# PEBBLE PROJECT

# FINAL ENVIRONMENTAL IMPACT STATEMENT

## VOLUME 3: CHAPTER 4—SECTION 4.1 – SECTION 4.19

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# 4.0 ENVIRONMENTAL CONSEQUENCES

## 4.1 INTRODUCTION

Chapter 4, Environmental Consequences, describes the potential impacts on the environmental resources addressed in Chapter 3, Affected Environment, that would occur under the No Action Alternative and the action alternatives.

Chapter 4 sections discuss direct, indirect, and cumulative effects[1] for each resource described in Chapter 3, and for spills in Section 4.27, Spill Risk,[2] for each alternative.

### 4.1.1 Impact Characterization

#### 4.1.1.1 Scope of Analysis

The Environmental Impact Statement (EIS) analysis area refers to the entire area of resource analysis that is specific to each resource discussed in Section 3.2 to Section 3.26.[3] Although the EIS analysis area can be delineated based on the physical footprint of the action alternatives, potential resource impacts are considered in a spatial context appropriate to each resource. The EIS analysis area is defined in each Chapter 3 and Chapter 4 section. See Section 3.1, Introduction to Affected Environment, for a detailed description of the scope of analysis for this EIS.

The project area refers to the exact project footprint for each action alternative.

#### 4.1.1.2 Factors of Analysis

Beneficial and/or adverse effects of the project were evaluated and described for each of the resources. Each resource characterizes impacts in relation to four factors:

- **Magnitude or Intensity—**The intensity the impact would have, measured in terms of change or degree of change in a resource condition. Common characterizations are acres of impact, number of units of change, differences in levels of use, etc.
- **Duration—**How long the impact would be expected to occur or last, measured in length of time. Common characterizations are short-term, long-term, for the life of the project, etc.
- **Geographic extent—**Where the impact would be expected to occur geographically in the EIS analysis area.
- **Potential to occur (likelihood)—**How probable the impact would be. Common characterizations include the likelihood of the impact if the project were to be permitted, or probability of occurrence based on the results of analysis or modeling.

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[1] Note that in this document, the terms "effect" and "impact" have the same meaning and are used interchangeably.

[2] As noted in Section 3.1, Introduction to Affected Environment, there is no corresponding spill risk section in Chapter 3, because spill risk would be considered an environmental consequence to the resources discussed in Section 3.2 through Section 3.26.

[3] Note that in Chapter 3 and Chapter 4, Waters of the US (WOUS) as defined under the Clean Water Act (CWA) and determined to be jurisdictional under US Army Corps of Engineers (USACE) authority (see Appendix J for the Preliminary Jurisdictional Determination from USACE) are discussed collectively with wetlands and other waters; all WOUS, wetlands, or other waters are together termed "wetlands and other waters." The term WOUS may appear in Chapter 3 and Chapter 4 under specific regulatory context.

Each section in Chapter 4 describes analysis methodology and includes explanations of how each factor applies to that resource. Note that analysis assumes normal operating conditions for the proposed project.

Project component values, such as road lengths and pad acreage, are approximations based on best available data. Due to differences in data processing systems (e.g., Geographic Information System [GIS]) and methodologies (e.g., number rounding), the values presented in the EIS may differ slightly from values presented in other project-related documents, such as permit drawings. These differences have been reviewed and were determined to have no material consequence to the analysis or the overall permitting process.

**Project components—**In Chapter 3 and Chapter 4, the project is discussed by its four major components (mine site, transportation corridor, ports, and natural gas pipeline corridor) for each alternative. See Section 3.1, Introduction to Affected Environment, for a brief description of project components. See Chapter 2, Alternatives, for a detailed description of components.

**Project alternatives—**See Chapter 2, Alternatives, for a detailed description of alternatives. Note that the action alternatives in Chapter 3 and Chapter 4 are referred to by name without including the word "Action" in front of the alternative name as is done in Chapter 2, Appendix K2, and Appendix B.

