

3.18 WATER AND SEDIMENT QUALITY

This section describes existing conditions related to surface water, groundwater, and sediment quality in the Environmental Impact Statement (EIS) analysis area, which includes the project footprint, and areas adjacent to or downstream of—and potentially affected by—project elements. In addition to areas potentially affected by Alternative 1a, areas potentially affected by the other alternatives and variants are also assessed. Geochemistry at the mine site is described as it relates to the potential for release of chemicals into water from mining activities. Information on water and sediment quality criteria that are used to compare to existing and future conditions are provided in Appendix K3.18.

Water quality evaluation factors to be considered by the US Army Corps of Engineers (USACE) in making determinations under Clean Water Act (CWA) 404(b)(1) Subpart C include the following physical and chemical characteristics of the aquatic ecosystem. These are addressed in this section of the EIS as noted below:

- **Substrate**—Substrate includes sediment at the bottom of waterbodies, as well as wetland soils. Baseline characteristics of waterbody substrate (sediment) in the four project components are summarized below, and additional details are provided in Appendix K3.18. Baseline information on wetland substrate is provided in Section 3.22, Wetlands and Other Waters/Special Aquatic Sites, and Section 3.14, Soils. Removal and disposal of dredged marine sediment under Alternative 2—North Road and Ferry with Downstream Dams, and Alternative 3—North Road Only, are addressed in Section 4.18, Water and Sediment Quality.
- **Suspended Particulates/Turbidity**—Measurements of total suspended solids (TSS) and turbidity in water are summarized in the surface water quality sections of this chapter, and additional details are provided in Appendix K3.18.
- **Water Quality**—Water quality data are summarized in the surface water quality sections of this chapter, and additional details are provided in Appendix K3.18.
- **Salinity Gradients**—Salinity trends are described in this section under “Marine Ports,” and additional details are provided in Appendix K3.18.

3.18.1 Mine Site Area

3.18.1.1 Geochemistry

Rock chemistry typically drives water quality, facility design, and water treatment requirements at hard rock mines (ADNR 2014). The open pit, bulk tailings storage facility (TSF), pyritic TSF, and water management ponds (WMPs) at the mine site pose the most significant risk to water quality because they expose fresh rock to oxidation and leaching processes that may generate acidic or neutral drainage containing leached metals that could impact water quality. The geochemistry of the rock that would be mined and exposed at the Pebble deposit is described in this section, followed by a summary of existing data for surface water, groundwater, and sediment at the mine site.

The Pebble deposit is a copper-gold-molybdenum porphyry deposit that was formed when older sedimentary and igneous rocks were intruded by a granitic magma laden with hot fluids carrying dissolved copper, gold, molybdenum, and silver, as well as quantities of rhenium and palladium. As the fluids cooled, concentrations of sulfide minerals such as chalcopyrite (CuFeS_2), molybdenite (MoS_2), and pyrite (FeS_2) hosting the copper, gold, molybdenum, and silver metals,

precipitated in quartz veins and disseminated throughout the granitic intrusive and adjacent sedimentary and igneous rocks.

Geochemical Processes

In the natural environment, rocks are physically and chemically broken down to create soil layers through exposure to air and water in a process called weathering. During chemical weathering, minerals in the rocks react with air (oxidation) and water (dissolving into solution) to release some of their constituents (ions) into the surrounding environment. The ions that go into solution may be transported away by overland runoff, streams, and groundwater. Therefore, weathering processes in rock can have a large influence on water quality. If a mineralized deposit is buried beneath other rocks, sediment, or soil, it naturally weathers very slowly. However, when a mineralized deposit is exposed at the surface, weathering can increase substantially due to direct exposure to rain, snow, and air.

Both ore and non-ore rocks contain minerals that can produce acid during weathering. The most common acid-generating mineral is pyrite (FeS_2), which contains iron and sulfur. The sulfur in pyrite reacts with oxygen and water to form sulfuric acid (H_2SO_4). The resulting acidic water is known as acid rock drainage (ARD), which in turn further accelerates the weathering process. Metals and other potentially harmful constituents can also be released during weathering in a process called metal leaching (ML). Most metals are released more rapidly in acidic water; however, some other constituents, including metalloids such as arsenic, molybdenum, and selenium, and salts such as sulfate, can be released into the environment even if the water draining the rock has a neutral or basic pH (Smith 2007). Acid generation can be counteracted if there are minerals present that neutralize the acid, such as calcite. Neutralization occurs through a reaction of calcite with the sulfuric acid. In the presence of calcite and other neutralizing minerals, acidification is typically delayed until the neutralizing minerals are exhausted.

The purpose of geochemical characterization at the mine site is to identify the potential for the rocks in and surrounding the mineralized deposit to produce ARD and/or ML that could affect surface water and/or groundwater quality. The characterization process involves studies of the mineralogy of the rocks, the quantities of minerals with potential to generate or neutralize acid, the amounts of leachable constituents in the rocks, and the expected rates of weathering and release of the leachable constituents during mining and after mining ceases. Geochemical characterization was undertaken as part of environmental baseline studies over a number of years to evaluate the potential for ARD and/or ML for the project (PLP 2018a; SRK 2011a, 2018a, 2018c). A summary of the results of these studies follows, and additional details are provided in Appendix K3.18.

Geochemical Characterization

The objectives of the geochemical characterization program were to predict the weathering and leaching behavior of rock, tailings, and other materials that would be produced during mining and processing. Data produced from geochemical testing are used to predict the chemistry of waters that contact the rock exposed in the open pit, and the waste rock and tailings stored in the TSFs, and determine their ARD/ML potential.

Sampling and Testing Program—Samples for geochemical testing include representative overburden, rock cores, and metallurgical waste (tailings) samples from the Pebble east and west zones (PEZ and PWZ), and rock core samples from borings drilled in three proposed construction rock quarry areas. Samples were selected from the numerous exploration cores drilled to outline the deposit. A visual analysis was performed to confirm that samples were representative across the lithologic and geochemical variations observed in the deposit. Additionally, a data gap analysis

was performed, and additional samples were manually selected to ensure a representative sampling pattern was used (SRK 2011a). A summary of the geochemical testing program is provided in Table K3.18-2. The samples included all the main Pebble deposit rock types and adjacent rock types that might be removed during mining. As of 2018, the program had included analysis of 1,023 rock samples from the Pebble deposit, and 26 samples of overburden materials. In addition, 64 tailings samples have been characterized, composed mostly of angular, pyritic, and tails from test processing of ore composites. To date, limited geochemical testing has been performed on the representative concentrate because possible designs for metallurgical processes are still at an investigative stage. Additional information pertaining to geochemical evaluation of samples and their representativeness of conditions at the mine site is provided in Appendix K3.18 and SRK (2019a).

The rock samples were tested using industry standard mineralogical and geochemical analysis techniques to assess the chemical and mineralogical makeup of rocks in the project area and evaluate the potential for the generation of ARD or leaching of metals into surface water or groundwater. Tests included mineral abundance, ARD potential, bulk chemical composition, and constituent mobility. Geochemical tests have included acid-base accounting (ABA), sequential net acid generation, shake flask extractions, meteoric water mobility, humidity test cells, subaqueous (saturated) leach columns, and on-site field weathering (barrel and bag) tests to evaluate rates of oxidation, acid generation, acid neutralization, and element leaching. The geologic settings between the PEZ and PWZ zones are comparable, with the same mineralizing system and the same host rocks. For this reason, use of samples from both the PEZ and PWZ provides the most representative and conservative assessment of ARD/ML potential because PEZ samples tend to be more acidic and have higher metal contents (SRK 2018f). Selected geochemical data are summarized in data tables in Appendix K3.18, and described below.

Acid-Generating Potential—In some mineralized deposits, rock type alone can be a good indicator of whether a rock would potentially produce ARD and/or ML. There are two main geological divisions at the mine site. The minable mineralization is hosted by sedimentary and plutonic rocks of pre-Tertiary age (older than 66 million years ago). After the pre-Tertiary mineralization, those rocks were partially eroded, then covered by other sedimentary and volcanic rocks later in the Tertiary (Paleogene and Neogene periods) (see Section 3.13, Geology). The later Tertiary age rocks at the mine site generally do not contain copper, gold, or other metals that would be economically viable to recover (SRK 2011a; PLP 2018a).

A summary of ABA data is provided in Table K3.18-3. ABA testing has determined that the pre-Tertiary mineralized sedimentary and plutonic rocks at the mine site are predominantly potentially acid generating (PAG). PAG waste rock has been defined by PLP as any rock with a neutralization potential (NP)/acid-generating potential (AP) ratio equal to or greater than the site-determined NP/AP criterion of 1.4 (PLP 2018a). The AP of these rocks is relatively high because they contain several percent pyrite, as indicated by total sulfur contents greater than 1 percent, and they have limited NP. The distribution of pyrite (and consequently AP) was found to be influenced by the hydrothermal alteration zones overprinted on the deposit. More details and uncertainties involved the development of a site-specific NP/AP ratio at the mine site are provided in Appendix K3.18. Because inherent uncertainty exists in the study of NP/AP ratios, a recommendation is provided in Appendix M1.0, Mitigation Assessment, to consider more conservative (higher) ratios as mine planning and design progress.

In contrast, the majority of the Tertiary age rocks that compose the cover and overburden materials at the mine site are considered non-PAG because they have less than 1 percent pyrite, low total sulfur concentrations, and excess NP because carbonate minerals are abundant. However, a small proportion of the Tertiary age volcanic rocks were found to be PAG.

Weathering and Leaching Rates—To develop an understanding of weathering and leaching processes that might affect rocks exposed during mining (e.g., pit walls and stockpiled waste rock and tailings), additional laboratory and field geochemical tests were conducted. Laboratory tests included humidity cell, subaqueous (saturated) column, stored bag, and field barrel tests. Humidity cell test data obtained for periods up to 8 years allow interpretation of long-term acid generation potential and neutralization rates as the rocks are oxidized and leached during wet and dry cycles. Humidity cell test results were used to confirm ABA criteria for segregating PAG from non-PAG rocks and waste, based on the NP/AP ratio. The ABA and humidity cell data indicate that PAG and non-PAG rocks can be distinguished using an NP/AP ratio of 1.4 (PLP 2018a), and are applicable to pre-Tertiary, Tertiary, and overburden materials. The discrete site-specific PAG criterion of 1.4 was determined through analysis of the molar release rate obtained from humidity cell tests (PLP 2018a). The molar release rate is an equivalent to the NP/AP criteria, and can be examined to determine the site-specific criterion for potential acid generation (Day et al. 1997). If the molar release ratio is greater than the NP/AP ratio, the waste rock has the potential to generate acid (SRK 2011a). PLP (2018a: Figure 11-28) depicts the molar ratio data from humidity cell tests used to determine site-specific NP/AP criterion of 1.4.

Humidity cell tests also help to estimate the potential lag or delay in the onset of ARD using the sulfide oxidation and release rates and pH profiles derived from the tests. The lag or delay in the onset of ARD occurs because acid-neutralizing minerals (e.g., calcite, feldspars, and micas) are not depleted instantly as acid is formed, but are consumed at different rates depending on their reactivity and abundance. Once the acid-neutralizing minerals are depleted, ARD may be initiated. Results show that pre-Tertiary rocks with low NP/AP ratios (less than 0.3) have little neutralization potential and are estimated to generate acid within 1 to 6 years (SRK 2018a). Pre-Tertiary rocks with NP/AP ratios of 1 have higher neutralization potential, which delays the estimated onset of acid generation from 8 to 20 years (SRK 2018a). These estimated times to onset of ARD are considered underestimates, because they are based on data developed under ideal, controlled laboratory conditions. Actual conditions in the field, with colder temperatures and long winters, are likely to be less conducive to acid formation, and further delay the onset of ARD. The effect of temperature conditions on the rate of oxidation is further discussed in Appendix K3.18. Paste pH results for aged rock cores stored at the site suggest that acidification may be delayed up to 40 years for 95 percent of the pre-Tertiary mineralized rock (SRK 2011a). Given differences in the various test conditions described above, laboratory and field tests suggest that oxidized pre-Tertiary mineralized rock may take in the range of years to several decades for acidification to occur.

Element release rates determined from kinetic (humidity cell, barrel, saturated column, and stored bag) tests, which were mostly performed on filtered samples, were mainly a function of leachate pH rather than the element content of the samples (SRK 2011a). Use of dissolved (filtered) concentrations are reasonable because element release is characterized by the chemical breakdown (dissolution) of minerals to form soluble species and secondary minerals. Because these processes occur in very slow-moving contact water, suspension and transport of particulates is not expected. Leaching of copper was found to accelerate as pH decreased; therefore, the potential for release of many metals is linked to the potential for acid generation, which is assessed using ABA data. However, the release of some elements—arsenic, molybdenum, and selenium—can be environmentally significant under circumneutral pH, as described in SRK (2011a). Tests on some samples of Tertiary rock showed elevated leaching of these elements under non-acidic conditions. Data analysis from the various geochemical tests performed yielded consistent results. Leaching data from humidity cell tests, barrel tests, and shake flask tests performed on samples collected in both the PWZ and PEZ were used to develop geochemical source terms for predictive water quality (SRK 2018c, f). To be conservative, the source term concentrations were developed at the 95th percentile. In general, the 95th percentile

release rates for Tertiary and Cretaceous rocks were similar under basic conditions, and significantly greater when using combined PWZ and PEZ datasets, compared to samples from the PWZ only (SRK 2019a, Figure 1). Additional information regarding how the data were used in water quality modeling is provided in Section 4.18, Water and Sediment Quality.

