4.18 WATER AND SEDIMENT QUALITY

This section describes potential impacts of the project on surface water, groundwater, and sediment quality within the Environmental Impact Statement (EIS) analysis area, which includes the project footprint and outside of the project footprint where direct or indirect impacts to downstream or downgradient surface water, groundwater, and substrate or sediment quality may occur. The following potential impacts were evaluated to meet applicable Clean Water Act (CWA) Section 404(b)(1) guidelines:

- Effects of ground disturbance and potential erosion on surface water and sediment quality.
- Effects of geochemical weathering of mined rock and tailings on the water quality of human-made waterbodies at the mine site.
- Effects of treated water discharge on water and sediment downstream of mine site facilities.
- Effects of dust deposition on water quality.
- Effects of tailings, waste rock, and contact water storage on groundwater quality and downstream resources.
- Effects of groundwater migration adjacent to the pit at closure.
- Effects of fill placement and erosion on substrate and sediment quality.
- Effects of marine construction and dredging on substrate and water quality.
- Effects on drinking water sources.

Information regarding impacts to surface water and groundwater occurrence and flow is provided in Section 4.16, Surface Water Hydrology and Section 4.17, Groundwater Hydrology.

4.18.1 Methodology for Impact Analysis

Impacts to surface water and sediment quality were evaluated based on baseline data, water management plans, and predictive water quality modeling. The methodology applied to analyze and predict direct or indirect impacts is based on the range of effects for each of following factors:

- Magnitude – Effects are assessed based on the magnitude of the impact, as indicated by the degree to which water or sediment quality may be altered from documented baseline conditions, with potential changes to chemical or physical condition (e.g., changes in chemistry, temperature, or turbidity).
- Duration – The duration of effects depends on project phase, length of construction activities, and the nature of activities. Water and sediment quality effects could be temporary during construction (e.g., turbidity from construction); or they could remain after construction throughout life of mine and into closure (e.g., impacts from treated water discharge).
- Geographic Extent – Effects could be localized, or could extend to downstream areas within the same watersheds.
- Potential – Most effects on water and sediment quality at and near the mine site are predictable, and considered likely to occur. The likelihood of occurrence for other project components would be determined by the nature of activity and proximity to water and sediment resources.

Clean Water Act 404(b)(1) Evaluation Factors. Evaluation factors considered by the US Army Corps of Engineers (USACE) in making determinations under CWA Section 404(b)(1), Subpart C, include impacts on the following physical and chemical characteristics of the aquatic ecosystem. Impacts related to these characteristics are addressed in this section of the EIS as noted below:

- **Substrate.** Substrate includes sediment at the bottom of waterbodies, as well as wetlands soils. Impacts on waterbody substrate (sediment) are summarized under Substrate/Sediment Quality in each of the four project component sections. Impacts on wetlands substrate are addressed in Section 4.22, Wetlands and Other Waters/Special Aquatic Sites.
- **Suspended Particulates/Turbidity.** Effects on turbidity and levels of suspended sediment are summarized under the "Surface Water Quality" heading in each of the four project component sections below.
- **Water.** Direct effects on surface water quality and potential effects on surface water quality from migration of contaminants in groundwater are summarized under the "Surface Water Quality" and "Groundwater Quality" headings in each of the four project component sections below. Additional details are provided in Appendix K4.18.
- **Salinity Gradients.** Effects on salinity gradients are described under Surface Water Quality.

4.18.2 No Action Alternative

Under the No Action Alternative, the Pebble Project would not be undertaken. No construction, operations, or closure activities would occur. Although no resource development would occur under the No Action Alternative, permitted resource exploration activities currently associated with the project may continue (ADNR 2018-RFI 073). Pebble Limited Partnership (PLP) would have the same options for exploration activities that currently exist. In addition, there are many valid mining claims in the area, and these lands would remain open to mineral entry and exploration. No project-related geochemical processes or impacts on surface water, groundwater, or sediment quality would occur under this alternative.

PLP would be required to reclaim any remaining sites at the conclusion of their exploration program. If reclamation approval is not granted immediately after the cessation of reclamation activities, the State of Alaska may require continued authorization for ongoing monitoring and reclamation work as deemed necessary by the State. Although these activities would also cause some disturbance, reclamation would benefit water and sediment quality.

The geologic material at the mine site would continue to naturally weather in place. Background water and sediment quality in the mine site vicinity would not change; certain constituents would still be present in amounts exceeding regulatory levels because of natural mineralization and geochemical weathering processes. Water quality along the transportation and pipeline corridors would continue to reflect the presence of elevated levels of some constituents, as described in Section 3.18, Water and Sediment Quality. Natural levels of sediment transport, deposition, and substrate modification would continue, and sediment would continue to contain certain constituents (e.g., metals) at elevated levels. No project-related geochemical processes or impacts on surface water, groundwater, or sediment quality would occur under this alternative.

4.18.3 Alternative 1 – Applicant's Proposed Alternative

This section describes the impacts of the project on surface water, groundwater, and substrate/sediment quality for each of the four project components under Alternative 1.

4.18.3.1 Mine Site

Surface Water Quality

Water originating in the mine site area would be managed in an environmentally responsible manner while providing an adequate water supply for operations. A primary design consideration would be to ensure the effective management of all contact water that would require treatment before release to the environment. This would include carefully assessing the layout of project facilities, process requirements, the topography, hydrometeorology, aquatic habitat and resources, and regulatory discharge requirements for managing surplus water. Water management strategies at the mine site are discussed in Section 4.16, Surface Water Hydrology. A map of the mine site layout showing water storage facilities, diversion channels, collection ponds, and flowlines is provided in Chapter 2, Alternatives, Figure 2-4 and Figure 4.16-1. Water balance model schematics showing estimated recycle flows between mine facilities are shown in Appendix K4.16.

All runoff water contacting the facilities at the mine site and water pumped from the open pit would be captured to protect overall downstream water quality. Prior to discharge to the environment, any water not meeting applicable discharge requirements would be treated. For example, contact water that may infiltrate into the groundwater system at the mine site would be collected at the mine site by the open pit groundwater wells or by pumpback wells located around the mine site. This water would be treated at a water treatment plant (WTP) and discharged as wastewater (i.e., surplus water). Non-acid-generating quarry or waste rock would be selected and used in construction of mine site roads and embankments, through techniques commonly used for grade control in open pit mines (PLP 2018-RFI 021c), such as testing for acid rock drainage (ARD) and leachable metals at specified intervals or block sizes. The project design incorporates an analysis of water collection and management, including quantity and quality estimates, water treatment options, design of water management facilities, and strategic discharge of treated water. Implementation of the water management plan would enable the process plant to operate without additional water from off-site sources. Additional details on surface water and groundwater hydrology are provided in Section 4.16, Surface Water Hydrology, and Section 4.17, Groundwater Hydrology, respectively.

The impact on surface water quality would be the discharge of treated process and runoff water that has come into direct contact with mining infrastructure. The duration and likelihood of treated discharge would be long term and certain, if the mine is permitted and built. The following subsections describe how contact and runoff water would be treated prior to discharge.

Water Treatment during Construction – Minimal water storage capacity would be available at the mine site until the completion of initial construction activities. Therefore, before completion of the bulk tailings storage facility (TSF) embankments and water management structures, all contact water not meeting water quality standards would be treated in modular WTPs and released. Contact water from the following sources and activities in construction would be expected to require treatment before release:

- Dewatering of the overburden aquifer above and near the pit deposit

- Water, primarily from precipitation, that accumulates in the open pit during construction
- Runoff from construction of TSF embankments.

Non-contact runoff water from excavation for site infrastructure such as the process plant, camps, power plant, or storage areas would be routed to sediment settling ponds before release. Non-contact runoff water that does not come into direct contact with mining infrastructure (open pit, waste rock and tailings stockpiles, etc.) is considered stormwater, as defined in 40 Code of Federal Regulations (CFR) Part 122.26(b)(13). Some or all of the stormwater discharge may require authorization from the Alaska Department of Environmental Conservation (ADEC) under the Alaska Pollutant Discharge Elimination System (APDES) Mine Site General Permit for stormwater, and would only require treatment for sediments prior to discharge into the environment. ADEC administers the APDES Program, in compliance with the CWA, 33 US Code (USC) Section 1251 et seq., as amended by the Water Quality Act of 1987, Public Law 100-4, Alaska Statute 46.03, and the Alaska Administrative Code (AAC), as amended, and other applicable state laws and regulations, to authorize and set conditions on discharges of pollutants from facility to waters of the US (WOUS)[1]. To ensure protection of water quality and human health, APDES permits place limits on the types and amounts of pollutants that can be discharged from a facility, and outlines best management practices (BMPs) to which a facility must adhere.

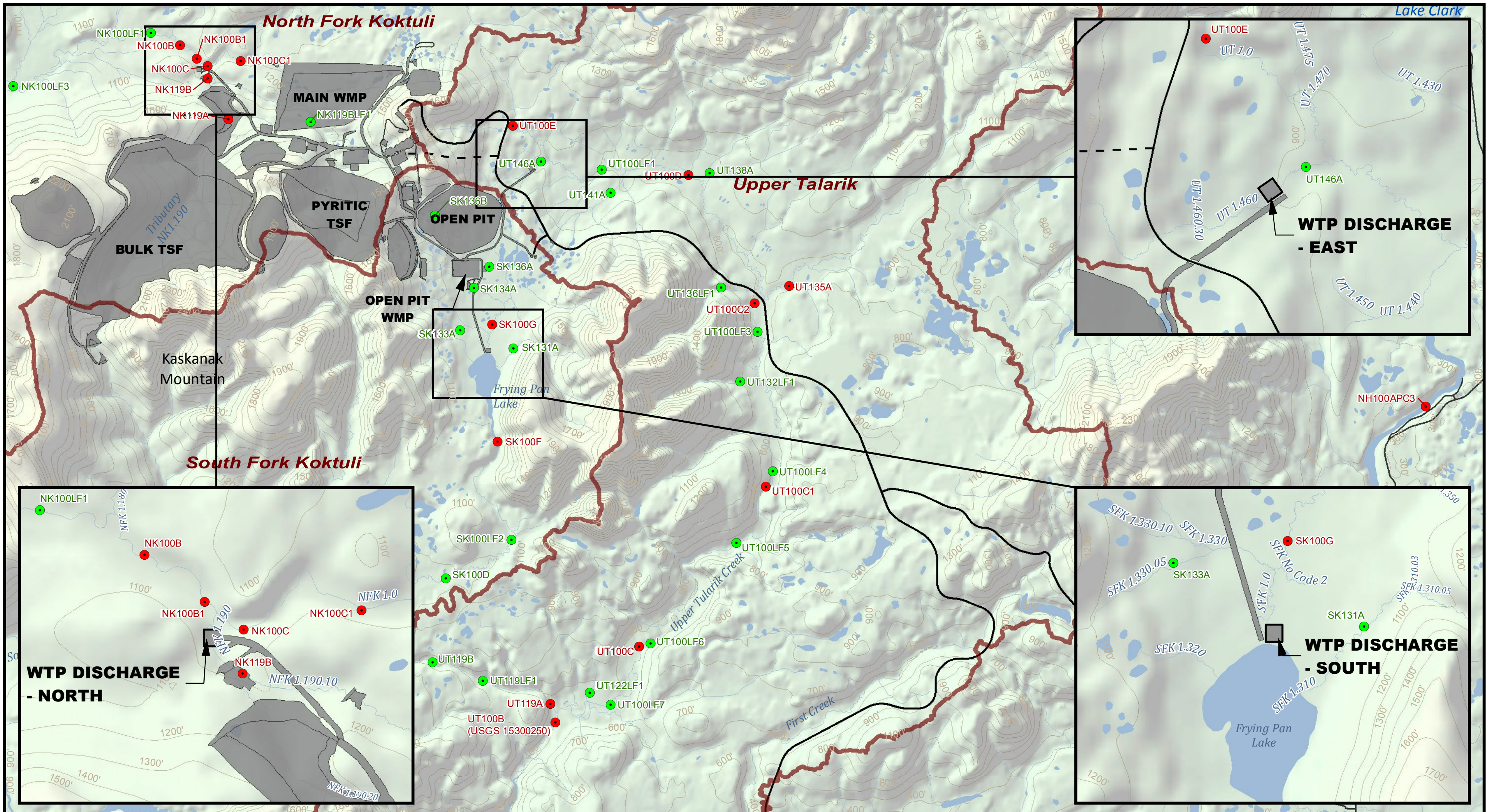
Water Treatment during Operations – During operations, the mine site would have two WTPs: the open pit WTP (WTP#1) and the main WTP (WTP#2). Both would be constructed with multiple, independent treatment trains, which would enable ongoing water treatment during mechanical interruption of any one train. Figure 4.18-1 provides a detailed view of WTP discharge locations and relevant nearby surface water monitoring stations and tributaries. Details of the WTP systems are provided in Appendix K4.18, and summarized below.

WTP#2 would treat water from the main water management pond (WMP), which would receive water from the bulk and pyritic TSFs and the TSF main embankment seepage collection pond (SCP). WTP#1 would treat water from the open pit WMP, which would be composed primarily of pit dewatering water. As described in Appendix K4.18, both facilities would employ treatment plant processes commonly used in mining and other industries around the world. Key treatment steps for both WTPs would include dissolved metals oxidization, co-precipitation, clarification, ultrafiltration, and reverse osmosis (see Chapter 2, Alternatives, Figure 2-11 and Figure 2-12). The open pit WTP would also include biological selenium removal, and the main WTP would include nanofiltration through high-pressure membranes (expected to remove selenium and other salts) and multiple-stage calcium sulfate precipitation with a lime softening process. Clarifier solids-filter backwash from both WTPs would be thickened/evaporated, and transferred to the pyritic TSF (HDR 2018a; PLP 2018d; PLP 2018-RFI 021d). Supplemental heating could be necessary during cooler periods to achieve minimum temperature levels for biological selenium removal to be effective. If hydraulic capacity of the WTPs is not adequate to meet the influent flow, additional trains would be installed as needed (PLP 2019-RFI 106).