**Project phases—**Impacts on some resources may vary depending on the project phase. See Chapter 2, Alternatives, for a detailed description of the proposed project phases. Chapter 4 includes analysis in the following phases:

- **Construction phase—**The period of construction of mine infrastructure prior to operations (4 years).
- **Operations phase—**The 20-year period of mine operations. Mining and milling operations would continue for the full 20-year operating life of the project.
- **Closure phase—**Activities occurring in the 20 years following the end of operations (for example, at closure year 15, pit backfilling would be completed; at closure year 20, reclamation of the pyritic tailings storage facility [TSF] and water management ponds [WMPs] would be completed, and the pit lake would be at maximum level).
- **Post-closure phase—**The period of time after the 20-year closure phase (for example, at closure year 50, maximum tailings consolidation would be expected).

### 4.1.2 Resource Interrelationships

Although resources are discussed in Chapter 3 and the impacts on those resources analyzed in Chapter 4 in discrete sections, these resources are dynamic and interrelated. A change in one resource can have cascading or synergistic impacts to other resources.

The site of the proposed project and the nature of open-pit mining activity would lead to a complex interaction between groundwater, surface water, and a number of water-related resources. The proposed project would also lead to a complex interaction between the aforementioned water-related resources and fish and aquatic resources. Impacts to water, fish, and wildlife resources could in turn have impacts on subsistence or commercial fishing; for example, water quality may affect fish populations, which in turn may influence subsistence or commercial fishing harvests and have implications for other human outcomes such as health and socioeconomics. Impacts described in one section may depend on the analysis from another section. During the writing process, preparers collaborated by sharing data and discussing interrelated aspects of the analyses to better capture the interrelated nature of environmental resources in both Chapter 3 and Chapter 4.

### 4.1.2.1 Types of Effects Considered

The National Environmental Policy Act (NEPA) requires three types of impacts to be evaluated: direct, indirect, and cumulative effects.

Direct, indirect, and cumulative effects are analyzed in each of the Chapter 4 sections by the four factors of analysis.

#### Direct and Indirect Effects

Under NEPA, direct and indirect effects are defined as:

**Direct Effects—**Effects caused by the action and occurring at the same time and place (40 Code of Federal Regulations [CFR] Part 1508.8).

**Indirect Effects—**Effects that are "caused by an action and are later in time or farther removed but are still reasonably likely. Indirect impacts may include growth-inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems" (40 CFR Part 1508.8). Indirect effects are caused by the project, but do not occur at the same time or place as direct effects.

#### Cumulative Effects

Cumulative effects are described under a separate subheading near the end of each section of Chapter 4.

Cumulative effects are interactive, synergistic, or additive effects that would result from the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions (RFFAs) regardless of what agency (federal or non-federal) or person undertakes those other actions (40 CFR Part 1508.7). This includes incremental impacts of the proposed action or alternatives when added to other past, present, and RFFAs. Interactive effects may be either greater or less than the sum of the individual effects; therefore, the action's contribution to the cumulative case could increase or decrease the net effects. Assessing the cumulative impacts from multiple projects/activities requires considering the impacts of their combined potential affected area and associated actions. It also requires a logical nexus with the potential effects of the proposed action. This means that the specific past, present, or RFFAs must have potential interactive, synergistic, and/or additive effects with direct and indirect impacts on a specific resource resulting from a proposed action and its alternatives.

**Past actions**—Past actions include activities that may have been initiated in the past but could also involve present operations such as infrastructure development and non-mining-related actions. These actions may have lingering effects in degrading the environment or may influence trends in the physical, biological, or social environment.

**Present actions**—Present actions include mining projects and related activities that have just been initiated or are currently underway and causing impacts. They may also include other non-mining-related projects that are currently in progress such as transportation, oil and gas development, or community development.

**Reasonably foreseeable future actions**—For this analysis, RFFAs are existing plans, permit applications, or fiscal appropriations that are likely (or reasonably certain) to occur. The Pebble Project expansion is considered an RFFA in this EIS.