Tailings—Ore processing based on a conventional flotation process to recover chalcopyrite and molybdenite, the primary copper and molybdenum minerals, followed by treatment of pyrite to recover gold, would result in a low-sulfide bulk tailing concentrate and a high-sulfide (pyrite-rich) tailing concentrate, respectively. Metallurgical process testing has produced a range of representative tailings products. Geochemical testing of 64 tailings samples indicates that the most volumetrically abundant product, bulk tailings, which would be produced under most of the processing approaches being considered, typically contains low to moderate total sulfur. Bulk tailings can be categorized as non-PAG if the total sulfur remains below 0.2 percent. Under equivalent conditions (including grain size and exposure to oxidizing conditions), the ARD potential for the bulk tailings is lower than that of mineralized rock, because most of the sulfur is removed to recover the economic minerals and separate out the pyritic tails while concentrating neutralizing minerals in the bulk tailings. Element leaching from the rougher tailings occurred at low rates, and unfiltered process supernatants were found to contain low levels of potential constituents relative to water quality standards. The pyrite and gold plant tailings have higher sulfide contents; are often classified as PAG; and leach metals at higher rates. Appendix K3.18 provides additional information on the geochemical characteristics of the tailings and supernatant.

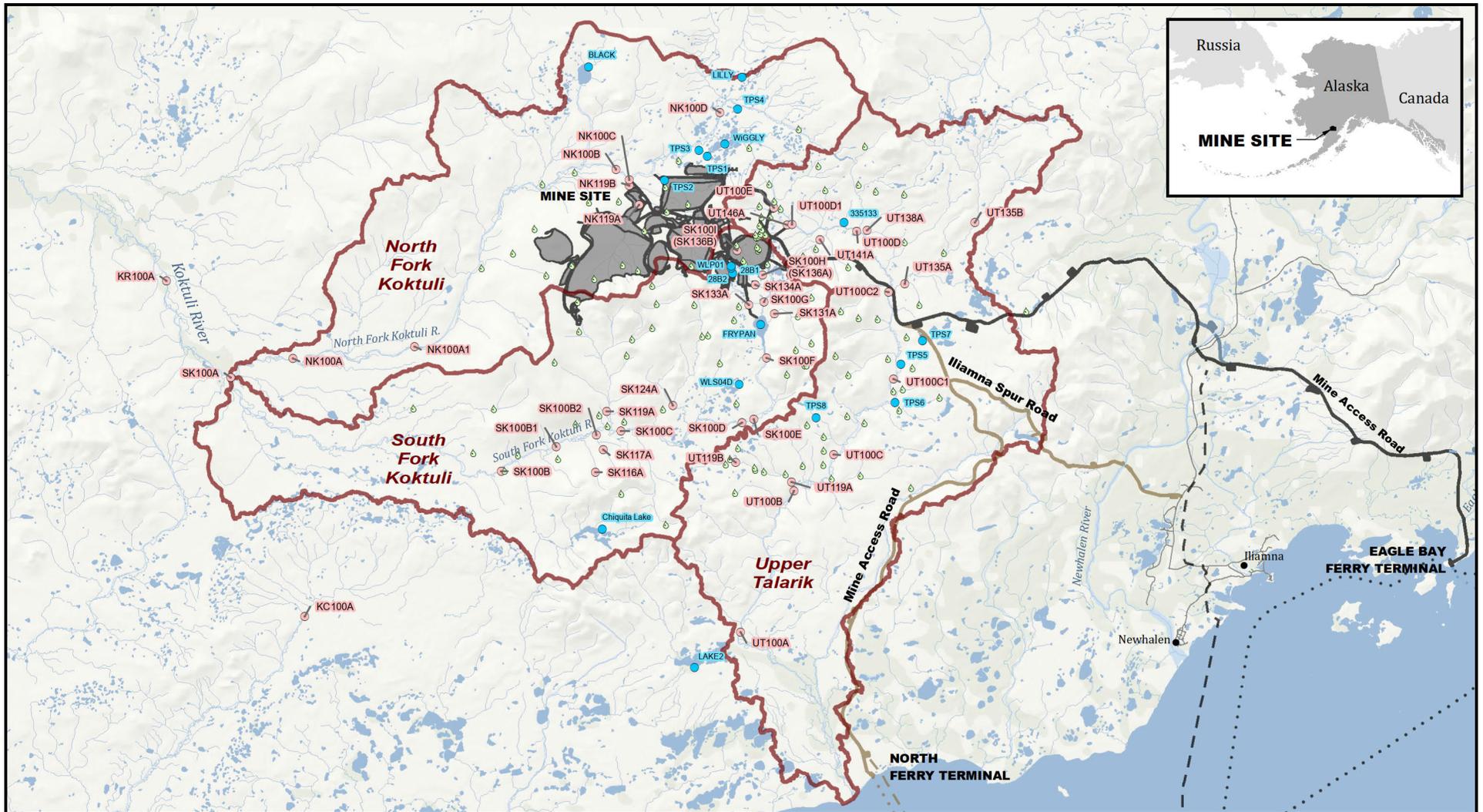
Open Pit Block Model—Because of the geochemical variability in the rocks, assessment of impacts resulting from geochemical processes requires consideration of the disposition and fate of the material that would be mined each year. The annual area and rock types mined can be estimated using a geologic block model (i.e., a computer model that shows the three-dimensional location of each type of rock and the likely order of mining). The geologic block model could be updated in the future to incorporate geochemical data so that mineralized and waste rock can be managed appropriately as mining proceeds. During mining, rock materials would be assessed using the block model to determine whether the mined rocks are PAG or non-PAG, and whether the mined material would be processed and disposed as tailings, or not processed and set aside as waste rock. Further information regarding the block model is provided in Appendix K3.18.

Based on the results obtained from the geochemical characterization studies, the majority of the rocks that would be expected to be mined from the PWZ do not have the potential for acid generation, and could be considered substantially acid neutralizing. However, some rocks do have the potential to leach certain constituents under circumneutral pH; mainly, arsenic and selenium. These results, and their influence on the existing baseline water quality at the mine site, are discussed in more detail in the next few sections.

3.18.1.2 Surface Water Quality

The Pebble deposit and project area are in the headwaters of the Upper Talarik Creek (UTC) and South Fork Koktuli (SFK) River drainages, and adjacent to the headwaters of the North Fork Koktuli (NFK) River drainage. The NFK River is on the northern side of the project area. The Kaskanak Creek (KC) drainage lies south of the SFK River drainage.

Sampling Program—Water quality studies were conducted by Schlumberger et al. (2011a) and ERM (2018a) to quantify chemical and physical parameters that describe the quality of the water at the mine site and surrounding areas that could potentially be impacted by the alternatives. Water quality data were collected for rivers, lakes, and seeps in the project area, and throughout a 965-square-mile area that includes the NFK River, SFK River, and UTC (Figure 3.18-1).



Sources: PLP 2019-RF1153;
Schlumberger et al. 2011a



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**Surface Water Quality
Sample Locations**

- Seep
- Stream
- Lake
- Major Drainage Boundary

Action Alternatives

- Ferry Routes
- Natural Gas Pipelines
- Alternative 1a
- Alternative 1
- Alternative 2 Newhalen River North Crossing Variant

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**SURFACE WATER QUALITY
SAMPLE LOCATIONS, MINE SITE AREA**

FIGURE 3.18-1

A comprehensive network of sampling stations was established in the project area for sampling surface water from streams, lakes, and seeps. Stream samples were collected from 44 locations during 50 sampling events from April 2004 through December 2008 (Schlumberger et al. 2011a). These included seven locations in the NFK, 18 in the SFK, and 15 in the UTC watershed; water quality sampling was conducted at most locations on a monthly or quarterly basis (Schlumberger 2011a, Table 9.1-2). Lake and pond samples were collected from 19 lakes once or twice per year in July and/or August during 2006 and 2007; these were collected as near-surface grab samples. Seep samples were collected from 11 to 127 sample locations (depending on the year), two to five times per year between March and November. Surface water samples were collected using a combination of grab and depth-integrated sampling. Grab sampling was used when necessary for safety in high-flow conditions, in shallow streams, and during freeze-over periods (Schlumberger et al. 2011a).

Altogether, between 2004 and 2008, over 1,000 samples were collected from streams, more than 600 samples from seeps, and approximately 50 samples from lakes. Additional samples were also collected during the supplementary water quality study period, which occurred from 2008 to 2013 (ERM 2018a).

Several tables are provided in Appendix K3.18 showing a summary of surface water quality data compared to criteria for waterbodies most pertinent to potential future impacts at the mine site. These include data for NFK, SFK, UTC, and Frying Pan Lake (Table K3.18-7 through Table K3.18-10). Additional water quality details on seeps and other lakes and streams in the mine site study area are provided in ERM (2018a: Tables 9.1-15 through 9.1-24) and Schlumberger et al. (2011a, Tables 9.1-31 through 9.1-36), and are incorporated by reference into the discussion below.

Overview of Sampling Results—The results of these analyses indicate that the baseline surface water resources can generally be characterized as cool, clear waters with near-neutral pH that are well-oxygenated, low in alkalinity, and generally low in nutrients and other trace elements. Water types ranged from calcium-magnesium-sodium-bicarbonate to calcium-magnesium-sodium-sulfate. Water quality data occasionally exceeded the maximum criteria for concentrations of various trace elements in some individual sample measurements; however, in no instance did the mean concentration of trace elements exceed the most stringent water quality guidelines. Cyanide was occasionally present at detectable concentrations in a limited number of samples. Cyanide detected in those samples is believed to be of natural origin, based on the distribution and lack of anthropogenic sources. Cyanide can occur naturally as a product of anabolism in some plants, bacteria, and fungi (CDC 2006). Additionally, there were consistently detectable concentrations of dissolved organic carbon. No detectable concentrations of petroleum hydrocarbons, polychlorinated biphenyls, or pesticides were found.

Some differences in water quality between watersheds and trends in water quality along streams were noted, based on repeated monthly or quarterly sampling at most locations in the NFK, SFK, and UTC over the 5-year sampling period. These are summarized below and in tables in Appendix K3.18. Higher concentrations of copper, molybdenum, nickel, zinc, and sulfate were present in SFK than in NFK, consistent with SFK's proximity to the Pebble deposit area. Total dissolved solids (TDS), pH, sodium, alkalinity, hardness, nitrogen (nitrate+nitrite), and nickel concentrations were greatest in the UTC drainage. The uppermost reach of UTC passes through a portion of the general deposit area, and had significantly higher concentrations of these naturally occurring constituents than in NFK. TSS, potassium, chloride, iron, and arsenic concentrations were highest in KC, while cadmium and lead concentrations were highest in the NFK drainage. These characteristics of KC and NFK likely indicate that these parameters are unrelated to the deposit area, and represent water quality signatures that are distinct from the other drainage areas.

The following paragraphs discuss some of the specifics of the sample results and trends observed in the NFK, SFK, and UTC. Data summaries for these streams are provided in Table K3.18-7 through Table K3.18-9, and trend analysis data in Table K3.18-14 through Table K3.18-16.

Total Dissolved Solids—The mean levels for TDS in streams, by watershed, ranged from 37 to 53 milligrams per liter (mg/L), which is 10 percent or less of the most stringent Alaska Department of Environmental Conservation (ADEC) water quality maximum criterion. Of the three streams that originate close to the deposit area, UTC and SFK had significantly higher TDS levels than NFK. Furthermore, a decrease in TDS levels with distance along the stream was more pronounced in the SFK and UTC watersheds than in the NFK watershed. Higher TDS in the UTC and SFK watersheds with decreasing trends downstream was expected, because the deposit area lies within their watersheds, and the oxidation of sulfide minerals associated with the deposit would release dissolved solids. The mean levels for TDS in lakes and seeps were similar to those for streams, with values of 49 and 42 mg/L, respectively.

Total Suspended Solids and Turbidity—Mean TSS values ranged from 1.19 mg/L to 3.21 mg/L in the NFK and UTC, respectively. The highest value for TSS was in KC, and the lowest was in the NFK. Because there is no Alaska water quality criterion for TSS, these values were compared to an effluent limitation guideline (ELG) in 40 Code of Federal Regulations Part 440 Subpart J (see Table K3.18-1). Mean TSS values did not exceed this criterion for any rivers in the mine site area; however, at least one exceedance was recorded in a sample collected at the UTC. The mean for TSS in lakes and seeps was similar to that for streams.