Based on an independent review of the WTP source terms and processes (Appendix K4.18; AECOM 2018i), discharge water from both WTPs is currently expected to meet ADEC criteria. However, there is some concern that salt and selenium could build up over time in the pyritic

[1] The regulatory definition of WOUS is given in 40 CFR 230.3(s). Locations within the project area in which wetlands and other waters of the US have been identified as jurisdictionally under the authority of the USACE are described in the Preliminary Jurisdictional Report in Appendix J. The project area is defined in Section 3.1, Introduction to Affected Environment, as "the exact project footprint for each action alternative."

TSF, which has the potential to lead to increased total dissolved solids (TDS) concentrations that would require treatment in the main WTP (AECOM 2018i). This may require further investigation as design progresses, and/or as a long-term adaptive management strategy. Assuming these protections are adopted, direct and indirect impacts of treated contact waters to off-site surface water are not expected to occur. However, over the life of the mine, it is possible that APDES permit conditions may be exceeded for various reasons (e.g., treatment process upset, record-keeping errors) as has happened at other Alaska mines. In these types of events, corrective action is typically applied in response to ADEC oversight to bring the WTP discharges into compliance.



Sources: HDR 2012; PLP 2013

Continuous Monitoring Gage Stations

Early Spring Low-Flow Measurement Sites

Alternative 1

Transportation Corridor

Natural Gas Pipeline

Mine Site

Other Features

100' Contour (Existing)

River/Stream

Lake/Pond

Major Drainage Boundary

US Army Corps of Engineers

0.5 0 0.5 1

Miles

WATER TREATMENT PLANT DISCHARGE LOCATIONS IN OPERATIONS

PEBBLE MINE EIS

FIGURE 4.18-1

In terms of magnitude and extent, all WTP#1 treated water and most WTP#2 treated water would be discharged to the environment downstream of the mine site. A small portion of the WTP#2 treated water would be used for process and power plant needs. Water discharge points would be located in the North Fork Koktuli (NFK) River, South Fork Koktuli (SFK) River, and Upper Talarik Creek (UTC) drainages (see Figure 4.16-1). Water from both treatment plants would be strategically discharged in a manner that would optimize downstream aquatic habitat, based on modeling and monitoring during discharge (PLP 2018d). WTP discharges as mitigation for streamflow reduction are further discussed in Section 4.16, Surface Water Hydrology and Section 4.24, Fish Values. The duration and likelihood of impacts would be long term, lasting for the life of the project and into closure.

ADEC regulates wastewater discharges from hard-rock mining facilities through various permits:

- APDES Individual Permit for point source discharge into wetlands and other waters
- Integrated Waste Management Permit for solid waste disposal and wastewater discharge not into wetlands and other waters
- APDES Multi-sector General Permit for stormwater discharge
- Domestic Wastewater Discharge Permit.

An APDES permit is necessary and would be issued unless discharge is not to wetlands and other waters, in which case a domestic wastewater discharge permit would be required. State of Alaska regulations require that the conditions of these permits comply with state water quality standards that are based on the use classification for the waterbody receiving discharge, and on the state's anti-degradation policy. For constituents that exceed criteria in background surface water and groundwater (see Section 3.18, Water and Sediment Quality, and Appendix K3.18), there are currently no plans to incorporate site-specific background levels of constituents into discharge limits (ADEC 2018-RFI 064a).

Water Treatment during Closure – Water treatment during closure/post-closure would use the operations WTPs #1 and WTP#2 as needed, with WTP#1 upstream of Frying Pan Lake reconfigured as WTP#3 (Knight Piésold 2018d), and separate WTP systems developed in later closure phases to treat SCP and pit water. Closure water treatment would occur as follows (HDR 2019b):

- Closure Phase 1 (years 0 to 15) – WTP#2 would treat water from the main WMP, and WTP#3 would treat water from the open pit during placement of pyritic tailings prior to filling of the pit lake.
- Closure Phase 2 (years 16 to 20) – No water treatment is anticipated during closure phase 2 as the pit lake fills, and WTP#2 would be decommissioned.
- Closure Phases 3 and 4 (years 21 to 50, and beyond year 50) – Water from the open pit would be pumped and treated to maintain the pit lake level at or below the maximum management level of 890 feet above mean sea level (amsl). Surplus water from the open pit, as well as the bulk TSF main SCP, would be treated as two stand-alone water treatment streams based on anticipated treatment needs, both of which would be housed in the same WTP building (HDR 2019b).

In terms of magnitude and extent, treated water would be discharged within the NFK, SFK, and UTC drainages at the locations shown on Figure 4.16-1 (Knight Piésold 2018d). Details of the WTP processes in closure phases are described in Appendix K4.18. Water quality would be monitored and treatment processes adjusted as needed. If hydraulic capacity of the WTPs is not adequate to meet the influent flow, additional trains would be installed as needed (PLP 2019-RFI 106). Table K4.18-14 provides an estimate of treated discharge water quality from the SCP, which is predicted to be within water quality standards. Water quality of discharge from the open pit WTP is the subject of ongoing engineering analysis (PLP 2019-RFI 106). Reclamation and closure plan and financial assurance mechanisms required by the State of Alaska would include financial provisions for operating water treatment facilities and conducting ongoing monitoring indefinitely in the post-closure period.

Effects of Ground Disturbance and Erosion – Ground disturbance during construction has the potential to lead to erosion and introduce suspended sediment and increased turbidity into waterbodies downstream of the mine site, potentially resulting in direct and indirect impacts to water quality. These effects are likely to occur, and the magnitude and extent of direct impacts would include increased turbidity, temperature changes, or changes in water chemistry in downstream waterbodies. Indirect impacts would also be expected to occur. The magnitude and extent of indirect impacts could include changes to dissolved oxygen (DO) content, or an increase or decrease in biologic activity within waterbodies resulting from the mine project. The duration and likelihood of impacts would be long term, and certain to occur if the mine is permitted and constructed. Implementation of the water management plan during the construction phase would include the following features:

- Water diversion, collection, and treatment systems would be installed to address the effects of ground disturbance and erosion on water quality during construction. The locations of these features would be determined based on minimizing sedimentation effects. Major features currently planned are shown on Figure 2-3 and Figure 4.16-1.
- BMPs for water management and sediment control structures, including temporary settling basins and silt fences, would be installed to accommodate initial construction at the mine site.
- Among the first facilities to be constructed would be water management structures that would be maintained for use in adaptive management during operations. These structures would include diversion and runoff collection ditches to minimize water contact with disturbed surfaces, and sediment control measures such as settling ponds to prevent sediment from reaching downstream waterbodies.
- Stormwater runoff from facilities that does not come in direct contact with mining infrastructure would be treated for sediment and discharged under general APDES stormwater permits (Knight Piésold 2018a).

During the operations phase, implementation of the water management and sediment control plan would focus on reducing the accumulation of contact water through diversion structures. Runoff and associated sediment control measures would be managed with BMPs and adaptive management control strategies. BMPs are described further in Section 4.14, Soils. Where water could not be diverted, it would be collected for use in the mining process, or treated and discharged.

Effects of Dewatering Water Discharge in Construction – Dewatering of the open pit is likely to have both direct and indirect impacts on surface water quality, resulting from changes to hydrologic flow regimes between groundwater and surface water, and discharge of pumped groundwater to surface waterbodies.

The construction phase would involve dewatering of the pit area beginning approximately 1 year before the start of operations. During construction, water collected from pit dewatering wells would be discharged to the open pit WMP, which is expected to be in place before preproduction (e.g., removal of overburden in the pit area) mining commences in Year 1. In the event that the open pit WMP is not available, water from dewatering wells would be treated prior to discharge by WTP#1 if it is in place; or by a modular WTP if WTP#1 is not in place. WTP processes for construction wastewater would include modules for the following processes as necessary: a temporary sedimentation pond; a sedimentation tank and/or sand separator; chemical addition and rapid mix module; a filtration module; and associated modules containing water feed/transfer pumps, chemical storage/feed systems, electricity generation, a workshop, and parts storage (PLP 2018-RFI 021b). WTP discharge locations are depicted on Figure 4.18-1. In terms of magnitude and extent, following module WTP processing, water from pit dewatering wells would be discharged to the SFK catchment (PLP 2018-RFI 021b). The duration of impact would be until the open pit WMP is in place. Under either the WTP#1 scenario or the modular WTP scenario, discharge would require an APDES permit, and must meet prescribed discharge limits and monitoring and reporting requirements.

Effects of Waste Rock/Tailings Storage and Water Management Ponds. Waste rock, TSFs, and WMPs would impact surface water or groundwater quality if not properly managed. Contact water that accumulates in on-site tailings and waste rock storage facilities and WMPs would be managed through containment and recycling/reuse so that it would not be released to surface water downstream of these facilities until intended for treatment and discharge. Water in these containments would not be considered WOUS prior to discharge; therefore, such water would not be subject to regulation under the CWA, or subject to APDES permitting requirements while retained within on-site water management facilities.

Bulk and pyritic tailings slurries from the mill would be directed to the bulk TSF and the pyritic TSF, respectively. Potentially acid-generating (PAG) waste rock from the pit would also be stored in the pyritic TSF. Section 3.18, Water and Sediment Quality, provides a description of these materials. Precipitation and runoff water would also collect in these facilities. The bulk TSF would maintain a small operating (supernatant) pond, while the pyritic tailings would remain fully submerged in the lined pyritic TSF to minimize ARD and Metal Leaching (ML), with sufficient coverage to prevent resuspension of tailings by wind-induced waves or oxidation of the tailings. Excess water from the pyritic TSF would be pumped to the main WMP (see Section 4.16, Surface Water Hydrology, Figure 4.16-2).

The main embankment at the bulk TSF would operate as an unlined flow-through facility. Water collecting in the bulk TSF would flow through the embankment to the main embankment's SCP. From there, water would be directed either to the main WMP for use in the mill, or to the WTP#2 for treatment and discharge. Excess surface water in the pyritic TSF would be similarly managed. Water treatment byproduct sludge and reject water (water resulting from the treatment process) would be directed to the process plant and added to the pyritic TSF via the pyritic tailings slurry line. A portion of the treated water from the WTP#2 would be returned for use in the process plant and power plant cooling towers. The magnitude and extent of impacts to surface waters would be that treated water from WTP#2 that is not needed for mine operations would be discharged downstream of the mine. The magnitude and extent of effects on shallow groundwater would be expected to be limited to the area between the bulk TSF and the SCP, with collection systems capturing and directing water. The magnitude and extent of effects could extend to deeper fracture-flow groundwater, depending on geologic and hydrogeologic conditions beneath the bulk TSF. The duration of effects would be long term, lasting for the life of the project, and certain to occur if the mine is permitted and constructed.

The predicted chemistry of geochemical sources contributing to the main and pyritic TSF ponds, the main SCP, and main WMP is discussed in Appendix K4.18 and shown in Table K4.18-2. Table K4.18-4 shows the predicted water quality in the ponds. Water in these ponds is predicted to contain levels of TDS, sulfate, and a number of metals in excess of water quality criteria (Appendix K3.18, Table K3.18-1). These data have been used in the development of WTP processes described in Appendix K4.18.

The size of the ponds and the design criteria intended to prevent overtopping of pond water are described in Section 4.16, Surface Water Hydrology. Upset conditions that could lead to unexpected release of pond water to the environment are addressed in Section 4.27, Spill Risk.

A water surplus is anticipated during operations under normal and wetter than normal climatic conditions (Knight Piésold 2018a). The magnitude, extent, and duration of impacts to surface water would be that treated surplus water would be discharged throughout the year. Section 4.16, Surface Water Hydrology, provides further details on the volume of water available for discharge, compared to baseline (i.e., pre-mine) flows in surrounding drainages.

Effects from Embankment Rockfill Runoff – Runoff from rockfill would impact surface water quality if not properly managed. Based on the geochemical analysis of source rock, the chemistry of runoff from rockfill in embankments is expected to be comparable to that of natural surface water and groundwater, with two possible exceptions (SRK 2018d):

- *Hydrothermally altered, sulfide-bearing PAG rock.* This rock would be managed separately based on PAG classification, and would be used only at limited locations on the northern embankment of the pyritic TSF where runoff would be directed to the main WMP. All other embankments would be constructed of non-PAG rock (PLP 2018-RFI 021c).
- *Rock containing explosive residues*. Explosives used during mining would consist of ammonium nitrate/fuel oil (ANFO) mixtures manufactured on site (PLP 2018d). A small amount of these materials may not be fully consumed, and residue may remain on rock used in embankment construction. In terms of magnitude of impact, these materials would impact surface waters through runoff. Runoff from embankments quarried with explosives would be contained and monitored until explosive residues have been leached (PLP 2018-RFI 021c). Explosives residue is considered in the prediction of surface water quality from mine site sources in Table K4.18-2 (SRK 2018a).