### *Past and Present Actions in the EIS Analysis Area*

Past and present actions that have an interactive, synergistic, and/or additive effect (per 40 CFR Part 1508.7) with a specific resource (such as lingering effects or influencing trends), are relatively limited for this project, and are described below:

- **Commercial and Subsistence Harvest of Fish and Wildlife**—Past and present harvest of fish and wildlife for commercial and subsistence purposes put some degree of pressure on those resources. Although commercial fishing in the Bristol Bay Watershed and Cook Inlet started in the 1880s, the period from the turn of that century through the adoption of the Alaska Limited Entry Act by the State of Alaska in 1972 saw incremental changes in both fishing technology and the understanding of the salmon fishery resource. It was likely that there were historic instances of overharvest, with implications for the overall salmon resource. As shown in Section 3.6, Recreational and Commercial Fisheries, the commercial harvest of salmon in Bristol Bay fisheries districts over the last 20 years has fluctuated significantly; in 2018, Bristol Bay saw record returns, even though Cook Inlet and other areas of the state saw declining returns. Factors influencing returns are complex and there are no clear long-term trends with commercial harvests. However, Fall et al. (2009) noted that subsistence harvest of salmon in the Kvichak and Nushagak rivers declined from long-term averages, even though the number of Bristol Bay subsistence salmon permits has been stable. Similarly, local and non-local residents have historically harvested fish and wildlife in pursuit of traditional subsistence activities and may affect such resources. For example, the subsistence harvest of Cook Inlet beluga whale is thought to have depleted its population and contributed to its listing as an endangered species (73 Federal Register [FR] 62919). There have been natural variability and changes in the historic distribution of some species harvested for subsistence and recreational purposes, such as returning salmon and caribou, although there is no clear agreement why. Regardless, fish and wildlife resources are managed by the Alaska Department of Fish and Game (ADF&G) and federal agencies to maintain sustainable populations and optimize public uses and economic benefits (ADF&G 2018p). Management tools such as harvest limits and areas open and closed to sport and commercial harvest of fish and wildlife are applied to maintain sustainable resources and allocate harvest. Section 4.23, Wildlife Values (non-threatened and endangered species), and Section 4.24, Fish Values, discuss historic trends for area wildlife and fish populations where appropriate.
- **Commercial Recreation and Tourism**—Southwest Alaska, including the Bristol Bay region and the project area, is renowned for sport fishing, hunting, boating, and wildlife viewing opportunities; there is a long history of these activities in the area. Similar to commercial fishing, sport harvest of fish and game is managed by the ADF&G and federal land managers to maintain sustainable populations. These activities take place primarily from late spring to early fall, and there may be small plane, helicopter, and boat traffic associated with access that contribute to the disturbance of wildlife, as well as recreational and subsistence activity experience.
- **Community Development and Infrastructure**—The transition from seasonal communities to fixed locations with housing, public facilities, and transportation infrastructure has resulted in wetlands fill and loss of habitat. These communities also generate sewage and solid waste and use fossil fuels for energy and heat generation. The limited number of communities, their relatively small footprint and population size, and the distance between communities have resulted in little past and present cumulative effects on a regional basis. Some transportation infrastructure such as

airports, boat docks, and connecting roads have increased accessibility to the region. This reduces costs for communities, but facilitates visitation to the region, including airport facilities in King Salmon and Iliamna.

- **Offshore Oil and Gas Exploration and Development in Cook Inlet**—Offshore exploration, development, and production of oil and gas in Cook Inlet has occurred in state and federal waters since the 1960s. These activities have the potential to impact marine mammals and are visible from key observation points on the shore of Cook Inlet and from aircraft and vessels transiting the area. Marine vessel and helicopter traffic are associated with these activities, and both oil and liquefied natural gas (LNG) have been shipped by tanker out of Cook Inlet. There have been minor spills and pipeline integrity incidents over the years; in 1987, the SS Glacier Bay struck a submerged obstacle in Cook Inlet, and an estimated 3,100 barrels of oil were assumed lost (Northern Economics 1990).
- **Mining Exploration Activities**—There are a number of mineral claims and resources in the Bristol Bay watershed that have been subject to mineral exploration activities. Exploration activities have been intermittent depending on the specific claim or resources. There has been small plane, helicopter, and boat traffic associated with exploration contributing to the disturbance of wildlife, as well as recreational and subsistence activity experience. There have also been areas of ground disturbance associated with exploration drilling and support facilities, including in the project area. In the immediate vicinity of the project, there has not been past or present mineral production activity. In Alaska, where infrastructure is limited and there are long distances to market, it is fairly common for deposits to undergo exploratory activity, but not progress to a stage where the nature of the mineral reserves, costs of development, and market price for minerals makes development feasible.
- **Williamsport-Pile Bay Road**—The Williamsport-Pile Bay Road, constructed in the 1930s, provides access between Cook Inlet and Bristol Bay via a 15.5-mile road to Iliamna Lake and down the Kvichak River. The road allows portage of fishing vessels bound for Bristol Bay commercial fisheries, as well as some goods and supplies for lake and river communities, which contributes to road and lake traffic during the summer season. This results in noise disturbance and dust during the summer months along the road, and noise from waterborne activities at Williamsport, Pile Bay, and along Iliamna Lake. The road is owned and maintained by the State of Alaska.

