 122 to 64 river trips and from 26 to 12 ocean trips during the Operations Phase. This would result in a proportionate reduction in the probability of tug and barge-generated wakes, prop wash, and riverbed scour that could adversely affect water quality, aquatic habitats, and anadromous and resident fish populations in the mainstem of the Kuskokwim River.	Compared to Alternative 2, this Alternative would reduce barging distance up the Kuskokwim River by 69 miles. This would result in a reduced impact extent.	Same as Alternative 2.	Same as Alternative 2.

Table 3.13-27: Comparison by Alternative for Fish and Aquatic Resources*

	Alternative 2 – Proposed Action	Alternative 3A – LNG-Powered Haul Trucks	Alternative 3B –Diesel Pipeline	Alternative 4 – BTC Port	Alternative 5A – Dry Stack Tailings	Alternative 6A –Dalzell Gorge Route
Behavioral disturbance and habitat alterations from fish displacement and stranding	Displacement and/or stranding of small young-of-year and possibly some juvenile anadromous fishes from ice breakup to late June during out-migration, particularly in confined channel segments. Potential risks where shallow gradient shorelines are exposed to wave forces from downriver-bound traffic traveling in narrow channel segments.	Compared to Alternative 2, fewer barge trips would result in a proportionate reduction in the probability of tug and barge-generated wakes, prop wash, and riverbed scour that could displace or strand fish.	Compared to Alternative 2, fewer barge trips would result in a proportionate reduction in the probability of tug and barge-generated wakes, prop wash, and riverbed scour that could displace or strand fish.	Compared to Alternative 2, this Alternative would reduce barging distance up the Kuskokwim River by 69 miles. This would result in a reduced impact extent.	Same as Alternative 2.	Same as Alternative 2.
Habitat alterations from prop wash scour of riverbed substrates and spawning gravels	Scouring to gravel-size riverbed substrates at localized areas along the navigation route, particularly in waters with an under keel depth shallower than 8 to 10 feet. Intensity of impacts would depend on depth, speed, location, and other factors associated with tug and barge traffic.	Compared to Alternative 2, this Alternative would result in a reduced impact probability due to fewer fuel barge trips.	Compared to Alternative 2, this Alternative would result in a reduced impact probability due to fewer fuel barge trips.	Compared to Alternative 2, this Alternative would reduce barging distance up the Kuskokwim River by 69 miles. This would result in a reduced impact extent.	Same as Alternative 2.	Same as Alternative 2.
Propeller-induced fish injury and mortality	Intensity of impacts would depend on time of year, time of day, fish life stages (and swimming ability), concentration of fish, and channel character. Fish eggs, larvae, and small young-of-year juvenile fish moving downstream would be at higher risk than upstream migrating adult fish.	Compared to Alternative 2, fewer barge trips would result in a proportionate reduction in the probability of propeller-induced fish injury and mortality.	Compared to Alternative 2, fewer barge trips would result in a proportionate reduction in the probability of propeller-induced fish injury and mortality.	Impacts based on time of year, time of day, fish life stages (and swimming ability), concentration of fish, and channel character; impact is reduced due to shorter distance of barge trips and wider channel traveled. Compared to Alternative 2, this Alternative would reduce barging distance up the Kuskokwim River by 69 miles. This would result in a reduced extent of propeller-induced fish injury and mortality.	Same as Alternative 2.	Same as Alternative 2.
Behavioral disturbance and habitat alterations from mine access road Construction and Operations	Impacts at approximately 51 stream crossings along the 30-mile long mine access road and associated infrastructure. BMPs would reduce the intensity of runoff, erosion, and sediment loads and minimize potential impacts to fish and their habitat.	Compared to Alternative 2, less maintenance due to reduced fuel deliveries would result in a proportionate reduction in the probability of impacts.	Compared to Alternative 2, less maintenance due to reduced fuel deliveries would result in a proportionate reduction in the probability of impacts.	Compared to Alternative 2, this alternative includes a 73-mile long mine access road (2.5 times longer than Alternative 2). This would result in a higher probability of behavioral disturbance and habitat alterations.	Same as Alternative 2.	Same as Alternative 2.
Habitat alterations from port site Construction and Operations	Construction at ports would involve 40,000 cy of fill and 1,600 of riprap along the shoreline at the Bethel Port site and 10,000 cy of dredged material along the shoreline at Angyaruaq (Jungjuk) Port site. These would reduce and alter fish habitat in areas at the port sites.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2; BTC Port site would also involve 10,000 cy of dredged material along the shoreline.	Same as Alternative 2.	Same as Alternative 2.

Table 3.13-27: Comparison by Alternative for Fish and Aquatic Resources*

	Alternative 2 – Proposed Action	Alternative 3A – LNG-Powered Haul Trucks	Alternative 3B –Diesel Pipeline	Alternative 4 – BTC Port	Alternative 5A – Dry Stack Tailings	Alternative 6A –Dalzell Gorge Route
Pipeline						
Behavioral disturbance and habitat alterations from stream crossings	Spring and winter open-cut stream crossings that would occur in areas frequented by burbot, northern pike, Arctic grayling, Dolly Varden, rainbow trout, and salmon species could disturb spawning and/or overwintering areas.	Same as Alternative 2.	Compared to Alternative 2, additional HDD crossing at Beluga River would slightly raise the risk of behavioral disturbance and habitat alteration. Under the Port MacKenzie Option, additional HDD crossing at Susitna River and crossing at Little Susitna River would slightly raise the risk of behavioral disturbance and habitat alteration.	Same as Alternative 2.	Same as Alternative 2.	Compared to Alternative 2, fewer stream crossings would result in a slightly reduced, but similar impacts to spawning and/or overwintering areas.
Behavioral disturbance and habitat alterations from water withdrawals and releases from ice road construction and pipeline testing	Discharge up to 15 Mgal of water and sediment to local drainages from hydrotesting would affect local water levels, streamflows, water quality, fish populations, and fish habitat.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.
Behavior disturbance and habitat alterations during Construction, Operations, and Closure of pipeline and related infrastructure	Impacts associated with runoff and stream sedimentation until disturbed soils are stabilized and reclamation has been completed.	Same as Alternative 2.	Compared to Alternative 2, there would be similar impacts from erosion and runoff due to additional 19-mile pipeline segment and the additional 12 ocean barge trips per year during Operations. The 289 acre ROW and 674 acre construction footprint under the Port MacKenzie Option and 5% area increase in ROW under the Collocated Natural Gas and Diesel Pipeline Option would result in similar impacts. There would be two additional river crossings under the Port MacKenzie Option. This would result in a proportionate increase in the probability of behavioral disturbance and habitat alterations.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.

Note: *The No Action Alternative would have no new impacts on fish and aquatic resources.