Effects from Small Hydrocarbon Spills – Inadvertent release of hydrocarbons would result in a direct impact to surface water quality if spilled materials come into contact with surface water. The likelihood of small hydrocarbon spills from mine-related sources (e.g., mine machinery, product or waste storage facilities, or transfer operations) would be reduced through the application of BMPs, including the use of certified containers to transfer and store fuels and lubricants; secondary lined containment around bulk storage facilities; and managed storage, reuse, and/or disposal of used fuel products. Should a small spill occur, controls would be implemented, including automatic shutoff devices, and in-place spill response equipment and procedures (PLP 2018d). Section 4.27, Spill Risk, describes the potential for and effects of a large hydrocarbon spill, which would have the potential for greater magnitude and extent of direct effects on surface water and sediment quality.

Effects of Discharge Water Temperature – Modeling of temperature impacts using documented baseline temperatures and flow data, and predicted WTP discharge temperature and flow rates, indicates the magnitude of expected effects on temperature (PLP 2018-RFI 047). In terms of extent of impacts to surface waters, the modeled temperature effects are based on a limited set of measured water temperatures and flow scenarios collected at specific locations; the calculated discharge impacts reflect those conditions and locations. The duration and likelihood of impacts would be long term, and certain to occur if the mine is permitted and constructed as designed. The calculated temperature effects provide a reasonable estimate of typical temperature effects from operational WTP discharges, summarized as follows:

- Temperature changes in the NFK watershed approximately 0.5 mile downstream of the WTP discharge point would be expected to be in the range of about -0.2 to +2.4 degrees Celsius (^oC); (average of about +1.2^oC) in summer months, and from about +1.7 to +3.6^oC (average of about +2.8^oC) in winter months.
- Temperature changes in the SFK watershed approximately 1 mile downstream of the WTP discharge point at the outfall of Frying Pan Lake would be expected to be in the range of about -1 to +1^oC (average of about -0.15^oC) in summer months.
- Temperature changes in the UTC watershed approximately 3 miles downstream of the WTP discharge point would be expected to be in the range of about 0 to +0.3^oC (average of about 0.12^oC) in summer months, and from about +0.3 to +0.7^oC (average of about +0.54^oC) in winter months.

Effects of Treated Water Discharge on Spatial Trends – Discharge of treated water from WTPs during operations would also have an effect on water conditions other than temperature within receiving waters (e.g., DO levels, turbidity, nutrient levels). As with temperature in terms of extent, these effects would be expected to be spatially limited to the area at and immediately downstream of discharge points, and would be managed by the planned strategic discharge of treated water between the three planned discharge points (PLP 2018d). The magnitude of changes in water condition that occur at each discharge point would also be expected to be diluted through natural flow over a relatively short distance, and to return to background or near-background conditions. The magnitude, extent, and duration of the effects of discharges on natural stream conditions would vary by location and seasonally, depending on background flow and other variable factors (e.g., fluctuations in water clarity, nutrient levels, or DO content). Streams in the area are naturally nutrient rich (PLP 2018d). Additionally, installing engineered discharge chambers at discharge points would reduce effects on certain water conditions such as turbidity and DO by baffling the discharge and allowing for more equilibration of water condition at the discharge point (Knight Piésold 2018f).

Effects from Deposition of Fugitive Dust – Fugitive dust from various mine site sources with elevated levels of certain metals would be deposited on soils surrounding the mine site. Impacts on surface water would be the leaching of these metals into runoff leading to downgradient waterbodies, or be deposited directly on waterbodies. In terms of impact extent, the modeled areal extent of dust deposition in construction and operation phases of the mine site is depicted in PLP 2018-RFI 065. Section 4.14, Soils, presents the incremental concentrations of metals that would be expected in the top inch of soil at the end of operations. Appendix K4.18 provides the methodology used to calculate the incremental increase in surface water, and Table K4.18-17 shows the results. In terms of impact magnitude, the calculations indicate an expected increase in the concentration of metals in surface water as a result of dust deposition, ranging from 0.1 to 0.7 percent, which would not result in exceedances of the most stringent water quality criteria (Appendix K3.18, Table K3.18-1) in background conditions or WTP outflow conditions. PLP is developing a fugitive dust control plan for mitigation and control of fugitive dust and wind erosion related to project activities. The anticipated plan would use BMPs and best available control technology (PLP 2018-RFI 071a). Dust suppression water would be used at the mine site and along the transportation corridor as described below (PLP 2018-RFI 021c). These impacts would be long term, lasting for the life of the mine, and would be expected to occur if the project is permitted and constructed.

Effects from Dust Suppression Water – During operations, dust suppression at the mine site would use untreated contact water from the open pit WMP. This water source would be applied only to areas of the mine site where runoff is collected and treated. The impact on surface waters would be that this water is discharged as described above for treated water discharge.

Outside of these areas, dust suppression would use non-contact water from other unaffected water sources outside of the mine site footprint (PLP 2018-RFI 021c).

Effects during Closure/Post-Closure – Once mining ceases, partial dewatering would be maintained within the open pit to allow the PAG waste rock to be moved from the pyritic TSF to the pit, and to maintain pit wall stability until the PAG waste rock buttresses the potentially unstable lower walls of the open pit (see Section 4.15, Geohazards, and Appendix K4.15). An initial layer of PAG waste rock would be placed 1 year prior to deposition of pyritic tailings (Knight Piésold 2018d). The remaining PAG waste rock would be deposited in the open pit concurrently with the pyritic tailings as it is exposed during reclamation of the pyritic TSF (Knight Piésold 2018b, 2018d). The pyritic tailings would be re-slurried using water in the pyritic tailings, and the tailings slurry pumped to the open pit for subaqueous disposal. The water level in the open pit would be maintained to allow controlled placement and management of the PAG waste rock in dry areas of the pit, while keeping a water cover over the submerged pyritic tailings. Backhauling of the PAG waste rock would end approximately 14 years into closure, and the transfer of pyritic tailings would end about 15 years into closure. Dewatering of the open pit would cease at the end of Closure Phase 1 once the transfer of these materials is complete. PAG waste rock would be submerged within 2 years of placement as the water level in the pit rises (PLP 2018-RFI 092). Once dewatering ceases, groundwater behind the pit walls would begin to rise to create a pit lake. The open pit would then be allowed to fill with direct precipitation, surface water runoff, and groundwater, but would be kept at a maximum management level so that groundwater would continue to flow into the open pit from all directions; and it would remain as a hydraulic sink to minimize the potential for subsurface releases to the environment (see Section 4.17, Groundwater Hydrology). The maximum elevation of the pit lake in closure is expected to be 890 feet amsl (Appendix K4.18, Figure K4.18-6). Additional general details of the pit lake are included in Table K4.18-12.

Surface runoff from reclaimed areas would be collected, and either treated in the WTPs, or directed to the open pit lake. The bulk TSF would be graded and revegetated to direct surface runoff toward the closure spillway at approximately Closure Year 10. This would reduce infiltration and direct runoff water to the eastern end of the bulk TSF, where it would be collected in seepage collection and recycle ponds. In terms of magnitude, duration, and extent of impacts, surplus free water on the surface of the bulk TSF would be pumped to the main WMP through approximately Year 15 post-closure, then to the open pit through approximately Year 50 post-closure. Seepage water from the embankment seepage collection systems would be collected, and either treated in the WTPs, or directed to the pit lake until determined to be suitable for discharge, anticipated after approximately Closure Year 50 (Knight Piésold 2018d).

Surface runoff into the pit lake would carry any metals leached from the pit walls. In addition, contaminated groundwater would flow into the pit as described below under Groundwater Quality. The resultant groundwater capture zone, in which all groundwater would flow into the pit in closure, would primarily be located in the SFK watershed, with parts extending under the pyritic TSF. The corresponding zone of influence of the pit lake would extend marginally farther out than the capture zone (Piteau Associates 2018a). The extent of the groundwater capture zones in operations and closure are discussed in Section 4.17, Groundwater Hydrology, and depicted on Figure 4.17-2 through Figure 4.17-4.

Water quality in the pit lake would be expected to be initially acidic, becoming slightly alkaline over time, with elevated concentrations of TDS, hardness, sulfate, and some metals (aluminum, antimony, arsenic, cadmium, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, and zinc) exceeding water quality standards as a result of the oxidation of sulfide minerals in the pit walls, and the natural concentrations of metals found in the unmined mineralized rock. Appendix K4.18 describes pit lake water quality modeling further.

Table K4.18-7 through Table K4.18-10 summarize predicted lake water quality for a fully mixed pit lake during the four closure phases. The evolution of pit lake water quality during closure was further evaluated using a one-dimensional hydrodynamic model to determine if thermal and/or chemical stratification is expected to develop within the pit lake. The hydrodynamic pit lake model approach and water quality results are also summarized in Appendix K4.18, and Figure K4.18-10 through Figure K4.18-15.

Once the level of the pit lake has risen to about 890 feet amsl, anticipated to occur at approximately Year 20 post-closure, water would be pumped from the pit to maintain the lake level at the maximum management level, and treated as required at WTP#3 (redesigned for post-closure from WTP#1). In terms of magnitude and extent, the treated water would be discharged to the environment downstream of the mine site in Frying Pan Lake in the SFK drainage. The duration of impact would be permanent, and it would be expected to occur only if mine closure is approved as described.

Summary of Mine Site Effects on Surface Water Quality. As described above, direct and indirect impacts to water quality are likely to occur as a result of permitted discharges of treated water to drainages downstream of the mine site. The duration of these discharges would range from long term, lasting from construction throughout the life of the mine; and in some cases, throughout post-closure. Process-related (contact) water would not be considered WOUS or subject to APDES permitting while such water is retained in on-site water management facilities and recycled/reused on site. Contact water collected in mine facilities (e.g., bulk TSF, pyritic TSF) is not expected to meet Alaska water quality criteria for discharge (AAC Title 18, Section 70, ADEC 2018b) and would not be released directly to the environment without prior treatment to meet specific discharge requirements. WTP processes are expected to be effective in treating water to meet discharge criteria, although concerns regarding potential long-term increased TDS levels may require further investigation as design progresses, and/or adaptive management strategies are implemented during operations (see Chapter 5, Mitigation). The discharge limits described in this section and Appendices K3.18 and K4.18 would become part of an APDES permit, which would have monitoring requirements to ensure that discharged water meets applicable water quality criteria. The geographic extent of impacts on surface water chemical quality attributable to contact water would be limited to areas used for on-site storage of contact water before treatment. The magnitude of temperature effects ranging from about -1 to 3.6^{o}C would occur up to 0.5 to 3 miles downstream of the mine site.

Groundwater Quality

Section 3.17, Groundwater Hydrology, and Section 3.18, Water and Sediment Quality, address the affected environment with respect to groundwater flow and quality, respectively. The principal mechanisms responsible for potential effects on groundwater quality at the mine site are summarized below.

Effects from TSF Seepage – The main embankment of the bulk TSF would be designed to promote seepage to the bulk TSF main SCP, thereby minimizing the volume of water contained within the tailings impoundment, and promoting embankment stability (see Section 4.15, Geohazards,). In terms of magnitude and extent, groundwater that would be affected by vertical seepage from the unlined bulk TSF would flow north down the NFK west drainage and be captured by the main SCP. The primary design criterion for management of this and other seepage collection systems at the mine site is defined as “no detectable seepage downgradient of the collection and pumpback systems” (PLP 2018j). Hydraulic containment of seepage flow from the bulk TSF would be achieved and maintained using a series of control measures, including:

- North-flowing underdrains beneath the bulk TSF.
- Tailings beaches that would promote a north-sloping phreatic surface in the bulk tails.
- Upstream liners, low-permeability core zones, and grout cutoff walls at the south embankment of the bulk TSF; and the main, south, and east embankments of the SCP.
- Seepage pumpback wells downgradient of the three SCPs (Knight Piésold 2018a; PLP 2018d; PLP 2018-RFIs 006, 006a, 008f).

The above drainage and hydraulic containment systems are currently conceptual only, and would be further developed in final design. Drainage materials that would be placed beneath the bulk TSF impoundment and embankment would help minimize the amount of vertical seepage to groundwater (e.g., PLP 2018-RFI 006: Figure 1).

In terms of magnitude and extent of impacts, groundwater modeling estimates that the bulk TSF would contribute about 0.2 cubic feet per second (cfs) of seepage to the underlying groundwater system during and at the end of mining (assumed to be accurate to within a factor of 5), as compared to about 9 cfs that are expected to flow through the bulk TSF main embankment (Knight Piésold 2018a; Piteau Associates 2018a). In terms of magnitude and duration of impacts, the seepage rate would decrease over time after closure as the tailings consolidate and pore waters are squeezed out. Affected groundwater migrating beneath the bulk TSF and downgradient to the main SCP would flow through the overburden and underlying weathered bedrock units shown on cross-section M-1 in Section 3.17, Groundwater Hydrology, Figure 3.17-8, and described in Appendix K3.17, Table K3.17-1. Additional discussion of the potential for contaminated groundwater to migrate in units beneath the bulk TSF and SCP, and uncertainties in the groundwater model, is provided in Section 4.17, Groundwater Hydrology.

The results of groundwater modeling performed by Piteau Associates (2018a) indicate that a sump or pumping wells with an operating elevation of 1,250 feet at the main SCP and a grout curtain with an effective hydraulic conductivity of 1×10^{-5} cm/s would be effective in capturing seepage. Containment of affected groundwater would be monitored using monitoring/pumpback wells to assess groundwater levels and quality (Knight Piésold 2018a). Any impacted groundwater that bypasses the SCP capture system is expected to be detected in these wells. Additional seepage collection, cutoff walls, and/or pumpback systems may be installed downstream if necessary, as determined by monitored water quality (PLP 2018-RFI 006a).