### *Reasonably Foreseeable Future Actions in the EIS Analysis Area*

For this analysis, RFFAs are existing plans, permit applications, or fiscal appropriations that are likely (or reasonably certain) to occur. The Pebble Project expansion is considered an RFFA in this EIS. Actions are considered reasonably foreseeable if they would occur or have potential impacts in the area analyzed for direct and indirect effects on a specific resource. In addition, the likelihood that a specific RFFA would occur must also be assessed. This is not based on speculation, but must be anticipated, to enter the permitting process based on project documentation, identified in public or private planning documents as scheduled for development, have identified indicated resources/reserves sufficient to develop a project, or have advanced exploration activities under way in the timeframe being used for assessment.

The following categories of RFFAs were considered for the cumulative effects analysis:

- Mineral Exploration and Mining
- Oil and Gas Exploration and Development
- Transportation and Infrastructure
- Energy and Utilities
- Commercial Fishing
- Subsistence
- Tourism, Recreation, and Sport Hunting and Fishing
- Scientific Research and Surveys
- Contaminated Sites and Industrial Pollutants
- Residential/Community Development

With regard to mineral and oil and gas resources, a distinction was made between exploration and development activities. Many of the mineral projects assessed are on lands open to mineral entry and have been the subject of exploration activities for more than 30 years but have not been developed. Detailed knowledge of the amount and grade of mineral reserves, along with ore price and the cost to develop, mine, and transport the ore to market is generally needed to make a development decision. For example, the Red Dog Project was originally developed in 1989, and the Alaska Industrial Development and Export Authority (AIDEA) constructed the Delong Mountain Transportation System to provide a public road and port system to serve the mine and potentially other mineral deposits in the region. Since that time, the mine has expanded to develop an adjacent deposit under the same ownership, but none of the nearby deposits (notably the Lik deposit) have been developed in nearly 30 years, despite the availability of the transportation system.

There are similar patterns of mine expansion in Alaska, developing adjacent, commonly owned, and measured/indicated reserves, including Greens Creek, Usibelli, and Fort Knox. The presence of existing mine/transportation infrastructure has not resulted in the development of a new mine in any of these cases but often results in mine expansion and/or an extended processing life. Similarly, oil and gas lease sales have been regularly held in waters of Cook Inlet for over 50 years; although exploration continues to occur, not all exploration activities have led to oil and gas development. Mineral and oil and gas exploration and development activities can have a variety of impacts on the physical, biological, and social environments.

The 2014 EPA *Assessment of Potential Mining Impacts on Salmon Ecosystems in Bristol Bay Alaska* evaluated the potential for other mineral deposits in the project area to be developed for the purpose of assessing potential cumulative effects from mineral development. Compared to NEPA guidance for assessing potential cumulative effects, the EPA study had a different purpose and used different assumptions regarding the development of additional mining projects and their relationship to the proposed project. EPA indicated that the purpose of the assessment was to determine the significance of Bristol Bay's ecological resources and evaluate the potential impacts of large-scale mining on these resources, using the methodology of an ecological risk assessment. The agency developed three Pebble Project mining scenarios based on preliminary details put forth in Wardrop 2011, the largest of which is Pebble 6.5 (it should be noted that the Pebble 6.5 scenario is similar to the Pebble mine expansion scenario, determined to be reasonably foreseeable and developed for analysis in this EIS). With regard to their assessment of cumulative risks of multiple mines, the EPA evaluated a number of known mineral deposits with potentially significant resources in the two major Bristol Bay watersheds. The EPA assumed that if the infrastructure for one mine is built, it would likely facilitate the development of other mines, and for the purposes of their study assumed that six additional mines would be developed. Based on the factors described above associated with development of mines in Alaska, the parameters for evaluating potential RFFAs described below, and the detailed assessment of regional mineral deposits presented in Table 4.1-1, this EIS generally differs in concluding which specific mineral prospects are reasonably foreseeable for exploration and development.