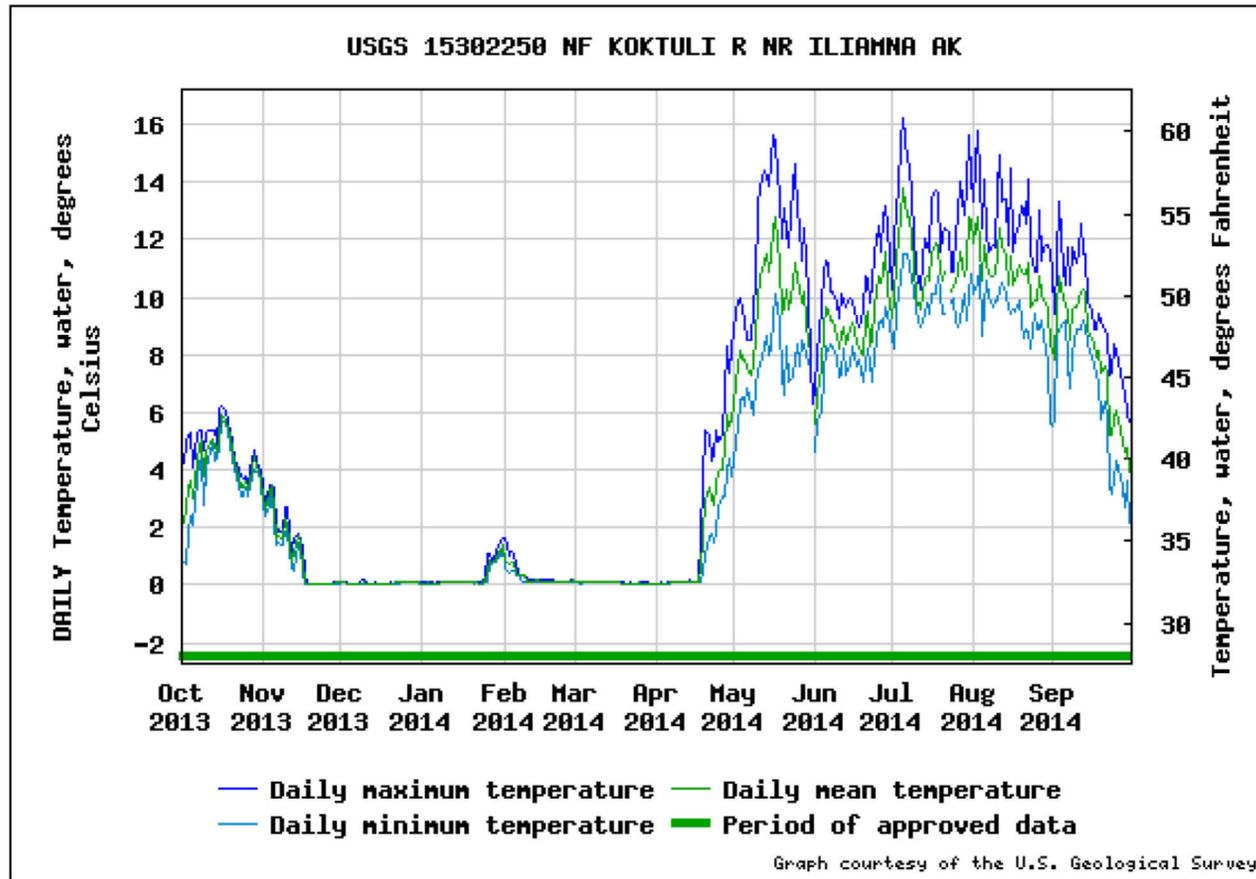
pH—The pH values in surface water were close to neutral. The mean pH for streams by watershed ranged from 6.7 to 7.0. The mean pH values for lakes and seeps were 7.2 and 6.5, respectively. Because of the exposed Pebble deposit and seasonally fluctuating groundwater conditions in the area (see Section 3.17, Groundwater Hydrology), it is possible that the oxidation of sulfide minerals releases acid in this area; however, based on the mean pH data, carbonate minerals may be providing some pH buffering. Although the mean pH values fell within the range for pH specified in the most stringent ADEC criteria (6.5 to 8.5), some individual water quality samples did not meet the water quality criteria for pH. Recorded pH values ranged from 3.31 to 9.33, with the lowest pH recorded in the NFK and the highest recorded in UTC. The frequency of this trend in seeps was at least double that of streams, depending on the watershed, suggesting that contact with local rock could be a contributing factor to pH outside of the 6.5 to 8.5 range.

Alkalinity—The alkalinity of the surface water samples was low. Mean alkalinity for streams, by watershed, ranged from 17 to 32 mg/L. Mean alkalinity for lakes and seeps was 19 and 23 mg/L, respectively. Alkalinity was the parameter that was most frequently detected outside the range of the most stringent ADEC criterion. In all, 43 percent of all surface water samples were below the minimum criteria for alkalinity, as specified by the ADEC. The frequency with which alkalinity values for lakes and seeps were below the minimum criterion was 10 to 20 percent higher than the frequency for streams.

Temperature—Mean water temperature in streams ranged from 4.0 to 4.8 degrees Celsius (°C), depending on the watershed. The standard deviation of temperature values measured in each watershed was approximately equal to the mean of the values, indicating a high level of variability. Lakes in the mine site area were considerably warmer, with a mean temperature of 12°C, and seeps slightly cooler, with a mean temperature of 3.4°C. Lake sample collection in July and August (compared to seep sample collection in March through November) could account for some of these temperature differences, and lake temperatures are expected to be cooler in other seasons.

Temperature recording at the US Geological Survey (USGS) gaging stations began in October 2013. Although long-term water temperature trends are not available, these may vary as a subdued expression of long-term air temperature trends. Mean annual temperature trends in the region indicate that air temperatures have increased approximately 3°C over the past 50 to 60 years (Knight Piésold 2012, 2018a); trends that are predicted to continue into the next century (SNAP 2018). Figure 3.18-2 shows daily water temperatures in the NFK River.

USGS Water-Year Summary for Site USGS 15302250



Source: USGS 2018



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DAILY WATER TEMPERATURES IN NFK RIVER

FIGURE 3.18-2

Dissolved Oxygen—Dissolved oxygen (DO) concentrations in streams were very similar in all watersheds, with mean concentrations that ranged from 9.7 to 9.89 mg/L. These values are close to the theoretical solubility of oxygen of 12.3 mg/L at 900 feet above mean sea level (amsl), and a water temperature of 4°C. Although most samples indicated high DO, 7 percent of the samples had DO concentrations lower than the most stringent ADEC minimum criterion.

Major Ions—Water type can be characterized by the presence and predominance of specific ions, including anions and cations. The water type of most samples from streams in the mine site area ranged from calcium-magnesium-sodium-bicarbonate to calcium-magnesium-sodium-bicarbonate-sulfate. The cation composition was dominated by calcium, and was relatively consistent. The anion composition had a wider range, with most stream samples being dominated by carbonate. The average water type of the lakes and seeps was generally the same as the streams; however, the seeps had a slightly greater range of water types, and the distribution of water types was slightly different. Specifically, the seeps included samples with a higher proportion of sulfate; and the samples also were distributed more evenly across the spectrum of anion composition, rather than being weighted toward the bicarbonate end of the spectrum.

Nutrients—Nutrients, which included total ammonia, total nitrogen (nitrate+nitrite), total phosphorous, and orthophosphate, had generally low concentrations, especially in lakes and seeps. Orthophosphate was generally not present at detectable levels, with one exception in the KC watershed. Total ammonia was detected in 19 to 36 percent of surface water samples, and mean concentrations ranged from 0.03 to 0.05 mg/L, depending on source (streams, lakes, or seeps). Nitrogen and phosphorous were detected in 66 to 98 percent of surface water samples, depending on the sample source. Mean concentrations of nitrogen ranged from 0.1 to 0.3 mg/L, and mean concentrations of total phosphorous ranged from 0.02 to 0.04 mg/L. None of the nutrient concentrations exceeded the most stringent ADEC maximum criterion. The coefficients of variation for nutrients were high compared to most other parameters; often in the range of 1 to 2.

Trace Elements—The trace elements aluminum, antimony, arsenic, barium, cadmium, copper, iron, lead, manganese, molybdenum, mercury, nickel, and zinc were detected in surface water grab samples, although at low concentrations. The frequency of detection depended on the watershed, and on whether the sample was collected from a stream, a lake, or a seep. Total and dissolved aluminum, barium, copper, iron, manganese, and molybdenum were typically the most frequently detected trace elements in the streams and lakes; the frequency of detection generally ranged from 85 to 100 percent, depending on sample source (streams, lakes, or seeps). The most frequently detected elements in the seeps were generally the same as those for the streams and lakes, but the frequency of detection was lower in the seeps (53 to 99 percent, rather than

Environmental baseline studies established that metals concentrations are generally below the most stringent State water quality criteria. However, the EIS analysis area does contain natural variance, and exceedances of State water quality criteria do naturally occur in surface waterbodies. For example:

In the SFK:

- Average copper concentrations in upper reaches of the SFK (Station SK100G) exceed the State water quality criteria.
- Elevated copper concentrations in the upper reaches of the SFK at this location are likely the result of close proximity to the copper ore body.
- Concentrations of copper in the SFK decrease downstream.

In the UTC:

- Baseline concentrations of nickel and arsenic in the UTC are roughly two and three times that of the NFK or SFK, respectively.
- Concentrations of nickel and arsenic are likely the result of bedrock geochemistry and natural processes involving the release of metals.

85 to 100 percent). Exceptions to this general pattern included a frequency of detection for total and dissolved arsenic in KC of more than 98 percent. The trace elements arsenic, lead, nickel, and zinc had an intermediate frequency of detection in most waters sampled, with the exception of zinc, which had a higher frequency of detection (98 percent) in lakes. Cadmium had the lowest frequency of detection.

Mercury was infrequently detected in samples, and was typically below the method reporting limit (MRL) and method detection limit (MDL), suggesting that baseline mercury concentrations are low. More than 1,400 samples were tested for mercury in the NFK, SFK, and UTC; mercury was below the MDL or MRL in approximately 95 percent of samples. MDLs for mercury ranged between 0.294 and 5 nanograms per liter (ng/L), and roughly 85 percent of samples analyzed had an MDL of 1.5 ng/L or less. The most frequently used MDL was 1.5 ng/L, which was the MDL for approximately 50 percent of samples analyzed (ERM 2018a). Although mercury was not typically detected, the MDLs and MRLs suggest that baseline mercury concentrations are below 5 ng/L, and likely below 1.5 ng/L, which is eight times less than the most stringent water quality criteria for mercury (12 ng/L, Table K3.18-1). Of the approximately 5 percent of samples where mercury was detected above the MDL and MRL, concentrations ranged from 0.001 ng/L to 12.2 ng/L across the NFK, SFK, and UTC.

Some trace element concentrations in stream samples exceeded the most stringent ADEC maximum criteria. These are described below in relationship to watersheds (trend analyses for data in individual watersheds are provided in Appendix K3.18):

- Copper from the SFK watershed exceeded the water quality criterion most frequently, with total and dissolved copper exceeding the criterion in 42 and 34 percent of samples, respectively. In contrast, copper had one of the lowest frequencies of exceedance in other watersheds. The relatively high frequency of exceedance in the SFK watershed is probably related to proximity of the deposit.
- Total aluminum exceeded the most stringent ADEC maximum criterion in 12 to 22 percent of the stream samples from the SFK, UTC, and KC watersheds; and in 6 percent of the samples from the NFK watershed. In contrast, dissolved aluminum exceeded the criterion in only 1 percent of the stream samples, and only in the UTC watershed; therefore, aluminum exceedances seem to be almost exclusively associated with suspended solids.
- Total lead exceeded the most stringent criterion in 8 to 16 percent of the stream samples, and was generally the next most frequently exceeded criterion after total aluminum. Dissolved lead exceeded the criterion in 1 to 6 percent of the stream samples, and was second only to copper for frequency of exceedance for dissolved elements.
- Total manganese exceeded the criterion in 15 percent of stream samples from the SFK and UTC watersheds, in 3 percent of the samples from the NFK watershed, and in none of the samples from the KC watershed. Similar to aluminum, manganese exceedances appear to be associated with suspended solids.
- Concentrations of total antimony, cadmium, iron, mercury, and zinc for the stream samples rarely exceeded the criteria (0.3 to 4 percent).
- In samples from seeps, exceedances of the most stringent maximum criteria included total and dissolved aluminum (17.2 percent total and 22.94 percent dissolved), total and dissolved copper (30.51 percent total and 42.78 percent dissolved), total and dissolved iron (4.61 percent total and 4.91 percent), total and dissolved nickel (23.21 percent total and 23.58 percent dissolved), total and dissolved lead (17.00 percent total and 36.31 percent dissolved), total and

dissolved cadmium (33.14 percent total and 42.78 percent dissolved), total and dissolved silver (14.34 percent total and 34.82 percent dissolved), total and dissolved zinc (11.03 percent total and 31.37 percent dissolved), and dissolved manganese (17.86 percent).

Cyanide was occasionally detected in the surface water samples. Total cyanide was detected in 2 to 15 percent of all samples, depending on sample source (streams, lakes, or seeps), and weak acid dissociable cyanide was detected in 5 to 13 percent of all samples. Concentrations of weak acid dissociable cyanide in samples were compared with the most stringent ADEC maximum criterion, and exceeded this criterion in 1 to 3 percent of the stream samples, depending on the watershed. Cyanide detections are believed to represent natural conditions, based on a lack of documented anthropogenic sources in the area. Cyanide ions can be generated naturally during biogenic processes of higher plant bacteria and fungi (Mudder and Botz 2000). Although cyanogenic compounds occur naturally in certain bacteria, fungi, algae, and higher plants, the most significant natural source of free cyanide in the environment is from hydrolysis of cyanogenic glycosides in higher plants (Halkier et al. 1988; Lechtenberg and Nahrstedt 1999; Vetter 2000; Zagrobelyny et al. 2004).

Dissolved organic carbon was detected in 93 to 100 percent of the stream samples, and the mean concentrations ranged from 1 to 2 mg/L, depending on the watershed.

Concentrations of petroleum hydrocarbons, volatile and semi-volatile organic compounds, polychlorinated biphenyls, and pesticides were not detected.

3.18.1.3 Groundwater Quality

Mine Site Monitoring Wells—A total of 77 groundwater monitoring wells with depths up to 200 feet below ground surface was installed in the project area. Two additional drillholes (DH-8417 and GH10-220) were used for groundwater sampling in deep bedrock in the deposit area at depths ranging from 210 to 4,050 feet. Table K3.18-17 provides a list of wells completed in and outside of the Pebble deposit area, along with depth and bedrock lithology. The location of the wells is shown on Figure 3.17-2. The results of groundwater quality testing are summarized in Table K3.18-18, and discussed below based on mean values for wells grouped by lithology (ERM 2018a). These data were used to predict the water quality of pit dewatering water going to water management ponds, and influent to the water treatment plants (see Section 4.18, Water and Sediment Quality).

Groundwater samples from depths of 200 feet or less were characterized by mean levels of TDS ranging from less than 90 mg/L to over 150 mg/L (higher in bedrock wells); mean pH values between 4.4 and 7.3; mean DO concentrations ranging from 2.6 to 9.1 mg/L; and mean concentrations of dissolved trace elements above the most stringent ADEC water quality maximum criteria for several constituents (aluminum, copper, iron, lead, and manganese).

Concentrations of TDS in groundwater generally decreased with distance from the deposit area, and results from deep drillhole DH-8417 (mean of 835 mg/L) suggest that concentrations of TDS increase with depth (Knight Piésold 2018a). Monitoring wells MW-14D in the SFK watershed and P08-69D in the NFK watershed were the only wells showing a relatively high TDS level that was not consistent with this general pattern. Although data from well MW-14D are somewhat anomalous, they could be interpreted to suggest that the deposit has influenced groundwater quality.