The predicted concentration of constituents in groundwater beneath the bulk TSF, and between the TSF and the main SCP, would be similar to those listed in Appendix K4.18, Table K4.18-4 for the main SCP. In terms of magnitude, several metals (aluminum, antimony, arsenic, cadmium, copper, lead, manganese, mercury, molybdenum, nickel, selenium, silver, and zinc), TDS, and sulfate in the main SCP are predicted to exceed baseline concentrations and regulatory criteria at the end of mining and the end of Closure Phase 3, and therefore would require continued treatment at WTP#3 in post-closure to meet discharge criteria (Knight Piésold 2018d).

The pyritic TSF would be fully lined. The potential for liner damage (e.g., from ice or placement of waste rock) leading to leakage of tailings porewater was evaluated in the EIS-Phase Failure Modes Effects Analysis (FMEA), and the likelihood of occurrence was considered to be low to moderate (AECOM 2018l). In terms of magnitude and extent of impact, potential leakage through the liner would be diluted by unaffected groundwater flowing north down the NFK east drainage, and would be intercepted by the main WMP and its downgradient seepage pumpback wells.

Based on the proposed seepage collection systems and contingencies, the vertical extent of impacts on downgradient groundwater quality outside of the mine would be expected to be limited to shallow groundwater in overburden deposits, and the bedrock contact zone between the TSFs and seepage collection facilities. The magnitude and duration of impacts on local groundwater within the mine site are expected to exceed water quality regulatory criteria, and those effects would persist through the life of the mine, and well into post-closure Phase 4. Should monitoring at seepage collection systems in post-closure indicate that water quality meets approved criteria for discharge without treatment, direct discharge would occur. In terms of duration, groundwater impacted by limited seepage from the TSFs would meet regulatory discharge criteria at approximately Closure Year 50 (see Appendix K4.18, Figure K4.18-9) (Knight Piésold 2018d), although collection and treatment of SCP water would continue as long as required.

Effects from WMP Leakage – Appendix K4.18, Table K4.18-4 shows the predicted concentration of mine-related constituents in water in the main and open pit WMPs. Water in these ponds is anticipated to contain TDS, sulfate, and a number of metals at levels exceeding discharge water quality criteria. Pond water leaking through the pond liners would be intercepted by underdrain systems included in the design of those facilities, and subsequently pumped back to the respective WMP (PLP 2018-RFI 019a); however, in terms of impacts, some water could bypass the underdrain system and seep into underlying shallow groundwater. In the case of the open pit WMP, all underlying shallow groundwater would be completely within the capture zone of the dewatered open pit during operations and post-closure; therefore, any impacted groundwater would be recycled through the dewatering and treatment process, or contained in the pit lake.

In the case of the main WMP, in terms of magnitude of impacts to groundwater, the estimated maximum leakage rate through the liner of 1 liter per second (Piteau 2018; PLP 2018-RFI 019c) or 0.035 cfs would potentially impact underlying shallow groundwater. In terms of extent of impacts, without intervention, this water would be expected to mix with shallow groundwater and discharge into the NFK watershed. To prevent this, a line of monitoring/pumpback wells would be installed along the northern side and at the northwestern corner of the main WMP. Should monitoring of these wells show impacts from liner leakage, the wells would be used to intercept and recycle shallow groundwater back to the main WMP. Based on the current mine plan, it is possible that gaps exist along the main WMP embankment that would allow potentially affected groundwater to flow through areas where wells are limited (e.g., along the southwestern side of the embankment; see Section 4.16, Surface Water Hydrology, Figure 4.16-1). As discussed in the EIS-Phase FMEA, the final location and spacing of pump-back wells would be determined based on additional hydrogeologic investigation as design progresses, to minimize the likelihood of this occurrence. Because the main WMP would be removed at the end of mining Closure Phase 2 (Knight Piésold 2018d), the duration of this potential effect would be through this closure phase; it would not occur during subsequent post-closure periods (Piteau 2018).

Effects from Pit Overburden Stockpile Seepage – Seepage from pit overburden materials that would be excavated and stockpiled would be expected to affect surface water or groundwater quality. Potential effects would be limited by segregating mineralized overburden from non-mineralized overburden, and stockpiling mineralized materials that exhibit a high potential for leaching in the pyritic TSF. Prior to excavation, overburden materials would be characterized by drilling and sampling, thereby allowing materials to be segregated visually during excavation. This technique is common in open pit mining for grade control (PLP 2018-RFI 021c). As a secondary control to address placement of potential PAG material in the non-mineralized overburden stockpile, multiple lines of monitoring wells would be installed downgradient from the stockpile and monitored for exceedances of applicable water quality standards. If exceedances were observed, the wells would be converted to pumping wells to intercept and redirect impacted water to the open pit WMP for treatment and permitted discharge (PLP 2018-RFI 021c).

Effects on Seeps – Most overburden with seeps overlying the open pit would be removed, and seeps present in the footprints of the TSFs and mine facilities would be covered. Although seeps could impact groundwater, any impacted groundwater would be captured by the seepage collection systems or contained within the open pit cone of depression, and would not be expected to surface as seeps within the mine site. However, should seeps occur downgradient of mine facilities, surface water runoff controls would be used to capture and route it to the appropriate collection ponds for treatment and subsequent discharge. Monitoring would also be conducted to recognize new seeps that may form, measure their water quality, and ensure that the seepage is captured and routed to the appropriate seepage control pond; or if water quality is satisfactory, discharged to the environment.

Dust Leaching to Groundwater – Fugitive dust deposited on soils surrounding the mine site has the potential to leach into groundwater. Section 4.14, Soils, presents the baseline and incremental concentrations of metals in soil at the end of operations. These results are compared to ADEC migration-to-groundwater levels to estimate the magnitude of this effect on groundwater. Appendix K4.18, Table K4.18-18 presents the metals concentrations in soil after dust deposition, as well as ADEC comparative action levels for the migration to groundwater criteria for soils. In terms of magnitude, the predicted percent increase in metals concentration in groundwater attributable to dust deposition was less than 0.8 percent for all metals, with the exception of antimony, which is predicted to increase in concentration by approximately 3 percent. Modeling and calculations of dust deposition do not indicate that any new exceedances of the ADEC levels would result from the dust effects. Arsenic was the only metal that would be expected to exceed these criteria; however, that exceedance would result from baseline soil conditions, and dust deposition would be expected to increase arsenic concentrations in soil by only about 0.6 percent. The duration of impact to groundwater would be long term, lasting though the life of the mine, and would be expected to occur at this magnitude if the mine is permitted and built.

Effects from Pit Lake in Closure – Surface water in the pit would continue to be pumped out during the first 15 years of closure while pyritic tailings and PAG waste rock are being placed in it. Pumping of groundwater may initially be maintained in an area of the open pit at the end of mining to facilitate safe placement of the waste while maintaining pit wall stability in the lower portion of the pit where faults are present (see Section 4.15, Geohazards) (PLP 2018-RFI 023a). In terms of magnitude and extent, pumping of water from the pit during early closure, and cessation of most groundwater pumping while waste is being placed would result in the groundwater level adjacent to the pit rising faster than the pit lake level rise, so that contact water in the pit is not likely to extend beyond the pit walls, except in the localized area of temporary wall stability depressurization. Hydraulic containment would be maintained during all closure phases because overall flow gradients would be toward the pit lake radially from all directions, thereby limiting the extent of migration and capturing any pit-contaminated groundwater (PLP 2018-RFI 019d).

In terms of duration of the impacts, all pit dewatering would cease once placement of the PAG waste rock and pyritic tailings is complete to allow the pit lake to rise and cover the waste. Inputs of contaminated water into the pit lake from the waste and walls are predicted to exceed regulatory limits for water quality for a number of constituents, including TDS, sulfate, and metals (see Table K4.18-7 through Table K4.18-10).

After lake level rise, groundwater gradients toward the pit would be maintained by managing the pit lake level through pumping and treating the lake water in perpetuity. With the pit water level maintained at the maximum management level of 890 feet amsl, groundwater flow is expected to be directed radially toward the pit from all directions, although there are uncertainties in the groundwater model, as described in Section 4.17, Groundwater Hydrology. At the maximum managed level, the pit water would be expected to be retained in the pit, and would not contribute (flow out) to affect the quality of groundwater outside of the radius of influence of the pit. In terms of impact extent, modeling indicates that the open pit hydraulic capture zone would extend 1,000 feet or more from the crest of the pit in post-closure (Piteau and Associates 2018a). To maintain the 890 feet amsl management level, the maximum anticipated flow through the WTP is estimated to be approximately 1,300 gallons per minute, or 2.9 cfs (Piteau and Associates 2018a), although this rate could be higher than predicted under the current groundwater model based on model uncertainties. At 2.9 cfs, this rate is well below the expected treatment rates during operations and early closure phases of up to 45 cfs (Knight Piésold 2018a) and 58 cfs (Knight Piésold 2018d), respectively. Section 4.17, Groundwater Hydrology and Appendix K4.17 provide additional information on the analysis of groundwater flow in closure.

Modeling of post-closure pit water quality indicates that the open pit water would need to be treated in perpetuity (Knight Piésold 2018d). To ensure that impacted groundwater is contained as planned, groundwater monitoring would be conducted at selected wells surrounding the pit lake to confirm that groundwater flow is toward the pit, and that impacted groundwater is not migrating outside of the pit. Should the monitoring find that groundwater does not flow toward the pit, or that groundwater quality outside the pit is degraded during the post-closure period, the maximum management level (890 feet amsl) currently proposed would be reconsidered, and the pit lake level would be lowered to maintain hydraulic containment.

Pit lake modeling indicates that the lake would become thermally and chemically stratified (Lorax Environmental 2018), as discussed in Appendix K4.18. In terms of magnitude and extent, pit lake water quality predictions for various closure and post-closure time periods indicate that hardness and trace metals (aluminum, antimony, arsenic, cadmium, copper, iron, mercury, manganese, molybdenum, nickel, lead, selenium, and zinc) in near surface (upper 30 feet) pit lake water would exceed discharge limits. Pit lake pH values are predicted to be slightly alkaline (7.6 to 8.2). At these pH values, the concentrations of some of the metals (aluminum, cadmium, copper, iron, mercury, manganese, nickel, lead, and zinc) may be reduced via precipitation, adsorption, or complexation (which was not accounted for in the model). However, several metals form oxyanions (arsenic, molybdenum, antimony, and selenium) are likely mobile at these pH values. Therefore, it would be important to continue to maintain the pit lake as a hydraulic sink in perpetuity to control releases of these (and possibly other) metals to the environment.

Effects on Drinking Water Wells – Groundwater is abundant in the project area, and would be used as a source of potable water for the mine facilities. The proposed water supply wells would be sited on a groundwater high located upgradient—and on the northern (opposite) side of—the NFK east and north drainages that contain seepage collection systems for the pyritic TSF and main WMP (Figure 4.16-1). Therefore, groundwater that would be potentially affected by mine site facilities would not be expected to affect drinking water sources used by on-site workers. Similarly, no effect would be expected on drinking water wells outside of the mine site area.

Effects of Wetlands Reduction – Disruption, in-filling, and removal of wetlands would be likely to influence groundwater recharge and discharge patterns, which would affect groundwater quality in the vicinity of the mine site. Currently, although sulfides appear to be naturally oxidizing in the deposit area, the groundwater is not acidic (see Section 3.18, Water and

Sediment Quality). Reducing conditions are prevalent, partly because of deposition of organic carbon from wetlands and infiltration of organic carbon during spring thaw. The redox (reduction-oxidation reaction) state of the overburden may change during mine operations as the water table is lowered, and previously saturated soils and sediments are exposed to oxygen. In terms of magnitude of impact, this change in redox conditions would be expected to result in the release of metals to groundwater as oxidation occurs, and possibly precipitate reduced metals within sediment pores. Concentrations of metals in shallow groundwater may also increase because of the disruption of wetlands and increased sedimentation, resulting in an increase in suspended particulates with adsorbed metals. If these effects on groundwater conditions were to occur, the effects would be within the groundwater capture zone of the open pit, and all impacted water would be treated prior to discharge to the environment.

Summary of Effects on Mine Site Groundwater Quality – The geographic extent of impacts on groundwater quality from mine site activities under Alternative 1 would be limited to effects on local groundwater in the near vicinity of mine facilities, within the footprint of the mine site. Section 4.17, Groundwater Hydrology, describes uncertainties in the groundwater model that could have implications as to the extent of affected groundwater. The magnitude of these impacts would be such that groundwater would not meet regulatory criteria at certain discrete locations within the mine site (e.g., shallow groundwater beneath the bulk TSF and groundwater in the open pit as the lake level rises). Groundwater entering the pit, where it would mix with pit lake water, would be pumped and treated in perpetuity to maintain the open pit as a hydraulic sink. In terms of duration, groundwater quality beneath the NFK west and NFK east drainages in the immediate vicinity of the mine site would be impacted during operations, but would be expected to improve in the decades after mine closure. Monitoring would be conducted at the SCPs after the end of mining and during the closure and post-closure periods, to determine whether water quality in these localized areas improves after mining ceases. If monitoring shows that water quality is not improving during the post-closure period, additional remedies would be implemented to treat the impacted groundwater, as needed. These impacts are expected to occur through post-closure if the mine is permitted and constructed.

Substrate/Sediment Quality

This section describes impacts on waterbody substrates. Impacts on wetlands substrates are addressed in Section 4.22, Wetlands and Other Waters/Special Aquatic Sites.

Effects of Fill Placement on Physical Substrate – The magnitude and extent of impacts of physical substrate would be that placement of fill for construction of TSFs, WMPs, stockpiles, seepage and sediment ponds, and other facilities at the mine site would bury substrate in a number of streams and ponds. Section 4.22, Wetlands and Other Waters/Special Aquatic Sites, lists the acreages of fill placement in both waterbodies and wetlands.