Table 4.1-1 presents the potential projects considered for analysis of cumulative effects, and conclusions regarding whether they are reasonably foreseeable. Figure 4.1-1 illustrates the location of RFFAs. Development of any of these projects would require some level of federal, state, and local permits and approvals. In many cases, development would be subject to a separate environmental assessment or EIS as part of the review and approval process. As discussed under past and present actions, activities associated with commercial, recreational, and subsistence harvest will continue to occur and have the potential to impact fish and wildlife populations. Although taken into consideration by federal and state management programs, these activities can contribute to cumulative effects of developing the project. Effects can include mortality and injury on an individual and population level, as well as disturbance and changes in distribution and migration, which can affect availability to various users. Climate change and other changes in the natural environment can contribute to cumulative effects through past, present, and RFFAs. Climate trends can affect water balance and stream flow, fish and wildlife habitat and distribution, and affect access for pursuit of subsistence activities and community travel. Climate change analysis framework for this EIS is included Section 3.1, Introduction to Affected Environment.

The following parameters were applied to identify and evaluate specific RFFAs for the cumulative effects analysis in the EIS:

- **Potential expansion of the proposed project**—The US Army Corps of Engineers (USACE) has determined that expansion of the Pebble Project, as originally discussed in the Wardrop 2011 Preliminary Assessment Technical Report (commissioned by Northern Dynasty Minerals to independently review and analyze project economics, current mineral resources, and valuation estimates in compliance with National Instrument 43-101, Standards of Disclosure for Mineral Projects in Canada) and refined in the response to RFI 062 (PLP 2018-RFI 062), will be analyzed under cumulative effects (Table 4.1-1; a list of assumptions associated with Mine Expansion are shown in Table 4.1-2). Estimates of permanent footprint acreage, direct wetlands impact acreage, miles of direct stream impacts, and number of stream crossings associated with expansion of the Pebble mine have been developed using GIS and are included in specific resource sections. As presented in the response to RFI 062 (PLP 2018-RFI 062), if Pebble Project expansion occurs, it is assumed to begin in year 20 of the proposed project operations.
- **Land status subject to mining**—Mineral projects must be on public lands designated as open to mineral entry or development, or on Alaska Native Claims Settlement Act lands where previous mining exploration or development activity have been allowed. When lands are classified as open to mineral development, it facilitates obtaining permits and other approvals for exploration and development activities.
- **Development projects with dedicated funding, currently in a federal, state, and/or local permitting process, undergoing a state or federal environmental assessment, or listed in a government planning document with a specific timeframe for development**—Projects may also be considered reasonably foreseeable for development if they: have dedicated funding and a schedule for development; have federal, state, or local permit applications under review or approved; are currently being evaluated through a federal NEPA compliance effort or State Best Interest Finding document (i.e., a state decision-making document that

determines if granting a permit is in the best interest of the state); or are identified in a published federal, state, or local planning document (e.g., scheduled lease sales and community capital projects) with a specific project description and timeframe for development.

- **Information to support the viability of development has been documented in a published or online report**—Projects that have conducted extensive exploratory drilling and analysis to compile information on mineral reserves in terms of measured, indicated, and inferred resources, along with characterization of the grades of ore in the deposit are included. The potential feasibility for development is evaluated based on the published information on results of drilling and delineation of measured, indicated, inferred, and grade of reserves. Estimated costs associated with development are also assessed to the extent available.
- **Proximity to project infrastructure and factors affecting co-use by other parties**—The question of whether development of the proposed project would facilitate development of other nearby mineral deposits depends in part on the proximity of a potential RFFA to the proposed project and ability to use project infrastructure. Creating access to project transportation infrastructure is expensive and depends on land ownership access and sensitivity of environmental resources along the access route. Project infrastructure would be privately funded; co-use of mining, port, and natural gas pipeline facilities would be dependent on permission from Pebble Limited Partnership (PLP). With regard to use of the access road by other parties, while privately funded, the State of Alaska would likely require PLP to allow access to other mineral deposit owners if an agreement could be reached regarding operation and maintenance costs. This is based on the precedent set in state permit conditions for granting Pogo Mine access (S. Buckley, personal communication 2018).
- **Geographic nexus with the direct and indirect effects of project development on specific resources evaluated in the EIS**—Along with the factors previously described, there would need to be interactive and synergistic effects of an RFFA (per 40 CFR Part 1508.7) on resources directly and indirectly affected by development of the project in a specific geographic range that varies by resource.