Most of the groundwater samples had a composition that ranged from calcium-bicarbonate to calcium-magnesium-bicarbonate and calcium-sodium-bicarbonate. Some samples from relatively close to the deposit area had a higher proportion of sulfate, suggesting that the groundwater in this area is influenced by oxidation of the sulfide minerals that are associated with the deposit. As the sulfide minerals oxidize, iron, sulfuric acid, and probably trace elements are released; and the acid

is neutralized by carbonate minerals such as calcite and dolomite, which release calcium, magnesium, manganese, carbonate, and usually some trace elements. This series of geochemical reactions increases the concentration of TDS and the proportion of sulfate in the groundwater.

Although sulfides appear to be oxidizing locally in the Pebble deposit area, the groundwater is not acidic overall. The lowest mean pH value of 4.4 was recorded at only one well in shallow bedrock. In the remaining wells, mean pH values ranged from 6.7 to 7.9, indicating broadly that the groundwater is not acidic. Eight wells (six completed in overburden, two in bedrock) had mean pH values greater than 7.0, and three of these wells (all completed in overburden) had the highest mean TDS concentrations observed.

The DO measured in the groundwater was generally high. Twenty-seven wells had mean DO concentrations of 8 mg/L or greater. Wells with relatively high TDS, measured in filtered samples, also generally showed relatively high concentrations of arsenic, barium, and molybdenum compared with other wells in the analysis area. All of the wells with more than two trace metals at relatively high concentrations were closer to the deposit area.

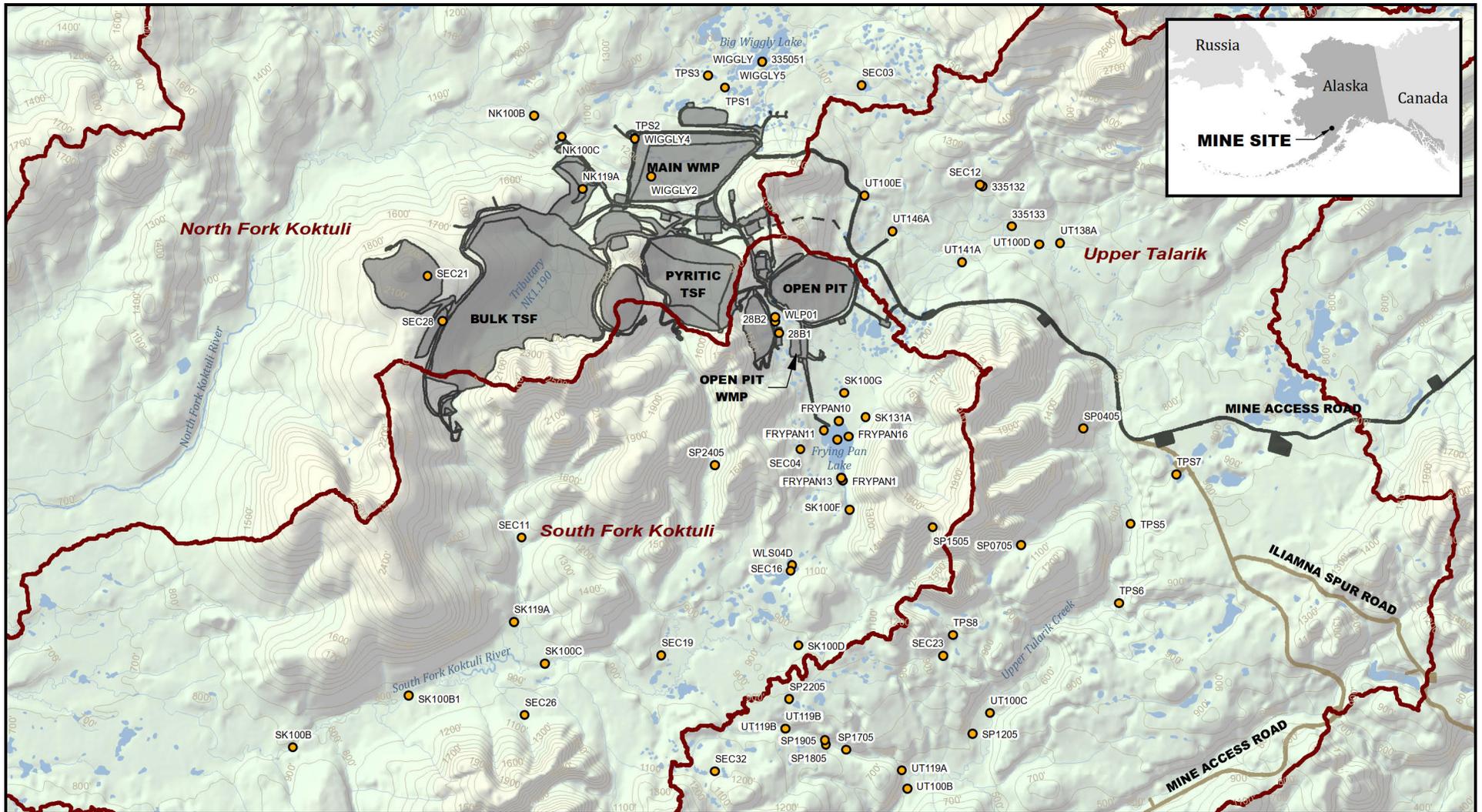
Some differences in concentrations were observed with depth, as indicated by wells completed in overburden versus those completed in bedrock (see Table K3.18-18). Specifically, concentrations of antimony, arsenic, copper, iron, manganese, and molybdenum tended to be higher in wells completed in bedrock than in wells completed in overburden. Conversely, concentrations of DO and nickel tended to be lower in bedrock wells than in overburden wells.

Drinking Water Protection/Drinking Water Wells—Drinking water sources are regulated by federal and state laws and regulations; mainly, the Safe Drinking Water Act (SDWA). Under the SDWA, the US Environmental Protection Agency (EPA) sets standards for drinking water quality and implements various technical and financial programs to ensure drinking water safety. Alaska has primacy on regulating public drinking water systems, with many references to federal regulations. Regulations also contain references to drinking water protection areas that have been mapped for many public drinking water systems. Along the transportation corridor, the region surrounding Iliamna Lake and the adjacent communities are in ADEC drinking water protection areas. There are currently no designated drinking water protection areas at the mine site (ADEC 2020a).

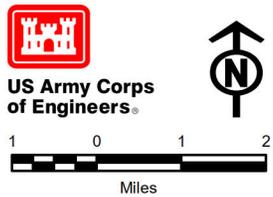
There are currently no drinking water wells at the mine site (ADNR 2018a). During exploration and monitoring activities, personnel typically stay in Iliamna and use local water supplies in that community (described below). With project development, groundwater wells would be installed on the northern side of the mine site to supply potable water. Groundwater testing at that location has shown that minimal treatment would be required (filtration, chlorination, and pH adjustment) to develop a potable water source (PLP 2020d).

3.18.1.4 Substrate/Sediment Quality

This section describes baseline information on waterbody substrates at the mine site. Baseline information on wetland substrate is provided in Section 3.22, Wetlands and Other Waters/Special Aquatic Sites, and Section 3.14, Soils. Baseline physical and chemical data on substrate/sediment from the major drainages and other waterbodies at the mine site were collected between 2004 and 2008 (Knight Piésold 2011a; HDR 2011a; R2 et al. 2011a; SLR et al. 2011a; Three Parameters Plus and HDR 2011). Sample locations are shown on Figure 3.18-3. The National Uranium Resource Evaluation (NURE) program also collected a variety of substrate samples across the region in 1977 (Grossman 1998). NURE data include basic physical substrate descriptions and thorough chemical analyses, as well as reporting of potential contaminant sources, and are included below. NURE collected and analyzed data for eleven elements, including arsenic, cerium, copper, hafnium, iron, lead, sodium, thorium, titanium, uranium, and zinc (Grossman 1998).



Sources: PLP 2019-RF1153;
SLR et al. 2011a



- Sediment Quality Sample
- Major Drainage Boundary
- Action Alternatives**
- Natural Gas Pipelines
- Alternative 1a
- Alternative 1
- River/Stream
- Lake/Pond
- 100' Contour (Existing)

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SEDIMENT QUALITY SAMPLE LOCATIONS, MINE SITE AREA

FIGURE 3.18-3

Physical Characteristics—Waterbody substrate data coverage in the mine site includes the SFK, NFK, and UTC drainages. Streambed sediment from these drainages is dominated by medium to coarse gravels to small cobbles, with boulders present in stretches of rapids. In areas of low water velocity and pools, sands and silts are more common, and organic sediments are present in some areas (Knight Piésold 2011a; R2 et al. 2011a). The NURE data collected from the region include basic physical substrate descriptions and thorough chemical analyses, as well as reporting evidence for potential local contaminant sources. Twelve samples of pond substrate collected by NURE within approximately 20 miles of the mine site were all reported as mud/fine sediment (Grossman 1998). Limited data from the shores of Frying Pan Lake show a sand, silt, and gravel substrate (R2 et al. 2011a).

Chemical Quality—Between 2004 and 2007, a total of 198 samples of sediment from lakes, ponds, seeps, and major and minor drainages in the analysis area were analyzed for their content of naturally occurring trace elements, anions, cations, and organics (SLR et al. 2011a). A summary of the data is provided in Table K3.18-19. Samples collected from wetland substrates are included in the summary of soil chemical quality in Appendix K3.14, Soils, Table K3.14-2 and Table K3.14-3.

Of the 26 trace elements for which samples were analyzed, all were present above analytical detection limits in at least some of the samples, with aluminum, calcium, iron, and magnesium present at substantially higher concentrations than the other elements. Mercury content of sediment samples from the mine site was the lowest level detected, at a mean concentration of 0.040 milligram per kilogram (mg/kg). Comparing sediment from the major drainages, copper was the only element showing significant variation, likely due to the difference in rock composition across drainages. Copper concentrations were particularly high in SFK sediment, likely due to copper-rich bedrock at the headwaters. In comparison to federal National Oceanic and Atmospheric Administration (NOAA) sediment quality guidelines (SQGs) (see Table K3.18-1), the highest detected concentrations of four metals (arsenic, chromium, copper, and nickel) exceeded concentrations that may have an adverse effect on benthic organisms (both the threshold effects level [TEL] and higher probable effects level [PEL]). These samples were from sediment in the SFK drainage (for arsenic and copper) and UTC drainage (for chromium and nickel). The mean concentration of arsenic exceeded the TEL across the study area.

Sediment from ponds and minor drainages in the mine site area showed higher concentrations of anions and cations such as sulfate, ammonia, and sodium than did other waterbodies. Total cyanide concentrations were the lowest of the analyzed anions on average, with a mean concentration of 0.39 mg/kg (SLR et al. 2011a). Of the 12 pond sediment samples analyzed by the NURE within 20 miles of the mine site area, none showed evidence of contamination (Grossman 1998).

Analyses of several organic compounds (gasoline-range organics [GRO], diesel-range organics [DRO], residual-range organics [RRO], volatile organic compounds [VOCs], semi-volatile organic compounds [SVOCs], and polynuclear aromatic hydrocarbons [PAHs]) were performed on one mine site pond sample to identify the potential presence of naturally occurring hydrocarbons. Of the compounds analyzed, DRO, RRO, and 12 of 18 PAHs were detected. Because of the remote, undeveloped nature of the area, these compounds are likely present due to the biogenic breakdown of aquatic plants, historic wildfires, or volcanic activity (Abdel-Shafy and Mansour 2015). Total organic carbon was detected in all 34 samples tested, with a mean concentration of 6.05 percent.

3.18.2 Transportation Corridor

This section addresses the available water and sediment quality data in the vicinity of transportation corridors under all alternatives. The transportation corridor under all alternatives would cross numerous streams in the Bristol Bay and Cook Inlet watersheds, including crossing Iliamna Lake. The transportation corridor originates in the Nushagak watershed at the mine site and traverses the Kvichak watershed on the northern side of the Alaska Peninsula; both are in the greater Bristol Bay watershed (see Figure 3.16-1). The southern end of the corridor terminates in the Tuxedni-Kamishak bays watershed of the greater Cook Inlet watershed. More detailed descriptions of these watersheds are provided in Section 3.16, Surface Water Hydrology.