Another impact of placement of fill would be changes in sediment supply to downgradient streams. In terms of extent of the impact, at mine site locations where streams would be filled, such as at the bulk TSF and associated seepage and sediment ponds, the downstream sediment supply to the NFK River would be cut off, depleting the natural supply of sediment to downstream gravels, and potentially affecting aquatic habitats (see Section 4.24, Fish Values). A decrease in water flow from fill placement would also lower the natural level of coarse sediment transport, potentially allowing more fine particles to accumulate within the streambed. These impacts of placement of fill would be permanent, and certain to occur if the project is permitted and constructed.

Summer-Only Ferry Operations Variant – The magnitude of impact of potential operational scenarios under the Summer-Only Ferry Operations Variant would be an additional effect on substrate because of the increased operational footprint at the mine site (Ausenco Engineering 2018). In terms of extent, ore concentrates and additional diesel fuel would be stockpiled at the mine site, requiring additional container and fuel storage areas that would total approximately 38 acres. These storage areas would be constructed partially or wholly on wetland areas, thereby directly affecting substrate. The impacts would be long term, and would occur if the Summer-Only Ferry Operations Variant is chosen, and the mine is permitted and built.

Effects of Erosion on Physical Substrate – Sediment release from erosion during construction and operations would be likely to impact water quality. BMPs (described above under Surface Water Quality) would be followed, and sediment control measures would be applied during construction, including the use of temporary settling basins and silt fences. Sediment control measures during operations through closure would include a number of diversion channels that would direct surface runoff away from project facilities, and sediment ponds that would allow material to settle out of the water column, inhibiting the extent of downstream sediment transport. Surface runoff and seepage from stockpiles would be captured by drainage ditches and routed into sedimentation ponds to allow settling before water is released downstream. The potential exists for erosion during periods of high precipitation and runoff to overwhelm the BMPs, resulting in an influx of fine sediment and increased turbidity into gravel-dominated streambeds. In terms of magnitude and extent of impacts, suspended fine particles would be expected to settle, and fill in interstitial spaces among the gravel, potentially affecting the streambed ecosystem (see Section 4.24, Fish Values).

Construction of the mine site facilities would block some streamflow, reducing natural erosion during high-precipitation events. However, in terms of magnitude and extent of impacts, increased streamflow where WTP effluent is discharged would increase the quantity of sediment that would be eroded, transported, and deposited downstream, thereby modifying substrate. Current designs for WTP discharge indicate that each outfall pipeline would be equipped with a discharge chamber to mitigate the potential for erosion at discharge points. Discharge chambers would be buried at sufficient depth for thermal insulation against freezing. Each outfall pipeline would be designed first to drain into the discharge chambers to reduce the energy of water outflow, then to release the water into the drainage (Knight Piésold 2018f). The duration of impacts would be long term and possible if control measures are inadequate or fail.

Impacts on Sediment Quality during Construction and Operations – Mining and exposing rock to chemical and physical weathering and erosion may increase the natural (pre-mine) rates of these processes and release constituents into surrounding surface water and substrate, thereby resulting in direct impacts to sediment quality. The magnitude of impact would be that substrate may be inundated with newly eroded materials, or undergo changes in chemistry due to the presence of weathering by-products. The evaluation of impacts on sediment quality depends largely on water quality and the other direct sedimentation impacts described above (e.g., erosion, dust). In terms of magnitude and extent, the chemical quality of sediment in some sections of streams at the mine site would be altered by fill placement, sediment accumulation upstream of embankments, and migration of contact water to downstream collection facilities. For example, contact water from the flow-through bulk TSF main embankment would introduce contaminants into native sediment between the TSF and the downstream SCP. Chemical components in water (such as metals and sulfate) would be absorbed by sediment or adsorbed onto sediment surfaces. Conversely, sediment would be expected to retain chemical constituents and slowly release them into water.

In terms of the extent of impacts on sediment quality, containment structures, and implementation of BMPs would limit impacts on sediment quality from surface disturbances to the project footprint. Water would be treated before discharge, and the potentially affected sediment would be contained by seepage and sediment ponds upstream of the discharge points. Likewise, although sediment in fully lined or contained facilities such as the pyritic TSF, WMPs, and pit lake would contain PAG materials and metals from the mining process, these would not affect native sediment in downstream waterbodies if properly managed.

Impacts on Sediment Quality from Fugitive Dust – Fugitive dust from various mine site sources and activities has the potential to affect sediment chemistry, particularly the concentration of metals. Appendix K4.18 provides the methodology used to calculate the predicted incremental increase in metals concentrations in sediment, and Table K4.18-16 shows the results. In terms of magnitude, total increases in metals concentration in sediment due to dust deposition are predicted to be less than 1 percent for all metals except antimony, which would be expected to increase by about 3 percent. Dust deposition would not be expected to result in any exceedances of the most stringent sediment quality criteria (Table K3.18-1).

Effects on Sediment Quality during Closure – Residual impacts from mine operations could remain beneath operational facilities. During closure and reclamation, soil and sediment beneath the facilities slated for removal (such as the pyritic TSF and WMPs) would be tested for contaminants, and any impacted materials exceeding applicable regulatory levels would be either treated or removed, and placed in the open pit (Knight Piésold 2018b). Surface runoff and groundwater that may be hydraulically connected to on-site sediment would be monitored downstream of the TSFs and WMPs at selected locations during post-closure to verify that potentially contaminated sediment is not affecting downstream water quality.

It is possible that mine-impacted sediment would remain between the reclaimed pyritic TSF and WMP footprints that are tested at closure. In these locations, the duration of impacts would be such that sediment can retain chemical constituents and slowly release them into overlying water, for decades or longer. Contaminants can be flushed out of coarse sediments such as gravels relatively quickly; by contrast, fine sediments like silts, muds, and clays found in some of the glacial lake deposits at the mine site could retain contaminants in porewater, and could store them for long periods of time because of their higher surface area. Even in areas where downstream water quality would be monitored; contaminants held in sediment would be expected to continue to be slowly released into waterbodies over the long term through runoff.

4.18.3.2 Transportation Corridor

Surface Water Quality

Road Corridor – In terms of magnitude, extent, duration, and likelihood, long-term impacts on surface water quality along the road corridor resulting from erosion at construction sites, material sites, and stream crossings would be expected, potentially causing increased suspended solids and turbidity in downstream waterbodies. Erosion and sedimentation would be managed by implementing BMPs as described in Section 4.14, Soils.

Based on a field review of geology at material sites, PAG material has not been identified at any site along the transportation corridor, and the rock types present are not typical of PAG rock. Rock types would be investigated further during site evaluation before construction. If PAG material is identified, it would not be used for construction, and the material site would be relocated to an alternate location with non-PAG rock (PLP 2018-RFI 035).

The potential for small amounts of vehicle- or ferry-related pollutants to affect streams along the transportation corridor is discussed below under "Substrate/Sediment Quality." Section 4.27, Spill Risk, discusses the potential for containers containing concentrate to affect water quality.

Ferry Construction and Operations – In terms of duration and magnitude, short-term but recurring impacts on surface water quality would result if ferry-induced suspended sediment in

Iliamna Lake near the terminals were to exceed background levels (see Appendix K3.18, Table K3.18-13). However, because the ferry would approach the dock perpendicularly at low power, and the propeller base plane would be 4 feet above the keel, the potential for propeller-induced erosion of the lakebed would be limited (PLP 2018-RFI 013). In terms of magnitude and duration, if fine bottom sediments were resuspended by ferry operations, it is expected that TSS concentrations would be expected to return to background levels within a short distance (less than 100 feet) from the ferry.

Stormwater runoff at the ferry terminals would be a potential source of impacts on surface water quality, potentially carrying suspended material and contributing to increased turbidity. Releases from ferry terminal facilities (e.g., generators, maintenance shops, or parking areas) would have the potential to affect surface water quality through stormwater runoff. Releases at the ferry terminals would be reduced through implementation of engineering controls (e.g., secondary containment, planned material management, and the presence of spill response equipment). In addition, stormwater capture and treatment systems would be in place at both ferry terminal locations to capture potential contaminants (PLP 2018-RFI 093). The duration and likelihood of impacts from construction and operation of ferry terminals would be long term and possible if control measures are inadequate or fail.

Groundwater Quality

Road construction, material site development, and ferry operations are not expected to affect groundwater quality.

Substrate/Sediment Quality

Erosion Effects – Project-induced erosion and increased sedimentation on waterbody substrates would be expected to occur during construction activities such as vegetation removal, excavation, and grading of road beds and material sites. In terms of duration and magnitude, long-term impacts ranging from direct inundation of substrate to minor changes to substrate characteristics and chemistry would result. Withdrawal of water from permitted waterbodies during construction and operations also has the potential to disturb fine sediment on streambeds and lakebeds. BMPs such as dust control and erosion and sedimentation control measures and compliance with permit stipulations for water extraction methods would be followed to reduce potential impacts. The extent of effects during road construction would likely be limited to stream crossing locations within the construction right-of-way (ROW). The duration and potential for erosion and sedimentation is expected to be seasonal (reduced in winter by frozen conditions), and to continue for the life of the unpaved roads, which would be permanent, because they would be needed to support water treatment at the mine site post-closure.

Should BMPs be inadequate or overwhelmed by high-precipitation events, eroded soils and sediments would be transported by water and wind, potentially causing sedimentation into nearby waterbodies. Section 4.24, Fish Values, describe effects on fish habitat and aquatic resources. Streams intersecting the transportation corridor vary in grain size and substrate composition, with some crossings composed mainly of sand, silt, and organic material; and others having a higher concentration of gravel, cobbles, and boulders (Section 3.18, Water and Sediment Quality) (PLP 2018-RFI 036). The Gibraltar River bridge crossing location is largely dominated by gravel and cobbles. Stream crossings in areas where substrate is predominantly fine-grained would likely be subject to greater erosional effects and impacts on substrate than those with predominantly coarser substrates (see Section 4.16, Surface Water Hydrology, for discussion of erosion and sedimentation at stream crossings)

Placement of Fill Material – Road construction would include the placement of fill onto waterbody substrates at stream crossings, lakes, and ponds along the transportation corridor, resulting in a direct long-term to permanent impact to sediment. Gravel fill would be placed at certain bridge abutments and at the ends of culverts larger than 3 feet in diameter to protect the bridge structures and substrate from erosion. Fill would also be placed inside larger culverts requiring fish passage to simulate streambed material for aquatic habitat. The areas and lengths of streams affected are quantified in Section 4.22, Wetlands and Other Waters/Special Aquatic Sites, Table 4.22-2, and shown on Appendix K4.22, Figure K4.22-1. The magnitude of the direct effect of fill placement would be to permanently bury existing sediment, because the road would remain during post-closure. In terms of extent and duration, fill placement at the ferry landings would extend about 105 to 155 feet onto the nearshore lake sediment (PLP 2018-RFI 093), and would remain in place at closure. Potential indirect effects under CWA Section 404(b)(1) include temporary localized sediment suspension and redeposition downstream during construction.

Sediment Contamination – Fuel, oil, and lubricants would be used during the normal course of operations; and if not properly managed, these materials could be inadvertently released onto the roadbed, and run off to stream or pond substrates, or could be released into Iliamna Lake and incorporated into lakebed substrate, resulting in direct impacts to sediment quality. These potential impacts related to sediment contamination would be reduced by following BMPs and fuel handling requirements, and would extend throughout the life of the mine and into post-closure. Section 4.27, Spill Risk, addresses impacts from potential major spills along the transportation corridor.

Summer-Only Ferry Operations Variant – Under the Summer-Only Ferry Operations Variant, the magnitude and duration of impacts from activities at the ferry terminals would be reduced for approximately 6 months per year, during the winter (Ausenco Engineering 2018). As a result, roadway use would also be greatly reduced, particularly on the southern side of Iliamna Lake. During the period of no use, the potential for impacts on substrate and sediment quality would also be reduced because of the lower activity levels. However, the potential for impacts would not be eliminated entirely, because fuel, lubricants, or other potential contaminants would still be stored at local ferry terminal facilities, and because some roadway use would still be expected. During the periods of ferry operation, the magnitude of activity would approximately double to account for the reduced length of the operational season. Overall, the magnitude, extent, duration, and likelihood of impacts of this variant on substrate would be essentially the same as the effects of Alternative 1.

4.18.3.3 Amakdedori Port

Surface Water Quality

Surface Water Runoff – Amakdedori port would be the shoreline hub for shipping, receiving, and storage of concentrate containers, fuel, reagents, and other freight for the project; and as a result, would experience impacts from those activities. In terms of magnitude and extent, the primary potential direct impact from surface water runoff would be the transport of contaminants from the port facilities into adjacent marine waters. These direct impacts would be reduced through engineering controls. For example, the outside of concentrate containers would be vacuumed or spray-washed at the port site (PLP 2018-RFI 45). In addition, the secondary containment (container barrier wall) built around the fuel tanks, and a perimeter containment curb constructed around the terminal would prevent surface water runoff from these facilities and activities from reaching off-site surface water.