**Table 4.1-1: Potential Reasonably Foreseeable Future Actions Evaluated for Cumulative Effects**

| Prospect, Project, or Activity | Description | Status | References | Reasonably Foreseeable? |
|---|---|---|---|---|
| **Potential Mineral Deposits in Southwest and Southcentral Alaska** | | | | |
| Pebble Project expansion—develop 55% of delineated resources | Expansion of the Pebble Project to develop 55% of its reserves over an additional 58 years of mining, and 20 to 40 years of post-mining processing low-grade ore and pyritic material, as outlined in response to RFI 062 PLP 2018-RFI 062) and summarized in Table 4.1-2. It would use the same transportation facilities, power plant, and natural gas pipeline facilities. It would need additional tailing storage, additional water storage, new waste rock storage facilities, additional processing facilities, a concentrate pipeline and a deep-water loading facility. It is not part of the proposed action, and would require additional permits and separate NEPA compliance. Table 4.1-2 presents assumptions for Pebble Project expansion development. | Potential project expansion.<br>Expansion was identified as an option in the Wardrop 2011 report and refined in the response to RFI 062 (PLP 2018-RFI 062). A similar expansion concept was analyzed as Pebble 6.5 in the EPA)Watershed Assessment (EPA 2014) on the basis of lands being classified as open for mineral exploration and development, and assuming access to Pebble Project infrastructure. | Wardrop 2011, EPA 2014, RFI 062 (PLP 2018-RFI 062) | **Yes—for continued exploration and development.**<br>Project expansion would begin in the timeframe of the proposed Pebble Project, in year 20 of proposed project operations.<br>Expansion would occur on state lands that are subject to PLP mining claims and open to mineral development.<br>PLP has existing permits for resource exploration, but has not submitted permit applications for expanded development; expansion is not part of a current NEPA compliance or Best Interest Finding effort, and is not described as reasonably foreseeable in a government planning document.<br>PLP has conducted extensive exploratory drilling and analysis to compile a 43-101 feasibility assessment level of information on mineral reserves in terms of measured, indicated, and inferred resources, along with characterization of the grades of component ore in the deposit and estimated costs of development of mine expansion (Wardrop 2011).<br>If the Pebble Project was permitted, Pebble expansion could use and expand on the project mine site and transportation infrastructure that would be in place, similar to what has happened with other Alaska mines where adjacent reserves are commonly owned. |
| Pebble South | A 54-square-mile porphyry copper deposit/claim approximately 9 miles southwest of Pebble deposit. Prospect is part of the PLPNDM Ltd. claim block. | Subject to further exploration.<br>Analyzed for cumulative effects in the EPA Watershed Assessment based on land classification of the deposit and assuming access to Pebble Project infrastructure. This deposit was not included in the assessment in Wardrop 2011. | EPA 2014 | **Yes—for further exploration.**<br>**No—for development.**<br>There is no indication that development of Pebble South would occur in the operations timeframe of the proposed Pebble Project.<br>Resource delineation has not progressed sufficiently to forecast development with regard to identifying measured or indicated resources; a project is not subject to development permitting or in a planning document. |