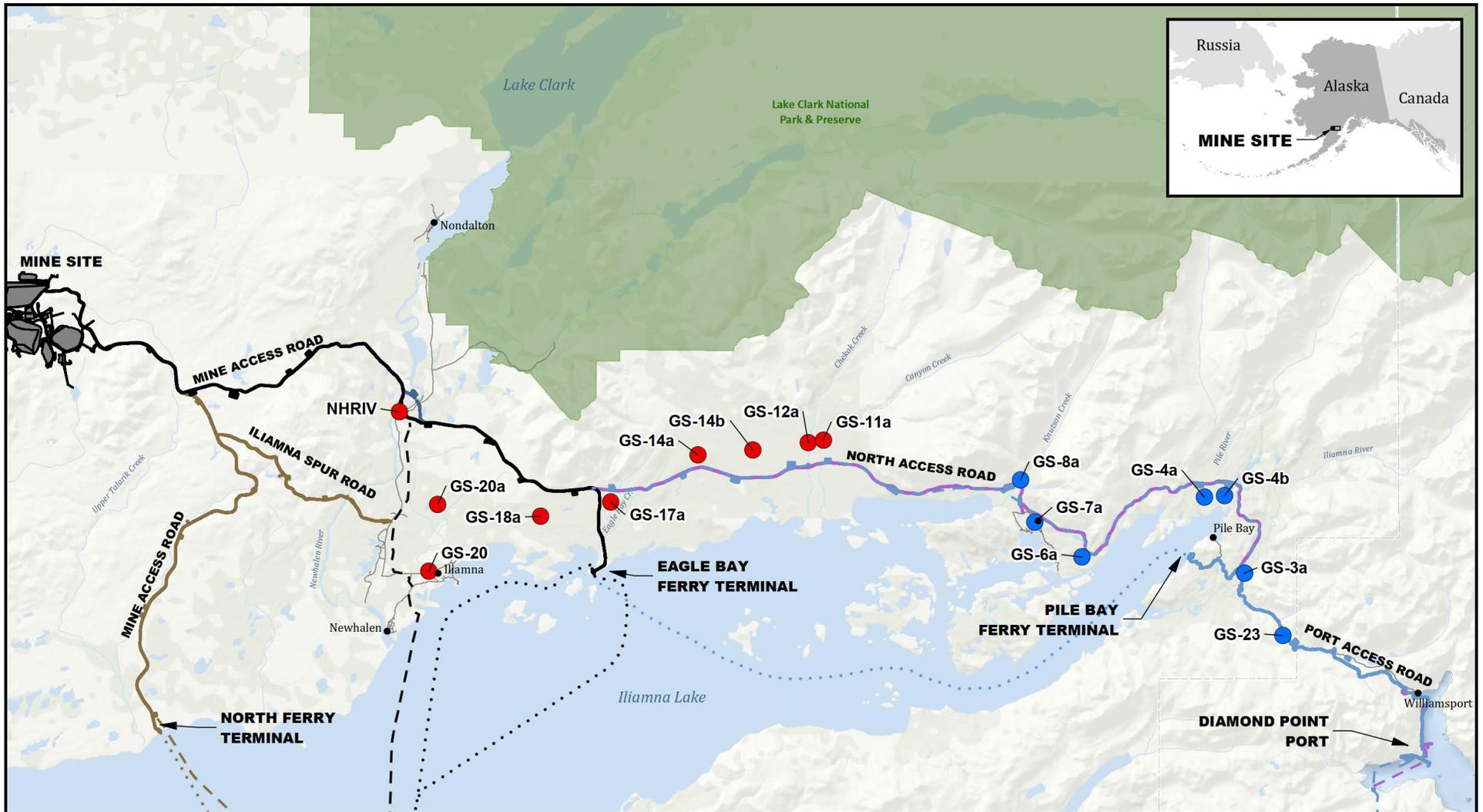
3.18.2.1 Surface Water Quality

Mine Access Road UTC Drainage—Surface water quality data described above for the UTC drainage at the mine site are pertinent to mine access road segments for all alternatives. All alternatives traverse the upper UTC watershed, while the Alternative 1 mine access road also extends through the lower UTC drainage (Figure 3.18-1). Stream data for UTC are summarized in Table K3.18-9, and spatial trends are presented in Table K3.18-16. Although exceedances were measured in some samples, mean concentrations of all measured constituents for the UTC were below the most stringent water quality standards. Additionally, field studies in 2018 included turbidity measurements at 19 stream crossing sites along the mine access road and the Iliamna spur road specific to Alternative 1. These measurements yielded results below the minimum detection level for the instrument used (65-centimeter turbidity tube; 7 Nephelometric Turbidity Units [NTU] detection level) (PLP 2018-RFI 036).

Mine Access Road and North Access Road—Three surface water sampling stations are on the mine access road segment from the mine site to the intersection with the access road to the Eagle Bay ferry terminal. Sixteen surface water sampling stations were established and sampled by Schlumberger et al. (2011a) along the north access road extending east from the Newhalen River (Figure 3.18-4) to Williamsport (Alternative 2 and Alternative 3). Approximately 12 samples were collected at each station over a 2-year period in 2004 and 2005. Table K3.18-11 and Table K3.18-12 provide a summary of the surface water quality data for the western and eastern parts of the north access road, respectively. Data are described below for both the Newhalen River and collectively for all stations along the north access road.

The surface water was characterized by low levels of TDS (2 to 126 mg/L for all stations, 18 to 45 mg/L for Newhalen River); mostly near-neutral pH (4.6 to 8.8 for all stations, 6 to 7.8 for Newhalen River); and high DO concentrations (9 to 19 mg/L for all stations, 9 to 17 mg/L for Newhalen River). Additionally, TSS for all stations ranged from 0.2 to 51.6 mg/L, and 0.5 to 9.1 mg/L for Newhalen River. During months when surface water samples were collected, temperatures ranged from 0.1 to 23°C for all stations, and 1 to 16°C at the Newhalen River station. The full annual range of water temperatures could not be characterized because samples were not collected during some winter months (November, December, or January).

The cation composition of the water samples was dominated by calcium, and was consistent between sampling events. The anion composition was typically dominated by bicarbonate, but varied over time. Concentrations of nutrients were low; specifically, most ammonia and phosphorous concentrations were below detection limits. Total nitrogen (nitrate+nitrite) averaged 1 mg/L for all stations and 0.37 mg/L for the Newhalen River. Collectively for all stations, concentrations of the trace elements aluminum, copper, lead, and zinc were above the most stringent ADEC maximum criteria in a few cases. Only aluminum was above the most stringent criterion in about half of the Newhalen River samples.



Sources: PLP 2020-RF1168;
 PLP 2019-RF1153; Schlumberger et al. 2011a



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Miles

- Surface Water Quality Sample Location - West
- Surface Water Quality Sample Location - East

Action Alternatives

- Ferry Routes
- Natural Gas Pipelines
- Alternative 1a

- Alternative 1
- Alternative 2
- Alternative 2 Newhalen River North Crossing Variant
- Alternative 3

Other Features

- Local Roads
- Borough Boundary
- National Park

**SURFACE WATER QUALITY
 SAMPLE LOCATIONS -
 NORTH ACCESS ROUTE**

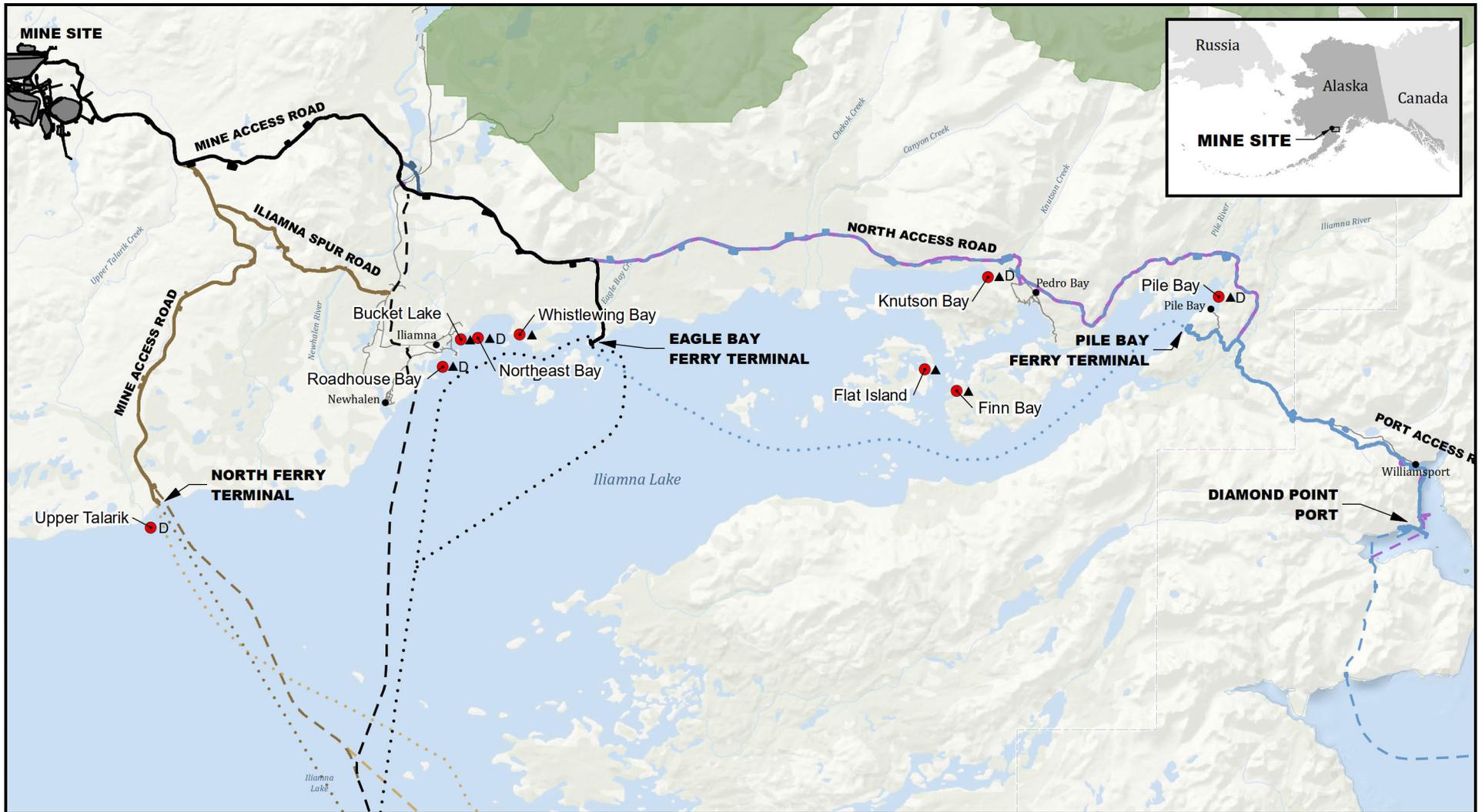
Port Access Road—Water quality data are limited along the port access road from the south ferry terminal to Amakdedori (Alternative 1a and Alternative 1). Field studies in 2018 recorded turbidity measurements at 97 stream crossings along the port access road at levels below the instrument detection level (7 to 11 NTU) for all but two stream crossings, at which turbidity levels of 24 and 13 were recorded. Turbidity measurements at the Gibraltar River crossing were also below the instrument detection level (PLP 2018-RFI 036). No additional water quality data were collected for the Gibraltar River. While turbidity measurements have not been collected along the road associated with the Kokhanok East ferry terminal variant, baseline conditions at stream crossings in this area are expected to be similar to those collected along the main port access road due to the similar nature of the terrain.

Iliamna Lake—A total of 176 surface water samples was collected at nine stations in northeastern Iliamna Lake (May to October) between 2005 and 2007 (HDR 2011a). Stations near Alternative 1 include one near the mouth of UTC, and four near Iliamna village; four additional sites were at the eastern end of the lake. Samples were collected at multiple depths at five of the nine locations (Figure 3.18-5). Ambient water measurements included DO, temperature, specific conductance, oxidation reduction potential, pH, turbidity, and water clarity. Table K3.18-13 provides a summary of the lake water quality data. Samples were collected and analyzed at various locations in four different regions: UTC, Iliamna Village area, Pedro Bay area, and at Pile Bay. The UTC drainage and Iliamna Village area sample locations represent water quality information for Alternative 1a; and the Pedro Bay area and Pile Bay area lend relevant water quality insight for transportation alternatives using mine access along the northeastern side of Iliamna Lake.

The sample data for all sites suggest that Iliamna Lake has water quality conditions similar to the natural conditions of other regional lakes. Aluminum, copper, iron, lead, manganese, and alkalinity were detected at concentrations that were outside the most stringent ADEC water quality criteria; however, mean concentrations did not exceed water quality criteria. Cation and anion dominance was generally characteristic for temperate lakes. Concentrations of major ions did not vary with depth, suggesting that the water at the sampling sites was well mixed. The concentrations of several major ions and TDS were lower earlier in the summer, peaked in September, and declined again in October. These temporary increases are likely associated with the influence of inflow from streams and precipitation.

Regional variations in constituent concentrations were observed for some trace elements, including aluminum, cobalt, copper, iron, lead, and manganese. In particular, significant variation was observed in the mean concentration of aluminum. Mean concentrations of total aluminum varied greatly between locations; mean concentrations at Pile Bay were more than 10 times those of the UTC area. Chromium, cobalt, copper, iron, lead, and manganese also showed some notable variation (about 50 percent change) in mean concentrations. Samples collected at UTC consistently yielded lower concentrations than other locations for these trace metals.

HDR noted that concentrations of nutrients and major ions found during the 2005 to 2007 study were similar to concentrations from a study conducted at Iliamna Lake nearly 40 years before. The single exception was sodium, which was present at nearly twice the concentration found in the earlier study. However, only a few ions (aluminum, copper, iron, lead, manganese, and alkalinity) had concentrations outside water quality standards established by ADEC for freshwater. The investigators attributed the latter to geological influences, and noted their consistency with previous studies conducted at Iliamna Lake and other area watersheds (HDR 2011a).



Sources: PLP 2020-RF1168;
 PLP 2019-RF1153; HDR 2011a



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Water Sample Locations

- Shallow samples collected 3' below lake surface
- D Deep samples collected at 1/2 total depth + 3' above lake bottom
- ▲ Sediment sample location

Action Alternatives

- Ferry Routes
- Natural Gas Pipelines
- Alternative 1a
- Alternative 1

- Alternative 1 Kokhanok East Ferry Terminal Variant
- Alternative 2
- Alternative 2 Newhalen River North Crossing Variant
- Alternative 3

Other Features

- Local Roads
- Borough Boundary
- National Park

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**SURFACE WATER AND
 SEDIMENT SAMPLE
 LOCATIONS - ILIAMNA LAKE**

FIGURE 3.18-5

Field data collected in 2017 added three additional sample locations assessing the surface water quality near the ferry terminals in Iliamna Lake. Samples were taken near the surface and near the bottom of the lake. These data did not yield any exceedances of the most stringent water quality criteria (Table K3.18-1) for total or dissolved metals, or any conventional parameters tested (GeoEngineers 2018a, Table 6a).