The WTP at Amakdedori port would treat surface runoff from the port facilities, which could potentially contain constituents from the above sources. In terms of magnitude and extent of impact to water quality, runoff water from the port facilities would have some similarities to mine contact water in terms of solids, but would not be expected to have the same levels of TDS, given the lack of material processing. Prior to discharge, the treatment process would include dissolved metal oxidation using potassium permanganate, followed by co-precipitation with ferric chloride. Water from the co-precipitated solids would flow into flocculators/clarifiers to separate out the solids. The clarified water would then be treated with sodium hydrogen sulfide, sodium hydroxide, and ferrous sulfate to further co-precipitate the remaining metals under reducing conditions. The solids removed would be thickened and disposed of appropriately, either at the mine site in the pyritic TSF, or at an approved offsite disposal facility via barge. Water treatment would also address any hydrocarbons (petroleum, oil, lubricants [POL]) in the runoff (PLP 2018-RFI 087). The treated water would be suitable for discharge, with a discharge point in marine waters at the end of the dock structure. A potable WTP and a sewage treatment plant would also be located at the port site. The duration of potential impacts would be for the life of the project, if the mine is permitted and the Amakdedori port is constructed and operated.

Dust Impacts on Marine Water Quality – In terms of impact potential, dust generation during bulk carrier loading operations would be mitigated by implementing BMPs to prevent the dust from entering the water. The copper and gold concentrate containers would be lowered into the hold of the bulk carrier prior to being emptied, deep enough to prevent crosswinds from generating dust. The containers would be emptied within 10 feet of the concentrate pile, minimizing dust generation, and the hold would be filled to only approximately 50 percent of capacity. Based on the typical dimensions of a bulk carrier, the inverting and discharge of containers would occur at least 20 feet below the hatch. The concentrate is expected to still be moist from processing, but a water fog system could be installed to minimize dust if required (PLP 2018-RFI 099; PLP 2018-RFI 045). Section 4.27, Spill Risk, addresses impacts on water quality under potential upset conditions.

Impacts on Salinity Gradients – Salinity gradients that might occur naturally at the locations of freshwater discharges into the port areas would assimilate quickly into adjacent marine waters due to natural mixing by wind-driven currents and waves, and therefore would not be affected by port operations.

Suspended Particulates/Turbidity from Causeway Fill – In terms of magnitude and duration of potential impacts on marine waters, increased concentrations of suspended sediment and redeposition would occur in Kamishak Bay during the placement of fill material for causeway construction and the installation of sheet pile for the wharf structure. Such conditions could persist for up to several days after the completion of construction. The duration and extent of the increase in suspended sediment concentrations would depend on the amount of fine sediment in the fill material and disturbed seafloor material, as well as weather conditions (i.e., tides and wind-driven currents and waves would disperse suspended sediment even as it settles to the seabed). Section 4.16, Surface Water Hydrology, also describes impact of in-water structures. Fill material would consist of either blasted granitic bedrock trucked along the road from the closest material site, MS-A08, or imported by barge from existing commercial sources (PLP 2018-RFI 005; PLP 2018-RFI 035) such as the granite quarry at Diamond Point (ADNR 2014a). The existing marine substrate at the port site consists of subtidal gravels (GeoEngineers 2018a). Although sediments in the area are generally coarse-grained (Section 3.18, Water and Sediment Quality), project-related activity would contribute to the magnitude, extent, duration, and potential of increased suspended sediment levels in marine water around the proposed port site.

Pile-Supported Dock Variant – Compared to the causeway alternative, this dock variant would essentially be transparent to water movements in the port area; that is, a pile-supported dock would not be capable of deflecting alongshore currents from the shore in the same manner as a solid-fill causeway. In terms of magnitude and extent, wake effects would be limited to a few pile diameters' distance from each pile (on the lee side). No alteration of water movements or sedimentation processes would occur. Vibrations caused by pile driving during construction could affect sediment substrate; however, these effects would be limited in duration to the actual pile-driving period.

Groundwater Quality

Impacts on groundwater quality at the port site are not expected. No excavation or placement of fill would occur at depths that intersect the water table. Using groundwater for drinking water supplies at the port would not adversely affect groundwater quality. A single groundwater well is planned for the port site for potable water supply (location to be identified during detailed design). The well would be sited on uplands far enough from shore to mitigate the risk of potential saltwater intrusion, and water would be piped to the port site from the wellhead (PLP 2018-RFI 022a).

Substrate/Sediment Quality

Effects on Freshwater Substrate – In terms of magnitude, extent, and duration, direct impacts to sediment in Amakdedori Creek on the southwestern side of the terminal and in ponds to the north may occur as a result of erosion and overland runoff, especially during construction. However, BMPs would be in place to avoid or reduce erosion and runoff. The port terminal would be built at an elevation of 35 feet, about 15 feet above the floodplain of Amakdedori Creek. As described above, runoff from the terminal would be contained and treated before discharge to Amakdedori Creek. Section 4.14, Soils, and Section 4.16, Surface Water Hydrology, provide further descriptions of BMPs and potential flooding effects, respectively.

Summer-Only Ferry Operations Variant – In terms of magnitude and extent, the Summer-Only Ferry Operations Variant would result in an increased operational footprint at the port site, which would cause increased effects on substrate (Ausenco Engineering 2018). The additional concentrate storage under this variant would require placement of fill along the eastern bank of Amakdedori Creek (PLP 2018-RFI 065). Section 4.22, Wetlands and Other Waters/Special Aquatic Sites, provides the acreage of wetland substrate loss under this variant. The impact of additional fill placement would be permanent and certain to occur if the Summer-Only Ferry Operations Variant is chosen, the project is permitted, and the port is built.

Effects on Marine Substrate – In terms of magnitude and extent of impacts on marine substrate, the causeway would be approximately 1,200 feet long with an average base width of 250 feet, and the wharf would extend another 700 feet, with a width of 120 feet (PLP 2018-RFI 093); the footprint on the floor of Kamishak Bay would be approximately 11 acres (see Chapter 2, Alternatives, Table 2-2). The duration and likelihood of effects would be permanent and certain to occur if the project is permitted and the causeway is constructed. Placement of fill and riprap on top of the seabed during causeway construction and installation of sheet pile for wharf construction would result in direct impacts, including the burial of substrate beneath the footprint, disturbance of seafloor sediment during fill placement and sheet pile driving, and settling of suspended solids away from the footprint, as described above under Surface Water Quality. Dredging of offshore sediment would not be required at the Amakdedori port site.

Section 4.24, Fish Values, discusses impacts on the primarily soft sediment habitat types in this area.

Fuel, oil, and lubricants may leak from vessels into Kamishak Bay and Cook Inlet waters, and potentially become incorporated into seafloor sediments. However, strong currents, shallow water, and high tidal exchange in Cook Inlet create an ongoing flushing of seawater in the inlet (USACE 2013). Potential contaminants from marine vessels accessing Amakdedori port would be diluted and flushed into the North Pacific Ocean, and would not be expected to contribute a negligible amount of contamination to existing low background levels (contaminate marine sediments (Section 3.18, Water and Sediment Quality). Section 4.27, Spill Risk, discusses impacts from upset conditions.

4.18.3.4 Natural Gas Pipeline Corridor

Surface Water Quality

The magnitude, extent, duration, and likelihood of impacts to surface water quality within the natural gas pipeline corridor would be associated with installation of the pipeline at water crossings and the use of local water sources for hydrostatic testing. Impacts at material sites and stream crossings would be the same as those described above for the transportation corridor.

In terms of magnitude of effects, surface water quality at pipeline stream crossings is expected to be within water quality standards for turbidity during construction. Natural turbidity measurements at stream crossings along the transportation corridor were mostly below the instrument's minimum detection level of 7 to 11 nephelometric turbidity units (NTU) during 2018 field studies (see Section 3.18, Water and Sediment Quality) (PLP 2018-RFI 036). ADEC water quality standards specify that turbidity levels may not exceed 5 NTU above these conditions (when the natural turbidity level is 50 NTU or less). It is possible that isolated occurrences of impacts above this standard could occur temporarily during construction (e.g., during high-precipitation periods along summer construction segments); planned redundancies in BMPs, erosion and sediment control measures, and reclamation/cleanup crew functions would reduce potential impacts. Exceedances of turbidity standards would not be expected during operations if appropriate pipeline cover material is applied, consistent with the US Department of Transportation Pipeline and Hazardous Materials Safety Administration code and BMPs, including water bars and diversion features. Impacts to surface water quality in excess of allowable standards from erosion of horizontal directional drilling (HDD) sites during and after construction would not be anticipated if proper procedures and BMPs are applied (PLP 2018-RFI011).

The removal of water from rivers and small lakes along the route for hydrostatic pipeline pressure testing would be required. However, the water volume removed for testing purposes would be small; therefore, impacts on surface water quality from hydrostatic testing are not expected. Discharges of hydrostatic test water would meet the requirements of the applicable APDES general permit, or other state-issued permit as applicable, depending on whether discharges are to land or water.

Groundwater Quality

Trenching Effects – The pipeline trench would likely intersect shallow groundwater intermittently along the overland portion of the route, causing potential impacts on groundwater quality similar to those of the transportation corridor. In areas of shallow groundwater, there would be local alterations to groundwater flow patterns (Section 4.17, Groundwater Hydrology), and small changes in the composition of groundwater that would likely not exceed applicable regulatory criteria. The extent of groundwater impacts would be limited to particular areas, primarily in the vicinity of stream crossings.

Horizontal Directional Drilling Effects on Drinking Water Wells – HDD operations would be required for the natural gas pipeline at the Kenai shore approach near Anchor Point, and potentially at other locations as permits require. Impacts of HDD operations on groundwater and potential drinking water sources would be expected to be minimal and localized, relative to baseline groundwater supply wells (see Section 3.18, Water and Sediment Quality). Dewatering would not be required for HDD operations, precluding the risk of changes in local groundwater flow patterns (see Section 4.17, Hydrogeology). Drilling fluid would likely be composed of bentonite and water. The potential risk exists for drilling fluids, injected under pressure, to propagate away from the borehole and escape into the local aquifer (PLP 2018-RFI 051). Drilling fluid returns would be closely monitored during operations to ensure no excessive fluid loss. Drilling fluid returns would be treated via a separation system, and the cleaned fluid would be reinjected into the borehole for use during drilling, or stored in tanks at the surface for later disposal off site (PLP 2018-RFI 051).

Substrate/Sediment Quality

Potential impacts on waterbody substrate from erosion and sedimentation, fill placement, and contamination would be similar to those described above for the transportation corridor. No waterbody substrates would be crossed by the pipeline segment east of Cook Inlet. West of Cook Inlet, trench excavation and placement of cover material at stream crossings would be within the acreages documented for the road fill prism in Section 4.22, Wetlands and Other Waters/Special Aquatic Sites. BMPs would be in place to control runoff and erosion during trenching, backfilling, and other ground-disturbing activities; therefore, impacts would be avoided or minimized.

Placement of fill at pipeline landfalls in Cook Inlet and Iliamna Lake would entail trenching into the existing bottom sediment and covering the pipeline with at least 3 feet of fill to a water depth of 12 feet (PLP 2018-RFI 013). Section 4.16, Surface Water Hydrology, addresses the potential for sediment suspension, plume transport, and redeposition to occur during construction in the marine environment.

4.18.4 Alternative 2 – North Road and Ferry with Downstream Dams

4.18.4.1 Mine Site

Buttressed Downstream Bulk TSF Main Embankment – Due to similar seepage design and downstream capture under Alternatives 1 and 2 , the downstream dam alternative for the bulk TSF main embankment would likely have similar impacts on surface water and groundwater quality as centerline construction. However, impacts to substrate (freshwater sediment) would be greater than Alternative 1, because construction of the downstream dam alternatives would require a 45 to 60 percent increase in fill over the centerline constructed dam due to the larger embankment footprint, and would cover approximately 23 more acres (PLP 2018-RFI 075). This would result in a corresponding increase in direct impacts on substrate in the NFK west drainage through permanent burial by fill, and a potential increase in erosion and redeposition impacts (described under Alternative 1).

4.18.4.2 Transportation Corridor

Mine Site to Eagle Bay, and Pile Bay to Diamond Point Roads – Under Alternative 2, two road segments would cross approximately half as many waterbodies requiring bridges or culverts as the transportation corridor under Alternative 1. Water quality and substrate impacts associated with the road segments and material sites would therefore be expected to be incrementally less than Alternative 1. As in Alternative 1, the impacts that would be expected would be potential direct and temporary effects on water quality due to sedimentation and turbidity generated through construction activities, which would be limited by use of BMPs and engineering controls (PLP 2018-RFI 086).

Eagle Bay to Pile Bay Ferry – Ferry operations from Eagle Bay to Pile Bay would have similar impacts on water and substrate quality as ferry operations in Alternative 1.

Summer-Only Ferry Operations Variant – Although the Summer-Only Ferry Operations Variant would reduce water quality impacts on the lake during the 6-month winter season, ferry operations and activity would be increased during the 6 months of ferry operations. Placement of additional fill at the mine site and the port site would be required to support additional storage areas for concentrate and diesel (PLP 2018-RFI 065), resulting in corresponding increases in burial of existing lake substrate and in suspended solids and turbidity during fill placement. Additional concentrate storage at the port site under this variant would also require an increase in fill placement along the western side of Iliamna Bay near Williamsport (see Section 4.22, Wetlands and Other Waters/Special Aquatic Sites, for the acreage of wetland and waterbody substrate coverage under this variant). The likelihood of small spills and contaminated runoff would increase because of the extra container and fuel storage under this variant, although this is expected to be mitigated by water treatment of runoff as described under Alternative 1 (major spills from extra container and fuel storage are addressed in Section 4.27, Spill Risk).

4.18.4.3 Diamond Point Port

Terminal Runoff and Lightering Locations – Impacts from surface water runoff and treatment at the terminal, and from dust at the lightering locations, would be the same as described for Alternative 1.