**Table 4.1-1: Potential Reasonably Foreseeable Future Actions Evaluated for Cumulative Effects**

| Prospect, Project, or Activity | Description | Status | References | Reasonably Foreseeable? |
|---|---|---|---|---|
| | | | | Pebble South claims are currently owned by NDM Ltd. If future drilling and resource delineation indicate that project development is feasible, construction and operations phases could access and use the Pebble Project transportation system. However, additional access would need to be constructed to connect to the project transportation infrastructure. |
| Big Chunk South | A 73-square-mile porphyry copper deposit/claim approximately 12 miles north of the Pebble project area. The claim block is entirely in the Chulitna River drainage, which flows into Lake Clark National Park and Preserve. | There have been some airborne surveys and limited drilling to delineate the resource. Mineral Claims transferred by Liberty Star to NDM Ltd. in 2014, which is when the last state exploration permit expired. Analyzed for cumulative effects in the EPA Watershed Assessment (EPA 2014) based on land classification of the deposit and assuming access to Pebble Project infrastructure. | EPA 2014 | **Yes—for further exploration.**<br>**No—for development.**<br>There is no indication that development of Big Chunk North would occur in the operations timeframe of the proposed Pebble Project.<br>Resource delineation has not progressed sufficiently to forecast development with regard to identifying measured or indicated resources; a project is not subject to development permitting or in a planning stage.<br>Big Chunk South claims are currently owned by NDM Ltd. If future drilling and resource delineation indicate that project development is feasible, construction and operations phases could access and use the Pebble Project transportation system. However, additional access would need to be constructed to connect to the project transportation infrastructure. |
| Big Chunk North | Porphyry copper deposit approximately 21 miles northwest of the Pebble project area. The claim block straddles the drainage divide between the Nushagak and Kvichak River watersheds. | Mineral claims transferred by Liberty Star to NDM Ltd. in 2014, Liberty Star to NDM Ltd. in 2014, which is when the last state exploration permit expired. Analyzed for cumulative effects of development in the EPA Watershed Assessment based on land classification of the deposit and assuming access to Pebble Project infrastructure. | EPA 2014 | **Yes—for further exploration.**<br>**No—for development.**<br>There is no indication that development of Big Chunk North would occur in the operations timeframe of the proposed Pebble Project.<br>Resource delineation has not progressed sufficiently to forecast development with regard to identifying measured or indicated resources; a project is not subject to development permitting or in a planning document.<br>Claims are currently owned by NDM Ltd. If future drilling and resource delineation indicate that project |

**Table 4.1-1: Potential Reasonably Foreseeable Future Actions Evaluated for Cumulative Effects**

| Prospect, Project, or Activity | Description | Status | References | Reasonably Foreseeable? |
|---|---|---|---|---|
| | | | | development is feasible, construction and operations phases could access and use the Pebble Project transportation system. However, additional access would need to be constructed to connect to the project transportation infrastructure. |
| Fog Lake | Gold and copper in volcanic rocks approximately 46 miles southeast of the Pebble Project and south of Iliamna Lake, and roughly 10 miles north of the transportation corridor to Amakdedori port. | As of 2008, exploration was occurring, but drilling had not been initiated; the exploration permit expired at the end of 2008. Analyzed for cumulative effects of development in the EPA Watershed Assessment (EPA 2014) based on land classification of the deposit and assuming access to Pebble Project infrastructure. | EPA 2014 | **Yes—for further exploration.**<br>**No—for development.**<br>There is no indication that development of Fog Lake would occur in the operations timeframe of the proposed Pebble Project.<br>The deposit is on lands that have had mining claims and are open to mineral development.<br>Resource delineation has not progressed sufficiently with regard to identifying measured or indicated resources; a project is not subject to development permitting or in a planning document.<br>Given the proximity to the proposed Pebble Project transportation corridor, if future drilling and resource delineation indicate that it is feasible to develop the project, it is possible that construction and operations phases could access and use the Pebble Project transportation system if an arrangement could be reached with PLP. However, additional access would need to be constructed to connect to the project transportation infrastructure. |
| Groundhog | 196-square-mile porphyry copper claim approximately 3 miles east of the Pebble Project area. | Exploration drilling under way. Hard rock exploration permit issued by the ADNR in 2017. Analyzed for cumulative effects of development in the EPA Watershed Assessment (EPA 2014) based on land classification of the deposit and assuming access to Pebble Project infrastructure. | EPA 2014 | **Yes—for further exploration.**<br>**No—for development.**<br>There is no indication that development of Groundhog would occur in the operations timeframe of the proposed Pebble Project.<br>Resource delineation has not progressed sufficiently with regard to identifying measured or indicated resources; a project is not subject to development permitting or in a planning document.<br>Given the proximity to the proposed Pebble Project transportation corridor, if future drilling and resource |