Drinking Water Sources—Three communities around Iliamna Lake have community surface water systems as their primary drinking water source, including Nondalton, Kokhanok, and Igiugig (see Figure 3.16-1). Nondalton uses infiltration galleries from Six Mile Lake (which drains into the Newhalen River); Kokhanok draws water from Iliamna Lake; and Igiugig has one active intake in the Kvichak River, just downstream of Iliamna Lake. No State of Alaska data are available on drinking water sources for Pile Bay and Williamsport (ADEC 2018; ADNR 2018a).

Past water system violations in these communities reported by ADEC (between 1995 and 2018) are mostly monitoring violations that represent failure to collect a sample. Drinking water standard exceedances are rare, but have included arsenic, coliform, copper iron, lead, and manganese (ADEC 2018).

3.18.2.2 Groundwater Quality

Mine Access and Port Access Roads—Limited groundwater quality data are available along the transportation corridor under all alternatives. Hydrogeological characterization and a description of aquifers beneath the transportation corridor are expanded in Section 3.17, Groundwater Hydrology. The transportation corridor under all alternatives can be characterized as similar to that of the mine site, port site(s), and drinking water wells. Along the north access road in the Nushagak and Kvichak watersheds, the groundwater quality of the transportation corridor is likely similar to that of the mine site along the western portion, and characterized more similarly to the drinking water wells sampled at Newhalen, Nondalton, and Iliamna. Trend analysis of the mine site groundwater system suggests that TDS concentrations decrease with distance from the mine site. The port access road (under Alternative 1a and Alternative 1) would traverse flat ground and low hills, much of which are bare rock covered with a thin layer of soil (AECOM 2018h). There are few known potentially groundwater-bearing surficial deposits along the port access road, with few intermittent glaciofluvial and alluvial surficial deposits (Detterman and Reed 1973). This terrain suggests that shallow groundwater occurrences along this route would be limited. Groundwater quality beneath the port access road is likely similar to that of the port site.

North Access Road—The north access road traverses a series of shallow intermittent surficial deposits, including glacial, glaciofluvial, and alluvial deposits, making groundwater quality potentially more variable along this route (Detterman and Reed 1973). The north access road would cross a variety surficial deposits, all of which have the potential to be groundwater-bearing. These are intermittent in the eastern part of the route and thicker in the western part of the road (Detterman and Reed 1973; Schlumberger et al. 2011a). Groundwater quality and characteristics can be influenced by these surficial deposits and bedrock geology, which is complex throughout the Cook Inlet basin (Brabets et al. 1999). A single groundwater quality sample was collected in Pedro Bay near the northern access route, and was similar in quality to wells sampled at Newhalen, Nondalton, and Iliamna (Schlumberger et al. 2011a).

3.18.2.3 Drinking Water Wells

The village of Newhalen uses both community and private groundwater wells as drinking water sources, while Iliamna and Pedro Bay rely on private groundwater wells. Drinking water wells were sampled at four locations (Newhalen, Nondalton, Iliamna, and Pedro Bay) in 2004 and 2005 to assess regional water quality across the transportation corridor (Schlumberger et al. 2011a).

These wells were similar in quality, with exceedances of drinking water quality standards for total arsenic in Newhalen, Nondalton, and Pedro Bay; and pH exceedances in Newhalen and Pedro Bay. Newhalen has had numerous monitoring violations from failure to collect a sample since 1995, but rare exceedance violations have only been registered for coliform (ADEC 2018a).

3.18.2.4 Substrate/Sediment Quality

Physical Characteristics—Stream substrates intersected by the transportation corridor under all alternatives include a wide range of fine to coarse sediments (Grossman 1998). Stream sediments at the northern end of the road corridor are dominated by sand and silt, with some stretches high in gravel and cobbles, while other stretches are rich in organic matter (PLP 2018-RFI 036). Limited substrate data along the Iliamna spur road (Alternative 1) show that some stream crossings are dominated by gravel and cobbles, while others are high in fine-grained sand, silt, and organic matter. Along the mine access road south of the intersection with the Iliamna spur road, substrates are dominantly silt, sand, and gravel (PLP 2018-RFI 036). No substrate data are available for streams along the southern portion of the mine access road (Alternative 1). A small number of nearshore and deeper water sediment samples from Iliamna Lake were collected in 2005 and 2006 (Figure 3.18-5). Substrate offshore of the north ferry terminal near the mouth of UTC was described as consisting of small gravel. Lake sediment analyzed near Iliamna Village was described as fine-grained material (HDR 2011a). Sediment samples collected near the ferry terminals in Iliamna Lake in 2017 consist primarily of underdeveloped sand-gravel beaches with intermittent cobble, larger rocks, and occasional outcrops of bedrock (GeoEngineers 2018a).

Stream substrates along the port access road show similar diversity to those north of Iliamna Lake. Sand and silt are the dominant sediment size, with a high percentage of organic matter present as well. Sampled streams have a higher percentage of boulders and less gravel south of Iliamna Lake. Sediment at the location of the Gibraltar River bridge is dominated by gravel and cobble substrate. Sediments in drainages with crossings by the other four bridges along the port access road tend to be more coarse-grained, with a higher percentage of cobbles and boulders (PLP 2018-RFI 036). Samples of substrate from four ponds within approximately 5 miles of the southern access road were all recorded as mud/fine sediment (Grossman 1998).

Chemical Quality—Table K3.18-20 provides a summary of Iliamna Lake sediment quality data collected in 2005 and 2006. Sediment quality measurements for Iliamna Lake were examined at the Iliamna Village area (four sample locations), Pedro Bay area (three sample locations), and at Pile Bay (one sample location). Minor variations in sediment content occur between the three areas; however, mean constituent concentrations only exceeded TELs for cadmium in the Iliamna Village area, and for copper at the Pile Bay location. In these instances, concentrations did not reach the probable effects level. Sediment samples collected from two locations near Iliamna Village (Figure 3.18-5) were analyzed for trace elements and other constituents (HDR 2011a). Sediment data showed levels for aluminum, copper, iron, lead, and manganese that exceed ADEC freshwater sediment criteria (same as SQGs). This is likely due to the highly mineralized nature of the local geology, and is similar to chemistry in other area lakes.

Of 12 pond substrate samples analyzed by NURE within approximately 20 miles of the north access road, none showed evidence of contamination from an outside source (Grossman 1998). Of four pond substrate samples analyzed by NURE within approximately 5 miles of the port access road, none showed any evidence of contamination from an outside source (Grossman 1998).

3.18.3 Marine Ports

3.18.3.1 Surface Water Quality

The following discussion of marine water quality presents regional information, as well as data collected in northern Kamishak Bay (2004 to 2012) and offshore of the Amakdedori port site (2018) that are pertinent to Alternative 1a and Alternative 1. Additional details of marine water quality in the Iliamna/Iniskin estuary north of Kamishak Bay that are pertinent to the Diamond Point port (Alternative 2 and Alternative 3) are provided in Appendix K3.18.

Suspended Particulates/Turbidity—Cook Inlet basin is an expansive watershed surrounding the 180-mile-long Cook Inlet waterbody. Covering more than 38,000 square miles of southern Alaska, it receives water from six major watersheds and many smaller ones. More than 10 percent of the basin is covered by glaciers, and suspended sediment loading in glacier-fed rivers without lakes is significant, leading to generally high suspended sediment load in some portions of Cook Inlet (PLP 2018d), particularly in the upper inlet areas.

Hart Crowser (2015a) provides physical and chemical data from the Ursus Cove area at the northern end of Kamishak Bay (about 17 miles northeast of Amakdedori), which are likely similar to the Amakdedori port site because of its exposure to lower Cook Inlet oceanographic conditions. Turbidity in the sampled areas at the northern end of Kamishak Bay ranged from near 0 to 13 NTU, probably reflective of varying exposures to wave activity. Turbidity was described as generally moderate, except near the shoreline during windy periods, and did not exhibit any obvious trends that would indicate point-source inputs (Hart Crowser 2015a). TSS was 5 mg/L at both surface and bottom, indicating a well-mixed and relatively clear water column.

Overall, turbidity in Iliamna Bay tended to be greater than in Ursus Cove and Iniskin Bay. Field turbidity measurements in Iliamna Bay indicate measured mean turbidity of approximately 21 NTU (Hart Crowser 2015a). Hart Crowser (2015a) notes that higher turbidity levels in Iliamna Bay may be the result of reflected wave energy and proximity to mudflats, although sediment characteristics in Iliamna Bay are similar to those of Ursus Cove. Turbidity in Iliamna Bay north of Diamond Point is also impacted annually by maintenance dredging at Williamsport, which temporarily increases turbidity in northern Iliamna Bay. Maintenance dredging typically occurs in May or June, and removes approximately 2,250 cubic yards of material (USACE 2011b).

The amount of suspended solids and accompanying turbidity in waters adjacent to the Amakdedori port site would be a function of seabed composition (e.g., silt, mud, sand). Extrapolation of onshore geophysical survey data (Zonge 2017) and NOAA (2015) nautical chart information for the approach to the port site suggest that the seabed in this area consists of sand and gravel with scattered boulders. This suggests that suspended solids are of naturally low concentrations, and that water is relatively clear (i.e., low turbidity). Field studies conducted in 2018 at four offshore locations near the Amakdedori port site (two near-bottom and two near-surface samples) measured no exceedances of the ELG for TSS with an average of 15.3 mg/L (GeoEngineers 2018a, Table 5). However, under energetic wave conditions, any loose sediment on the seabed would be stirred upward into the water column, thereby temporarily increasing suspended solids and turbidity.

Salinity Gradient and Temperature—The Amakdedori port site is on the open coast of Kamishak Bay. Therefore, water properties such as salinity and temperature can be expected to be similar to those of lower Cook Inlet (Muench and Schumacher 1980). However, some freshening of surface waters in the immediate vicinity of Amakdedori Creek might occur; while under southerly winds, greater freshening could occur as a result of flows from sources to the south, such as McNeil and Kamishak rivers. The extent of any freshening is dependent on flows from those sources and the persistence of southerly winds. The freshening of surface waters

would be manifest as a thin, low-salinity lens overlying saltier water, which would be mixed quickly into the water column by any wave action produced by brisk winds.

Hart Crowser (2015a) temperature and salinity data from the Ursus Cove area are likely to be similar to the Amakdedori port site, although they may be influenced by freshening from upland sources through Ursus Lagoon. For the 2012 sampling period (August), mean water temperatures ranged from 12.9 to 14°C, while mean salinities ranged from 22.8 to 25.7 parts per thousand. Hart Crowser (2015a) reported similar observations in Iliamna Bay. Field measurements indicate that mean surface water temperatures in the bay ranged from 6.4 to 12.1°C, with an average of approximately 9.4°C throughout the bay. Salinity in Iliamna Bay was similar to that of Ursus Cove and the Amakdedori port site, ranging from 16.1 to 28.7 parts per thousand. The small range in data for both temperature and salinity suggests a fairly homogenous water column. Temperature exhibited seasonal warming up to mid-summer, and then subsequent cooling, but was also a function of water depth, indicating the role of insolation as a factor in temperature trends. Salinity decreased from spring to late summer, reflecting the influence of upland sources on coastal waters, and then increased in autumn months.

Organics and Inorganics—The area surrounding Cook Inlet north and east of the port site is a relatively populated and industrialized region of Alaska. Therefore, its waters are influenced to some degree by urban (and a small amount of agricultural) runoff, oil and gas activities (e.g., accidental spills, discharges of drilling muds and cuttings, production waters, and deck drainage), effluent from municipal wastewater treatment facilities, oil and other chemical spills, offal from seafood processing, and other regulated discharges. Waters free from contaminants, however, are considered a principal component of the Cook Inlet beluga whale critical habitat in the Amakdedori port area. Therefore, the comparatively low levels of contaminants documented in Cook Inlet beluga whales, as well as in chemical analyses of water and sediment in the area, suggest that contaminant concentrations in lower Cook Inlet are low (NMFS 2016a).

Hydrocarbon concentrations sampled in 2004 at the northern end of Kamishak Bay, as well as metal and trace element concentrations collected in 2008, showed little to no effect from anthropogenic sources. The majority of organic constituents tested were not detected (Hart Crowser 2015a: Table 34-7). Inorganics analyzed in both surface water and bottom water at a depth of about 50 feet in northern Kamishak Bay (Hart Crowser 2015a: Table 34-8, Station MRC20) showed that none exceeded Alaska water quality standards or National Recommended Water Quality Criteria (EPA 2018d). In samples collected offshore of the Amakdedori port site, exceedances of marine water screening levels were measured in boron for both total and dissolved metal concentrations at all locations. Additionally, total iron concentrations exceeded the marine screening level for all sample locations (GeoEngineers 2018a: Table 5).

3.18.3.2 Groundwater Quality

Aquifer systems found in small drainages around the Cook Inlet region, such as those in the Amakdedori and Diamond Point port areas, include groundwater occurrences in saturated fractures in bedrock that provide water to streams near the port areas during winter (Glass 2001). Aquifers are primarily situated in glacial and fluvial deposits overlying sedimentary and low-grade metamorphic bedrock. Glacial deposit aquifers have been described as irregular in distribution and highly variable in composition and flow (Brabets et al. 1999).

The thickness of surficial deposits in the Amakdedori port area are believed to range from about 50 to 100 feet thick in the port area, based on geophysical survey results (Zonge 2017). Potential groundwater-bearing surficial deposits in the Diamond Point area would be limited to alluvium and alluvial fan deposits in the small drainage west of Diamond Point, and morainal deposits in

uplands west of the terminal (Detterman and Reed 1973). There are no existing drinking water wells in either port area. Potable water supplies for seasonal work at the Diamond Point quarry come from temporary mobile sources (ADNR 2014a).