Groundwater Quality at Dredge Disposal Area – Because of the differences in the approaches to the proposed dock facilities between Amakdedori port and Diamond Point port, dredging of marine substrate at the Diamond Point location would be required to achieve a minimum 20-foot water depth. This dredging would generate approximately 650,000 cubic yards of material, of which a minimum of 50 percent would be used in dock construction. The remaining dredged material would be transported and disposed of onshore in a bermed facility located west and upland of the dock site, about 200 feet from the shoreline (PLP 2018-RFI 063). Most interstitial water (e.g., water contained in the dredged sediment) would be expected to drain back into Cook Inlet during placement of the dredged material onto a barge prior to transport; however, some limited amount of water would remain in the dredge spoils, and would be placed in the upland disposal site with the solids. The saline water placed in the bermed containment would be expected to seep into underlying soils, and would mix with any shallow groundwater present. The overall area of the potential groundwater impact would be somewhat limited by the proximity of the disposal site to the shoreline.

Impacts on Salinity Gradients – Salinity gradients that might occur naturally at the locations of freshwater discharges into the port area would assimilate quickly into adjacent marine waters due to natural mixing by wind-driven currents and waves, and therefore would not likely be affected by port operations.

Proposed Earthen Fill Dock: Suspended Particulates/Turbidity and Substrate Effects – Construction of dock facilities at Diamond Point would have greater direct impacts on marine substrate than construction under Alternative 1, because the footprint of these structures would cover roughly 90 more acres of seabed with fill than the Amakdedori port structures (PLP 2018-RFI 072). Placement of the fill causeway and wharf structure would contribute suspended sediment to the water column, leading to temporary turbidity and redeposition in the vicinity of construction. These effects are expected to be greater than those of the Alternative 1 causeway construction because of the greater amount of fill placement, and because the finer seabed material in Iliamna Bay is expected to travel farther before settling. This would cause an increase in the extent of turbidity effects and redeposition compared to Alternative 1, and an increase compared to the Pile-Supported Dock Variant under this alternative.

Some dredging of shallow offshore sediments would be required for construction of a marine vessel channel at the Diamond Point port. Initial dredging and maintenance dredging over 2 decades of production at the mine would cover an area of approximately 60 acres. These activities would temporarily increase suspended solids in the water column, which would be redeposited on marine substrate; effects that would not occur under Alternative 1. The extent of these effects would range from localized, to beyond the mouth of Iliamna Bay, depending on tides and wave conditions.

Pile-Supported Dock Variant: Suspended Particulates/Turbidity and Substrate Effects – Construction of a pile-supported dock at Diamond Point would result in fewer direct impacts on substrate than a fill causeway, because the piles would be driven through vibratory and hammer methods and would require no fill (PLP 2018-RFI 072). Effects would be slightly greater than the effects of constructing a pile-supported dock under Alternative 1 because the footprint of the piles would be about twice as large as the dock footprint under Alternative 1. Temporary and limited impacts from increased suspended sediment in marine waters would be expected to occur during construction of the pile structure.

4.18.4.4 Natural Gas Pipeline Corridor

For the portion of the natural pipeline corridor crossing Cook Inlet from the Kenai Peninsula, impacts on water and sediment quality would be the same as described under Alternative 1. From the point the pipeline would come ashore at Ursus Cove to the mine site, the Alternative 2 pipeline corridor would cross approximately 28 percent more waterbodies than the Alternative 1 route, but would eliminate the crossing of Iliamna Lake. The increase in waterbody crossings would suggest an incremental increase in the potential for impacts to water and sediment quality, primarily through the local and temporary direct effects of sedimentation during construction. Sedimentation would be minimized through the use of engineering controls and BMPs such as silt fences and bale check dams. In addition, the pipeline trench would have the potential to intersect shallow groundwater in the area between Ursus Cove and Diamond Point; however, impacts to groundwater would be expected to be limited and temporary.

4.18.5 Alternative 3 – North Road Only

A continuous overland access road would connect the Diamond Point port to the mine site under Alternative 3. The natural gas pipeline would be commonly aligned with the transportation corridor under this alternative, and would align with the same route as the natural gas pipeline under Alternative 2. Impacts to water and sediment quality on the pipeline corridor would be very similar to those described for the Alternative 2 transportation corridor. The following section describes impacts for the mine site, transportation corridor, and port that would be unique under Alternative 3.

4.18.5.1 Mine Site

Under Alternative 3, impacts on the mine site would be the same as for other alternatives, with minor differences in effects under the Concentrate Pipeline Variant. Impacts of this variant are described below.

Concentrate Pipeline Variant – The concentrate pipeline from the mine to the port under this variant would require an electric pump station at the mine site, which would require a small increase in fill placement over stream substrate in an NFK east tributary (PLP 2018-RFI 066). This would slightly increase the long-term direct impact at the mine site through burial of natural sediment. This variant would also reduce the amount of WTP water released at discharge locations at the mine site by approximately 1 to 2 percent (PLP 2018-RFI 066). This would result in slight reductions in temperature effects, impacts on substrate, and turbidity or erosional effects at the locations of treated water discharges. Inclusion of the concentrate pipeline would result in a slight increase in the potential for minor spills at the mine site. Section 4.27, Spill Risk, examines major spill scenarios.

4.18.5.2 Transportation Corridor

Alternative 3 would increase the project footprint, but would eliminate surface water quality impacts associated with the ferry crossing of Iliamna Lake. The northern access all-road route would result in an increase of about 20 percent in the number of stream crossings relative to Alternative 1, with a corresponding increase in direct but temporary water quality and substrate impacts (described under Alternative 1).

Concentrate Pipeline Variant – Inclusion of a concentrate pipeline under this alternative would result in slightly greater direct impacts on water and substrate/sediment quality than the all-road route alternative without the concentrate pipeline. The concentrate pipeline would be buried during road construction, and the road corridor would be widened by less than 10 percent to accommodate the pipeline, which would marginally increase the turbidity effects on water quality and fill placement over substrate. An electric pump station would be required along the transportation corridor under this variant (PLP 2018-RFI 066), resulting in a small increase in the footprint in an upland area that is unlikely to affect water quality or substrate. Inclusion and operation of the concentrate pipeline would also result in an increased potential for impacts on substrate and surface water quality due to potential minor spills/leaks, although the likelihood of occurrence would be low with the use of a leak-detection system (major spill scenarios for concentrate are discussed in Section 4.27, Spill Risk). Because only the molybdenum concentrate (2.5 percent of the total concentrate production) would be trucked from the mine site to the port, a large reduction in road traffic would be anticipated, thereby reducing some potential direct and indirect impacts from dust, erosion, and runoff.

Concentrate Return Water Pipeline Option – Under this option, the return water pipeline would be buried in the same trench as the slurry and natural gas pipeline, requiring the trench to be widened by a few feet, and resulting in an increased footprint of the transportation corridor and a slight increase in direct impacts (PLP 2018-RFI 066). Therefore, the return water pipeline would result in a minimal increase in the same water quality and substrate/sediment quality effects as described above. Under this option, there would be a potential for minor spills of contact water from the pipeline affecting water and sediment quality that would not exist under the other options.

4.18.5.3 Diamond Point Port

Concentrate Storage and Bulk Handling – Concentrate would be dewatered at the port site, and the dewatered concentrate would be stored in a large building until the loading of concentrate onto bulk carriers for transport. The storage building would result in a slight increase in the footprint at the port site beyond that of Alternative 2, with a corresponding slight increase in direct impacts from substrate burial at the small tributary to Cottonwood Bay (see Chapter 2, Alternatives, Figure 2-64). Bulk handling of the concentrate would use controls to reduce dust emissions, such as covered conveyors that are used at Red Dog Mine dock facilities (PLP 2018-RFI 066). If not properly managed, the storage and handling of bulk concentrate would result in an increased potential for direct effects on water and sediment quality.

The water removed from the concentrate would be treated in a WTP to meet marine water quality standards, and discharged through an outfall pipeline and diffuser to the marine environment. Treatment would consist of adding chemicals for pH adjustment and metals precipitation, followed by use of clarifiers for solids removal and additional metals precipitation with sodium hydrogen sulfide and filtration. Solids and/or brine captured in the clarification and filtration steps would be trucked to the mine site or barged to an off-site disposal facility (PLP 2018-RFI 066).

4.18.5.4 Concentrate Pipeline Variant

The concentrate pipeline option using a return-water pipeline would result in no additional project footprint at Diamond Point, and would preclude the need for the discharge of treated water at the Cook Inlet terminus. This Concentrate Pipeline Variant would eliminate the need for a dewatering WTP at the port; instead, requiring a return-water pump station of appropriate capacity (PLP 2018-RFI 066). This option would result in a negligible change in the footprint at the port site, and likely no changes in impacts on substrate compared to Alternative 2 or Alternative 3 without the return water pipeline. Therefore, the effects on water and sediment quality would be the same as Alternatives 2 and 3.

4.18.6 Summary of Key Issues

Table 4.18-1 summarizes general anticipated impacts on surface water, groundwater, and substrate/sediment quality from construction, operations, and closure of the mine site and associated development and activities.

Table 4.18-1: Summary of Key Issues for Water and Sediment Quality

Impact-Causing Project Component	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Mine Site			
Mine Site Construction	**Surface Water**: Ground disturbance and fill placement would result in increased turbidity in local waterbodies and streams, to be mitigated through BMPs. **Groundwater**: Metals concentrations in shallow groundwater may increase as a result of the disruption of wetlands and fill placement. **Substrate**: Ground disturbance and fill placement would result in substrate burial[1] and increased erosion and sedimentation if BMPs are inadequate, and would reduce natural levels of coarse sediment transport to downstream substrates.	**Surface Water**: Impacts similar to those of Alternative 1. **Groundwater**: Impacts similar to those of Alternative 1. **Substrate**: Impacts similar to those of Alternative 1.	**Surface Water**: Impacts similar to those of Alternative 1. **Groundwater**: Impacts similar to those of Alternative 1. **Substrate**: Impacts similar to those of Alternative 2. *Concentrate Pipeline Variant:* Small increase in substrate burial in NFK east tributary.[1]
Tailings and Contact Water Storage (TSFs and WMPs)	**Surface Water**: Pond water quality in TSFs and WMPs would exceed water quality standards, but would be contained within the mine site footprint and treated prior to discharge to the environment. Runoff of contact water from the TSF and WMP embankments would be monitored, and diverted to WMPs or WTPs for treatment as necessary. **Groundwater**: Local impacts on shallow groundwater quality in the NFK west, east, and north drainages are likely from vertical seepage through the bulk TSF, or leakage through the pyritic TSF or WMP liners. This would result in localized exceedances of water quality standards within the mine site footprint, which would be captured and treated prior to discharge to the environment. No mine site effects on drinking water wells are expected. **Substrate**: Burial from fill placement in the NFK west, east, and north drainages.	**Surface Water**: Impacts similar to those of Alternative 1. **Groundwater**: Impacts similar to those of Alternative 1. **Substrate**: Impacts similar to those of Alternative 1.	**Surface Water**: Impacts similar to those of Alternative 1. **Groundwater**: Impacts similar to those of Alternative 1. **Substrate**: Impacts similar to those of Alternative 1.

Table 4.18-1: Summary of Key Issues for Water and Sediment Quality

Impact-Causing Project Component	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Fugitive Dust Effects	**Surface Water**: Metals concentrations in surface water predicted to increase by 0.1% to 0.7% as a result of fugitive dust deposition, including direct fallout and through runoff, although no exceedances of water quality standards are expected. **Groundwater**: No leaching to groundwater above ADEC migration-to-groundwater levels, except for arsenic, which exceeds baseline, and with a predicted 0.6% dust-related increase. **Substrate**: Metals concentrations in sediment would increase by 0.1% to 3%, but no exceedances of SQGs.	**Surface Water**: Impacts similar to those of Alternative 1. **Groundwater**: Impacts similar to those of Alternative 1. **Substrate**: Impacts similar to those of Alternative 1.	**Surface Water**: Impacts similar to those of Alternative 1. **Groundwater**: Impacts similar to those of Alternative 1. **Substrate**: Impacts similar to those of Alternative 1.
Treated Water Discharge	**Surface Water:** WTPs would effectively treat metals and other constituents in WMPs and TSF pond water to meet discharge criteria; the potential exists for an increase in TDS during operations, requiring adaptive management of WTP processes. Temperature changes in the range of -1°C to +3.6°C are predicted in the NFK, SFK, and UTC drainages about 0.5 mile to 3 miles downstream of WTP discharges. **Groundwater:** WTPs would effectively treat dewatering water from open pit and potential groundwater contamination from TSFs captured in seepage collection systems. **Substrate:** Potential erosion effects from WTP effluent would be minimal with discharge chambers to dissipate outflow energy.	**Surface Water**: Impacts similar to those of Alternative 1. **Groundwater**: Impacts similar to those of Alternative 1. **Substrate**: Impacts similar to those of Alternative 1.	**Surface Water**: Impacts similar to those of Alternative 1. *Concentrate Pipeline Variant*: Estimated decreased discharge volume by 1% to 2% would result in marginal changes in temperature effects. **Groundwater**: Impacts similar to those of Alternative 1. **Substrate**: Impacts similar to those of Alternative 1.
Mine Site Closure	**Surface Water**: Impacted sediment between the locations of TSFs and SCPs/WMPs locations, if present, would continue to release contaminants into surface water over time. Pit lake water quality would exceed water quality standards, but would be pumped to maintain operational levels and treated prior to being discharged to the environment. **Groundwater**: Local groundwater quality in the immediate vicinity of the pit and downstream of TSFs may exceed water quality standards, but would be contained by overall gradient toward pit lake or SCP capture, and treated to meet discharge criteria. **Substrate**: Potentially contaminated sediment between TSFs and SCPs/WMPs would be monitored after closure and remediated if necessary.	**Surface Water**: Impacts similar to those of Alternative 1. **Groundwater**: Impacts similar to those of Alternative 1. **Substrate**: Impacts similar to those of Alternative 1. *Downstream Bulk TSF Variant:* Increased substrate burial beneath the bulk TSF would be permanent.	**Surface Water**: Impacts similar to those of Alternative 1. **Groundwater**: Impacts similar to those of Alternative 1. **Substrate**: Impacts similar to those of Alternative 1.