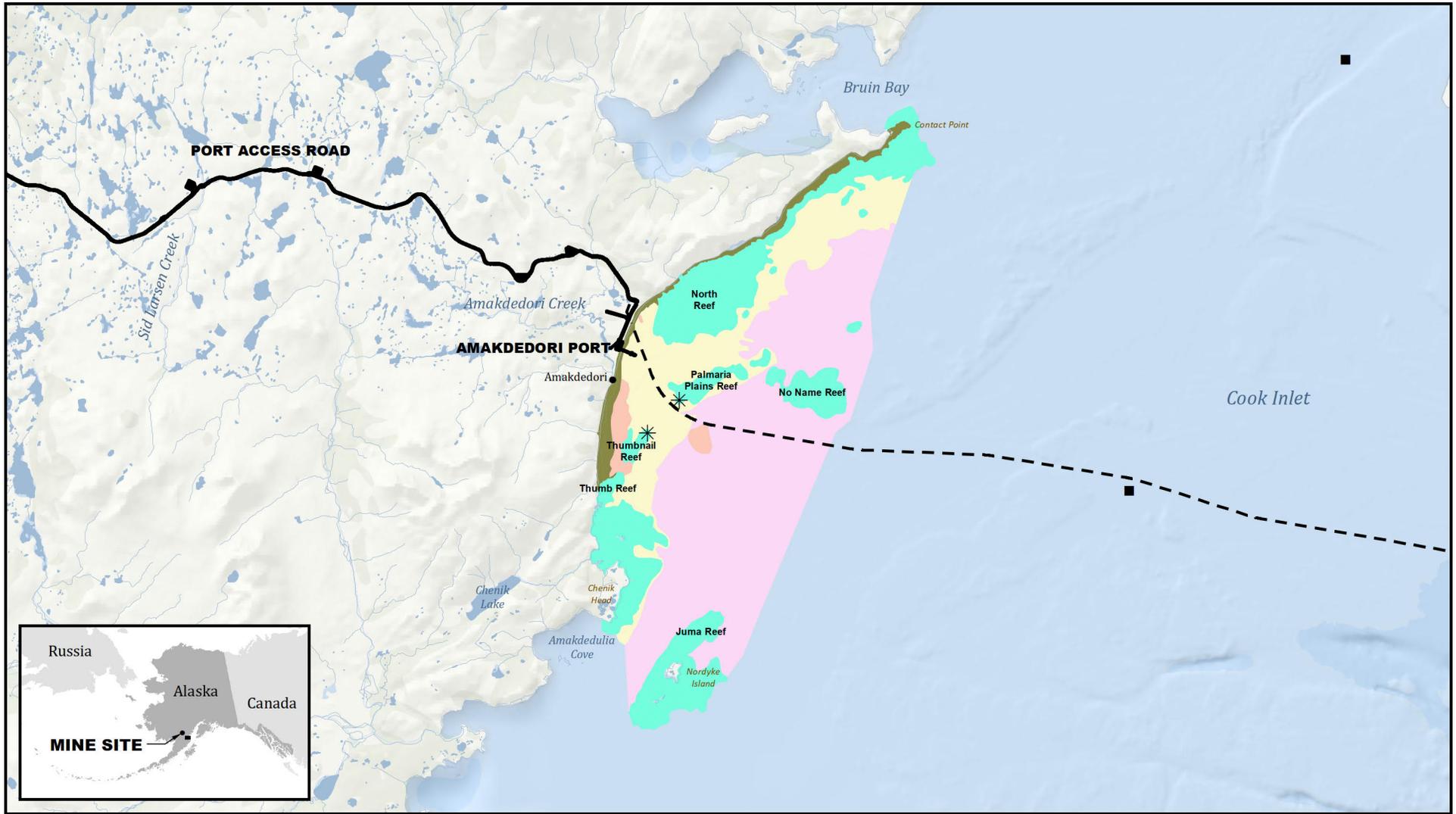
3.18.3.3 Substrate/Sediment Quality

Physical Characteristics—Studies in upper and lower Cook Inlet provide a general characterization of seafloor substrate and sediment depositional processes in the region. Lower Cook Inlet is a tidal embayment with a substrate of abundant glacial sediments, predominantly cobbles, pebbles, and sand, with minor amounts of silt and clay (Sharma and Burrell 1970). Large ice-rafted boulders are also present in some areas (Thurston and Choromanski 1994). Over 40 million tons of sediment are discharged per year into the inlet by surrounding major drainages (Rember and Trefry 2005). Sediment transport in some areas of upper Cook Inlet has been shown to be exceptionally high, with 10,000 to over 100,000 cubic yards of sediment moving in and out of the Port of Anchorage area in a matter of days or weeks (USACE 2013). A combination of shallow water, high tidal fluctuations, and strong currents constantly mobilize seafloor sediments in the inlet, keeping sediments in suspension, resulting in highly turbid water, and inhibiting deposition of fine-grained sediments (Rember and Trefry 2005). Fine sediments introduced by major rivers feeding into upper Cook Inlet are carried in suspension, and have been shown to be deposited as far as 150 miles south in lower Cook Inlet (ADL 2001). Analysis by Atlas et al. (1983) determined that Kamishak Bay is a natural depositional area for fine sediments and hydrocarbons. Kamishak Bay is primarily composed of unconsolidated sediment with fine silt/clay being found intertidally and sub-tidally, with rocky substrates occurring along much of the shoreline, and extending into the intertidal zone (GeoEngineers 2018c). At the Amakdedori port site, studies suggest that substrates are a mixture of sands and fine materials, gravel, and rocky reefs. The areas accounting for these substrate types are relatively equally dispersed, with nearshore areas primarily typified by gravels and reef features, and outer areas more typified by sands and fines (GeoEngineers 2018c, Figure 4).

The shoreline at Amakdedori is a wave-dominated coastal berm largely composed of weathered cobbles, boulders, and exposed bedrock rising from the intertidal zone (GeoEngineers 2018a, c). Amakdedori Creek alluvial fan-delta deposits extend about 1,000 feet offshore into Kamishak Bay (PLP 2018-RFI 039). Seafloor sediment at and around the Amakdedori port location is primarily composed of subtidal gravel and beach complex (GeoEngineers 2018a, Figure 2). Bathymetry in Kamishak Bay around the Amakdedori port location was investigated through a multi-beam survey in 2017, which indicated that the seafloor is relatively smooth, with a gentle slope (60 feet over 5.6 miles). Results from three boreholes indicate that sub-bottom sediment consists primarily of fine silty sand with occasional coarse gravel and shell fragments, and a fines content ranging from 14 to 19 percent. Sediment samples from the estuarine environments of Iliamna and Iniskin bays, about 30 miles northeast of the port site, revealed substrates of fine sediment (SLR et al. 2011a).

Waterbody substrate data from the onshore environment at the Amakdedori port site are limited. Sediment from two ponds, one about 0.5 mile north and the other approximately 3 miles south, was described as mud/fine sediment (Grossman 1998).

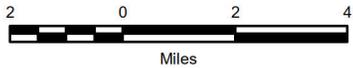
Figure 3.18-6 through Figure 3.18-8 depict spatial characterization of marine substrates for Amakdedori Bay, Ursus Cove, and Iliamna Bay following 2018 field investigations (GeoEngineers 2018c). Substrate along the Ursus Cove beach is characterized primarily by beach complex with intermittent rock and sand/fine substrates (GeoEngineers 2018c). Iliamna Bay is composed of mixed gravel at the mouth of the bay, and transitions to sand and fine sediments, and mixed fine sediments further inland. The shoreline of Iliamna Bay is largely beach complex with intermittent reefs, transitioning to mixed fine sediments further inland (GeoEngineers 2018c).



Sources: PLP 2019-RF1153;
GeoEngineers 2018c



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Habitat Types

- Beach Complex
- Mixed Fine
- Mixed Gravel
- Reef
- Sand/Fine

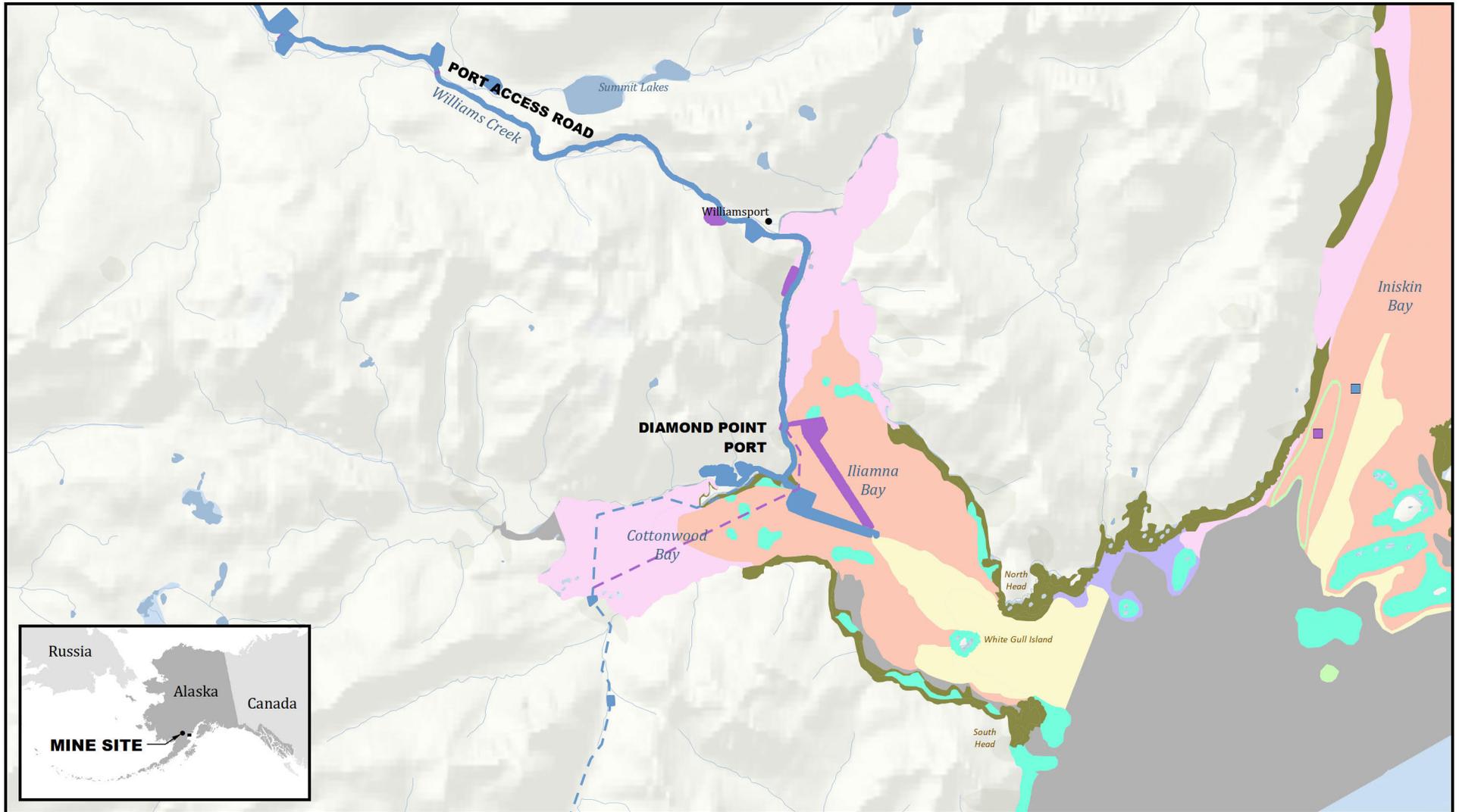
Alternative 1a

- Lightering Locations
- Lighted Navigation Buoys
- Natural Gas Pipeline
- Transportation Corridor/Port

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MARINE SUBSTRATE CHARACTERIZATION - AMAKDEDORI

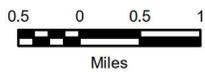
FIGURE 3.18-6



Sources: PLP 2020-RF1168; PLP 2019-RF1153;
GeoEngineers 2018c



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Habitat Types

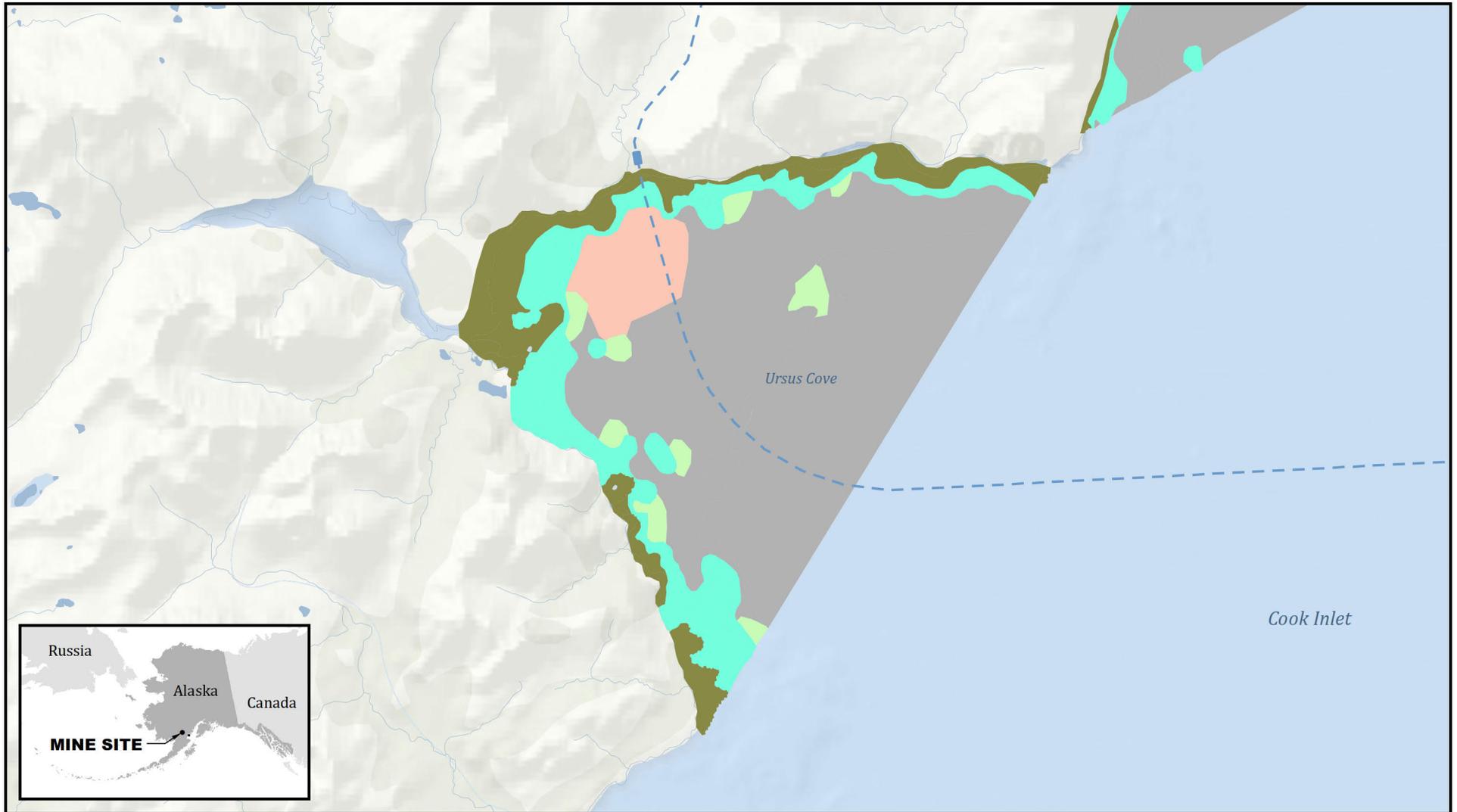
- Beach Complex
- Hard
- Mixed Fine
- Mixed Gravel

- Reef
- Rocky
- Sand/Fine
- Unknown

Action Alternatives

- Lightering Locations
- Natural Gas Pipelines
- Alternative 2
- Alternative 3

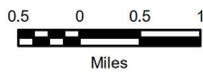
MARINE SUBSTRATE CHARACTERIZATION - ILIAMNA BAY



Sources: PLP 2019-RF1153;
GeoEngineers 2018c



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Habitat Types

- Beach Complex
- Reef
- Rocky
- Sand/Fine
- Unknown

Alternative 2

- - - Natural Gas Pipeline

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MARINE SUBSTRATE CHARACTERIZATION - URSUS COVE

FIGURE 3.18-8

Chemical Quality—Data on regional sediment chemical quality in Cook Inlet are found in PLP baseline studies and other substrate studies, including the Integrated Cook Inlet Environmental Monitoring and Assessment Program. Limited data from dredging operations and sediment sampling suggest that sediments generally have low concentrations of contaminants (USACE 2013; ADL 2001). Low levels of hydrocarbons have been detected at multiple sites in the inlet, potentially connected with offshore oil development, past oil spills, or natural oil seeps in the region. Glacial sediments, which are continually transported into the inlet by the major drainages, may also bring metals and hydrocarbons from upstream sources into Cook Inlet. Municipal discharges and seafood processing also contribute potential contaminants to Cook Inlet substrate. Extreme tidal fluctuations and strong currents constantly disperse and dilute potential pollutants in the inlet (ADL 2001).

Sampling of offshore sediment has been conducted at two locations near the Amakdedori port site, and in various other locations in lower Cook Inlet. Sediment quality data from the two locations near the Amakdedori port site were analyzed for concentrations of inorganic and organic chemicals. Results indicate that concentrations of metals fell below the TEL for all measured quantities except for manganese and nickel. An exceedance of nickel in marine sediments was detected in one sample collected from subtidal sands/fines, but mean concentrations did not exceed the marine TEL. Manganese concentrations exceeded the marine TEL for both sampled locations in subtidal sands/fines, and yielded a mean concentration of 380 mg/kg, exceeding the marine TEL (GeoEngineers 2018a, Tables 7a and 7b).

Samples of fine sediment were collected from the offshore estuarine environments of Iliamna and Iniskin bays near Diamond Point. Some of the samples showed arsenic, copper, nickel, and zinc levels higher than the threshold of biological effect, and measurable hydrocarbons. There is current development in the Diamond Point area, and minor marine vessel traffic at Williamsport at the head of Iliamna Bay. Estuarine sediments are generally more fine-grained than offshore of Amakdedori, which is more exposed to open water. Fine-grained sediments generally retain chemical pollutants more than coarse-grained sediments, due to higher surface area to volume ratios.

Chemical substrate data from the onshore environment at the Amakdedori port site are limited. Sediment from two ponds, one within 0.5 mile to the north and one about 3 miles south of the port site, were analyzed by NURE and were reported to have no contamination (Grossman 1998).

3.18.4 Natural Gas Pipeline Corridor

3.18.4.1 Surface Water Quality

Surface water quality data for the onshore part of the natural pipeline corridor are summarized above under “Transportation Corridor,” (including the area of the pipeline-only segment from Iliamna Lake to the mine access road under Alternative 1a). Additional water quality information for Cook Inlet and Kamishak Bay pertinent to the pipeline is summarized above under “Surface Water Quality, Marine Ports.” The pipeline would tie into the existing natural gas supply at a compressor station near Anchor Point. This would result in no additional stream or waterbody crossings on the Kenai Peninsula. The closest stream to the horizontal directional drilling (HDD) part of the corridor is about 200 feet to the north (PLP 2017, Figure G-012).

A description of Cook Inlet bathymetry and oceanographic conditions is provided in Section 3.16, Surface Water Hydrology. The USGS National Water-Quality Assessment (NAWQA) Program described water quality in the Cook Inlet as generally good, and that much of the water originates from melting snow and glaciers, resulting in a relatively low level of contaminants (Glass et al. 2004). Further assessment by Saupe et al. (2005) used approximately 20 sample locations,

testing a wide variety of water quality parameters, including trace metals, dissolved oxygen, and nutrient levels. All samples collected met the applicable water quality criteria. No evidence suggested heavy metal pollution in Cook Inlet; however, some evidence of elevated mercury in suspended sediments was found, which is likely the result of a combination of natural and anthropogenic sources (BOEM 2016a).

3.18.4.2 Groundwater Quality

Summary groundwater quality information pertinent to the natural gas pipe corridor is described above in “Transportation Corridor.” The only additional sections of pipeline that do not match the road alternatives would be the pipeline-only segment from Iliamna Lake to the mine access road (Alternative 1a); at the eastern end of the pipeline on Kenai Peninsula (all alternatives); and the short section from Ursus Cove to Diamond Point (Alternative 2 and Alternative 3).

As described in Section 3.17, Groundwater Hydrology, groundwater beneath Kenai Peninsula is known to occur in thick glacial and alluvial deposits (Karlstrom 1964; Nelson and Johnson 1981). Seven private groundwater wells are currently located a distance of 600 to 1,600 feet away from the HDD part of the pipeline terminus. Groundwater quality data are not publicly available for private wells (ADNR 2018a).

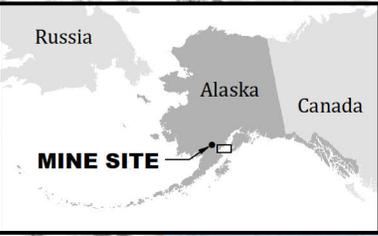
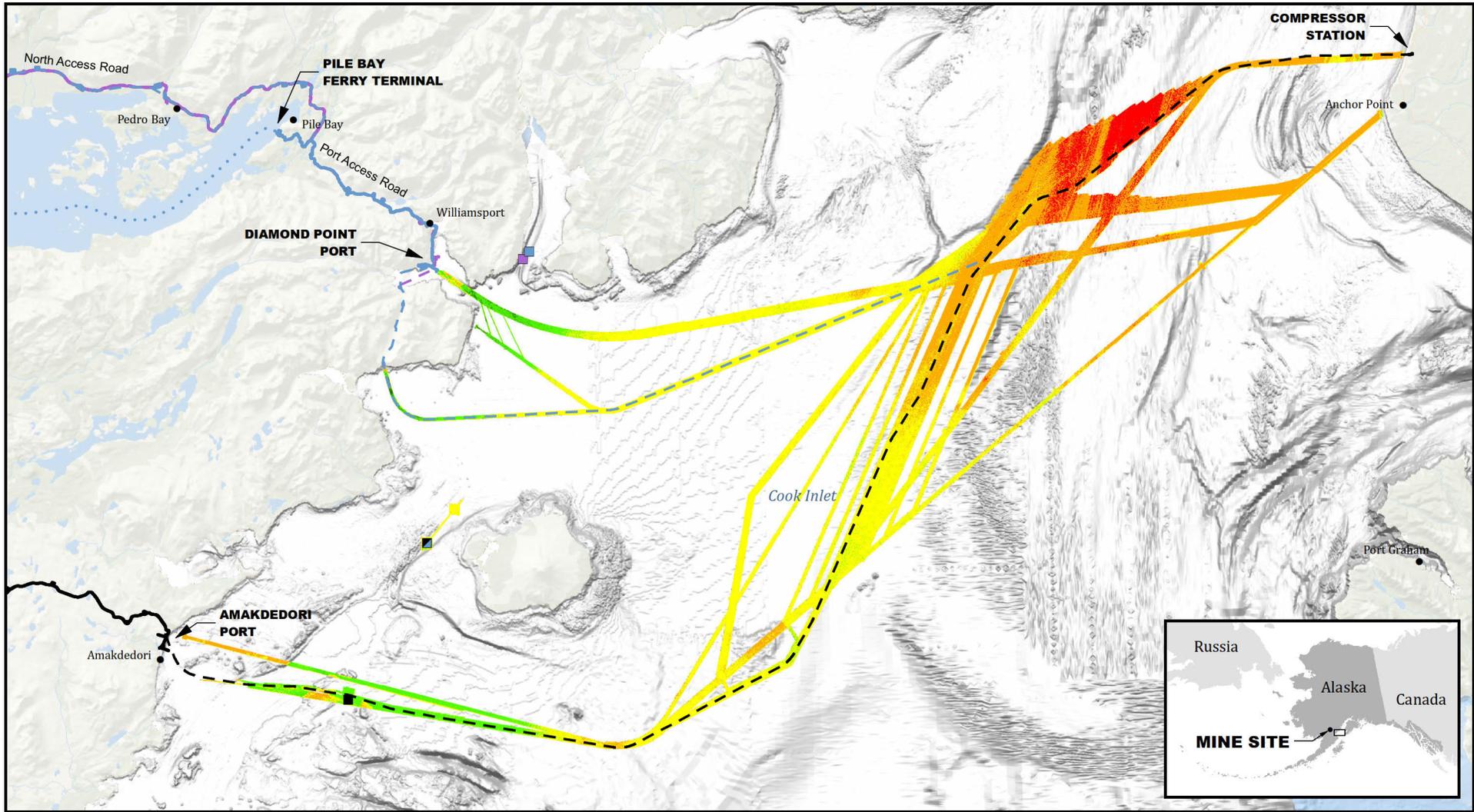
There would be limited shallow groundwater occurrence in a narrow strip of alluvial deposits along the short pipeline corridor between Ursus Cove and Diamond Point (Detterman and Reed 1973). No groundwater quality data have been collected in this area.

3.18.4.3 Substrate/Sediment Quality

Physical Characteristics—Substrate along the Cook Inlet crossing pipeline route ranges from coarse sands and gravel in the northeastern portion of the pipeline route, becoming finer following the pipeline route to the southeast. Along the center of the pipeline crossing of Cook Inlet, substrate transitions to fine to medium sands, and becomes even finer silts and fine sands to the west approaching Kamishak Bay, Ursus Cove, and Iniskin Bay (IntecSea 2019). Figure 3.18-9 depicts physical characteristics and distribution of substrate along potential crossings of Cook Inlet under all alternatives. A description of nearshore Cook Inlet physical substrate characteristics is provided above under “Marine Ports.” Field studies indicate that the substrate in the western portion of Kamishak Bay is primarily composed of subtidal gravel with intermittent reef and sand/fine substrate in the region near the port location (GeoEngineers 2018a, Figure 2). Publicly available information regarding the substrate of Cook Inlet in areas further offshore is sparse. Substrate in the vicinity of mooring facilities could include flows from Augustine Volcano, which have been documented to occur approximately every 300 years (Section 3.15, Geohazards and Seismic Conditions).

Water depths in the center of Cook Inlet range from about 50 to over 500 feet (NOAA nautical chart #16660). Numerous oil and natural gas pipelines currently span the bottom of Cook Inlet; however, all current pipelines are in the northern part of the Cook Inlet, and there are none in the vicinity of the project (ADNR 2018d). Pipeline damage has previously been documented from boulders moved on the seafloor by strong tides and currents.

Chemical Quality—Substrates in Cook Inlet are derived primarily from river-borne sediments and have low concentrations of metals and low toxicity (ADL 2001; BOEM 2016a; Saupe et al. 2005). There is no known evidence linking enhanced metals concentrations in bottom sediments to anthropogenic sources (BOEM 2016a). Chemical quality of sediment in the nearshore parts of Kamishak Bay and Iliamna/Iniskin estuary are summarized above under “Marine Ports.” Sediment quality data for the offshore part of the pipeline route are limited, as described previously. Sediment sampled from one stream in the Kenai Peninsula area near the eastern end of the pipeline did not show evidence of contamination (Grossman 1998).



Sources: PLP 2020-RF1168; PLP 2019-RF1153; IntecSea 2019

US Army Corps of Engineers

Miles

- | Preliminary Surficial Sediment Interpretation | Action Alternatives |
|--|--|
| Clays | Lightering Locations |
| Silt | Ferry Routes |
| Fine to Medium Sands | Natural Gas Pipelines |
| Medium to Coarse Sands | Alternative 1a |
| Coarse Sands to Gravel or Larger, or Rock | Alternative 2 |
| Other | Alternative 3 |

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SEAFLOOR SEDIMENT DISTRIBUTION - COOK INLET PIPELINE CORRIDORS

FIGURE 3.18-9