Table 4.18-1: Summary of Key Issues for Water and Sediment Quality

Impact-Causing Project Component	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Transportation Corridor			
Road Construction and Operations	**Surface Water**: Localized (affecting stream-crossing points and areas downstream) and temporary increase in turbidity at approximately 100 stream crossings during construction. Impacts are expected to be short term and limited to the construction phase, and would be mitigated through BMPs. **Groundwater**: Impacts anticipated to be negligible. **Substrate**: Potential erosion and sedimentation during construction at stream crossings to be mitigated through BMPs. Placement of fill at bridge and culverts would bury existing substrate.[1]	**Surface Water**: Localized increased turbidity, but 50% fewer stream crossings than under Alternative 1. **Groundwater**: Impacts similar to those of Alternative 1. **Substrate**: Potential increase in substrate impacts[1] with additional stream crossings.	**Surface Water**: Magnitude of impacts similar to those of Alternative 1, but in different locations. *Concentrate Pipeline Variant*: Marginal increase in turbidity due to wider road corridor. **Groundwater**: Impacts similar to those of Alternative 1. **Substrate**: Impacts similar to those of Alternative 2. *Concentrate Pipeline Variant:* Marginal increase in substrate[1] due to wider road corridor.
Ferry Construction and Operations	**Surface Water**: Potential for ferry-induced increase in nearshore TSS/turbidity during operations; expected to return to background levels within a short distance (less than 100 feet) from ferry. *Summer-Only Ferry Operations Variant:* Reduced TSS/turbidity impacts in winter and increased impacts in summer; overall same as Alternative 1. **Groundwater**: No impacts anticipated. **Substrate**: Fill placement at the ferry during construction would extend 100 to 150 feet onto the nearshore lake substrate. *Summer-Only Ferry Operations Variant:* Increased fill placement on lake substrate during construction at terminals.[1]	**Surface Water**: Impacts similar to those of Alternative 1. Ferry terminal locations changed to Eagle Bay and Pile Bay. *Summer-Only Ferry Operations Variant:* Impacts similar to those of Alternative 1. **Groundwater**: No impacts anticipated. **Substrate**: Impacts similar to those of Alternative 1. Ferry terminal locations changed to Eagle Bay and Pile Bay. *Summer-Only Ferry Operations Variant:* Impacts similar to those of Alternative 1.	**Surface Water:** No impacts on lake water quality anticipated (no ferry). **Groundwater**: No impacts anticipated. **Surface Water:** No impacts on lake substrate (no ferry terminals).

Table 4.18-1: Summary of Key Issues for Water and Sediment Quality

Impact-Causing Project Component	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Port Site			
Causeway Fill/ Construction	**Surface Water**: Placement of fill during construction would result in a localized increase in TSS/turbidity in Kamishak Bay for the duration of construction activities. *Pile-Supported Dock Variant*: Would reduce TSS/turbidity impacts due to reduced area of disturbance.[1] **Groundwater**: No impacts anticipated. **Substrate**: Placement of fill during causeway construction would result in disturbance of seafloor sediment and burial of substrate beneath the causeway footprint.[1] *Pile-Supported Dock Variant*: Less burial of marine substrate during construction.[1]	**Surface Water**: Greater extent of TSS/turbidity increase due to finer-grained sediment and dredging activities; extent would range from the close vicinity of the dock to the mouth of Iliamna Bay, depending on tides and waves. *Pile-Supported Dock Variant*: Impacts similar to those of Alternative 1. **Groundwater**: Impacts similar to those of Alternative 1; stockpile of dredged material may have local impacts on shallow groundwater quality. **Substrate**: Area of direct impact on substrate would increase[1] due to a larger causeway and access route. *Pile-Supported Dock Variant*: Impacts similar to those of Alternative 1.	**Surface Water**: Impacts similar to those of Alternative 1. **Groundwater**: Impacts similar to those of Alternative 1. **Substrate**: Impacts similar to those of Alternative 1. *Concentrate Pipeline Variant:* The WTP would effectively treat dewatering water to meet discharge limits prior to discharge to marine environment.
Natural Gas Pipeline			
Construction Effects	**Surface Water**: Impacts similar to those for the transportation corridor under Alternative 1. **Groundwater**: Impacts west of Cook Inlet similar to those for the transportation corridor under Alternative 1. The risk of HDD drilling fluid affecting drinking water supply wells during construction on Kenai Peninsula is expected to be localized, and minimized through pressure monitoring during drilling; drilling fluid and cuttings would be disposed of off-site. **Substrate**: Impacts similar to those for the transportation corridor under Alternative 1.	**Surface Water**: Impacts similar to those for the transportation corridor under Alternative 2 (road and ferry). **Groundwater**: Impacts west of Cook Inlet similar to those for the transportation corridor under Alternative 2. Impacts east of Cook Inlet same as those for Alternative 1. **Substrate**: Impacts similar to those for the transportation corridor under Alternative 2 (road and ferry).	**Surface Water**: Impacts similar to those for the transportation corridor under Alternative 3 (road construction). **Groundwater**: Impacts west of Cook Inlet similar to those for the transportation corridor under Alternative 3. Impacts east of Cook Inlet the same as those for Alternative 1. **Substrate**: Impacts similar to those for the transportation corridor under Alternative 3 (road construction).

Notes:
[1] Acreages of waterbody substrate burial provided in Section 4.22, Wetlands and Other Waters/Special Aquatic Sites.

4.18.7 Cumulative Effects

The cumulative effects analysis area for water and sediment quality includes all watersheds in which project-related activity would occur, where direct and indirect effects on surface water, groundwater, or substrate (encompassing the footprint of the proposed project, including alternatives and variants, and areas downgradient) could reasonably be expected to contribute to cumulative effects. In this area, a nexus may exist between the project and other past, present, and reasonably foreseeable future actions (RFFAs) that could contribute to a cumulative effect on water and sediment quality. Section 4.1, Introduction to Environmental Consequences, details the comprehensive set of past, present, and RFFAs considered for evaluation as applicable. A number of the actions identified are considered to have no potential of contributing to cumulative effects on water and sediment quality in the EIS analysis area. These include offshore-based developments, activities that may occur within the EIS analysis area but are unlikely to result in any appreciable impact on water or sediment quality, or actions outside of the cumulative effects analysis area (e.g., Donlin Gold, Alaska Peninsula oil and gas exploration).

RFFAs that could contribute cumulatively to surface water quality and sediment impacts, and that are therefore considered in this analysis, are limited to those activities that would occur within the Nushagak River or Kvichak River drainages, or in other waterbodies intersected by the transportation corridor in the Cook Inlet drainage. RFFAs that could contribute cumulatively to impacts on groundwater quality are more limited, consisting only of activities in the mine site area, or immediately within or adjacent to the transportation corridor.

Past, present, and RFFAs that could contribute cumulatively to water and sediment quality effects, and are therefore considered in this analysis, include:

- Pebble Project buildout—development of 55 percent of resource over a 78-year period
- Pebble South
- Big Chunk South
- Big Chunk North
- Fog Lake
- Groundhog
- Shotgun
- Diamond Point rock quarry

4.18.7.1 Past and Present Actions

Past and present activities that may have affected water and sediment quality in the analysis area include boat operations in Iliamna Lake and Cook Inlet used for fishing and tourism; communities that generate sewage and solid waste, and use fossil fuels for energy and heat generation; past mining exploration; and dust generation and small fuel leaks/spills along existing roads (see Section 4.1, Introduction to Environmental Consequences). Some regional organizations have expressed concerns regarding permit violations and environmental degradation associated with past Pebble project exploration activities. ADNR conducts annual inspections during exploration activities, and has generally found that exploration activities are in compliance with standard practices. In some instances, additional reclamation at explorations sites has been required. In general, past and present actions have had some localized, and in most cases, short-term effects on water and sediment quality.

4.18.7.2 Reasonably Foreseeable Future Actions

No Action Alternative

The No Action Alternative would not contribute to cumulative effects on water and sediment quality.

Alternative 1 – Applicants Proposed Alternative

Pebble Mine Expanded Development Scenario – An expanded development scenario for this project, as detailed in Section 4.1, Introduction to Environmental Consequences, Table 4.1-2, would include an additional 58 years of mining and 20 years of milling (for a total of 98 years) over a substantially larger mine site footprint, and would include increases in port and transportation corridor infrastructure. The mine site footprint would have a larger open pit and new facilities to store tailings and waste rock (see Section 4.1, Introduction to Environmental Consequences, Figure 4.1-1), which would contribute to cumulative effects on water and sediment quality due to the nearly tripled footprint area and substantially longer duration of mining activity.

The Pebble mine expanded development scenario project footprint would impact approximately 34,790 acres, compared to 12,371 acres under Alternative 1, with a notable expansion into the UTC watershed that the proposed Alternative 1 generally minimizes. The magnitude of cumulative impacts to water and sediment quality would generally be temporary, but the duration of effects would be greater than under Alternative 1 as proposed.

The Pebble project expanded development scenario would result in additional development not included under Alternative 1:

- Increased pit footprint
- Increased TSF and PAG rock storage capacity with additional SCPs
- new waste rock storage and footprints with additional SCPs
- Additional processing infrastructure
- Construction of a new port site with additional access road and pipelines (concentrate and diesel) extending to the mine site.

The estimated area of disturbance would be nearly tripled over the proposed project alone, based on projected infrastructure buildout at the mine site. The buildout would correspond to an increase in the magnitude and local extent of cumulative ground disturbance impacts potentially contributing to sedimentation and fill placement on substrate, with a duration increase of up to 98 years. The potential for cumulative impacts on surface water, groundwater, and sediment would increase substantially. Additional design features to capture and treat impacted water and waste streams would be necessary to manage mine site impacts. An access road concentrate pipeline and a diesel pipeline from the mine site to Iniskin Bay would be constructed at Year 20, all having potentially limited impacts on water and sediment quality due to trenching activities, and potentially increased erosion. The increase in diesel fuel use over an extended period of time would also increase the likelihood of hydrocarbon spills and contribute to increased potential cumulative impacts; however, installation of a pipeline would reduce the overall cumulative impacts from spills compared with truck transport of fuel from the port site to the mine site.

Other Mineral Exploration Projects – Mineral exploration is likely to continue in the EIS analysis area for the mining projects listed previously in this section. Exploration activities, including additional borehole drilling, road and pad construction, and development of temporary camp and other support facilities, would contribute to the potential cumulative effects on water and sediment quality, although impacts would be expected to be limited in extent and low in magnitude.

Several RFFAs associated with mineral exploration activities (e.g., Pebble South, Big Chunk North, Big Chunk South, Fog Lake, and Groundhog) would have some limited impacts on surface water and sediment quality in common watersheds to the Pebble project (e.g., drill pads, camps); however, they would be seasonally sporadic, temporary, and localized, based on their remoteness. The potential would also exist for greater impacts on surface water and sediment quality through local co-use of transportation infrastructure with the Pebble project.

Road Improvement and Community Development Projects – Road improvement projects would have impacts on water and sediment quality, primarily through increased erosion potential, and would contribute to cumulative effects in the EIS analysis area. The most likely road improvements in the area would be within the development footprint of existing communities, with only Iliamna and Newhalen being considered to be within the analysis area for water and sediment quality cumulative effects. Some limited road upgrades may also occur in the vicinity of the natural gas pipeline starting point near Stariski Creek, or in support of mineral exploration previously discussed. None of the anticipated transportation development within the EIS analysis area would contribute greatly to cumulative effects on water and sediment quality.

Additional RFFAs that have the potential to affect water and sediment quality in the EIS analysis area are limited to the Diamond Point rock quarry. That RFFA would include the excavation of rock, which would require removal of soil overburden materials, potentially resulting in increased sedimentation in local surface water or effects on sediment quality. The estimated area that would be affected by the Diamond Point rock quarry is approximately 140 acres (Diamond Point LLC 2018).

Alternatives 2 – North Road and Ferry with Downstream Dams and Alternative 3 – North Road Only

Pebble Mine Expanded Development Scenario – Under expanded mine site development, contributions to cumulative effects on water and sediment quality under Alternatives 2 and 3 would be less than under Alternative 1, because the expanded mine scenario under these alternatives would not use the southern port access corridor or Amakdedori port site. Under Alternatives 2 and 3, project expansion would use the existing Diamond Point port facility, the same natural gas pipeline, and portions of the constructed portion of the north access road. A concentrate pipeline (Concentrate Pipeline Variant) and a diesel pipeline from the mine site to Iniskin Bay would be constructed, both having potentially limited impacts on water and sediment quality due to trenching activities, and potentially increased erosion.

Other Mineral Exploration Projects, Road Improvement and Community Development Projects – Cumulative effects of these activities on water and sediment quality would be similar to those discussed under Alternative 1. As previously discussed under Alternative 1, the proposed Diamond Point rock quarry has the potential to affect water and sediment quality in the EIS analysis area. The footprint of the Diamond Point rock quarry coincides with the Diamond Point port footprint under Alternatives 2 and 3. The increase in soil disturbance and erosion impacts would result in cumulative effects on water and sediment quality, and those effects would be the same as identified under Alternative 1. Cumulative impacts would likely be less under Alternative 2 due to commonly shared project footprints with the quarry site.

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