**Table 4.1-1: Potential Reasonably Foreseeable Future Actions Evaluated for Cumulative Effects**

| Prospect, Project, or Activity | Description | Status | References | Reasonably Foreseeable? |
|---|---|---|---|---|
| | | | | delineation indicate that it is feasible to develop the project, it is possible that construction and operations phases could access and use the Pebble Project transportation system if an arrangement could be reached with PLP. However, additional access would need to be constructed to connect to the Pebble Project transportation infrastructure. |
| Humble | Also known as Kemuk, a 173-square-mile gold and porphyry copper deposit/claim considered geologically similar to the Pebble deposit. Deposit is approximately 83 miles southwest of the Pebble Project area. | This project has been removed from the Millrock Resources website and no longer appears to be active; the exploration permit expired in 2017. Analyzed for cumulative effects of development in the EPA Watershed Assessment (EPA 2014) based on land classification of the deposit, and assuming access to Pebble Project infrastructure. | EPA 2014 | **No—for further exploration.**<br>**No—for development.**<br>There is no indication that development of Humble would occur in the operations timeframe of the proposed Pebble Project.<br>The deposit is on state lands that have had mining claims and are open to mineral development.<br>Resource delineation has not progressed sufficiently with regard to identifying measured or indicated resources; a project is not subject to development permitting or in a planning document.<br>The project is closer to tidewater at Dillingham than the Pebble Project and would not likely use the project transportation system. |
| AUDN/Iliamna | 113-square-mile porphyry copper claim block approximately 55 miles southwest of the Pebble Project area in the Kvichak River watershed. | Millrock Resources began exploration in 2012, but the project has been removed from the Millrock Resources and TNR Gold Corp websites and no longer appears to be active. Analyzed for cumulative effects of development in the EPA Watershed Assessment (EPA 2014) based on land classification of the deposit. | EPA 2014 | **No—for further exploration.**<br>**No—for development.**<br>There is no indication that development of AUDN/Iliamna would occur in the operations timeframe of the proposed Pebble Project.<br>The deposit is on state lands that have had mining claims and are open to mineral development.<br>Resource delineation has not progressed sufficiently with regard to identifying measured or indicated resources; a project is not subject to development permitting or in a planning document.<br>The project is closer to tidewater at Naknek than the Pebble Project, and would not likely use the project transportation system. |

### Table 4.1-1: Potential Reasonably Foreseeable Future Actions Evaluated for Cumulative Effects

| Prospect, Project, or Activity | Description | Status | References | Reasonably Foreseeable? |
|---|---|---|---|---|
| Kamishak | Porphyry copper in a breccia pipe roughly 49 miles southeast of the Pebble Project area, and roughly 10 miles south of the transportation corridor to Amakdedori port. | There were 18 holes drilled between 1990 and 1991; an additional 5 holes were drilled in 2006. As of 2008, reserves had not been identified, and the exploration permit expired. | EPA 2014 | **No—for further exploration.**<br>**No—for development.**<br>There is no indication that development of Kamishak would occur in the operations timeframe of the proposed Pebble Project.<br>The deposit is on lands that have had mining claims and are open to mineral development.<br>Resource delineation has not progressed sufficiently with regard to identifying measured or indicated resources; a project is not subject to development permitting or in a planning document.<br>Given the proximity to the proposed Pebble Project transportation corridor, if future drilling and resource delineation indicate that it is feasible to develop the project, it is possible that construction and operations phases could access and use the Pebble Project transportation system if an arrangement could be reached with PLP. However, additional access would need to be constructed to connect to the project transportation infrastructure. |
| Shotgun | Quartz-feldspar porphyry deposit with gold as the primary interest, located roughly 99 miles northwest of the Pebble Project, 90% owned by TNR Gold Corporation. If developed, Shotgun could access tide water via barge transport from Dillingham (93 miles away) up the Nushagak River to Koliganek, New Stuyahok, or Ekwok (49, 68, and 74 miles away, respectively). | There have been extensive drilling programs since the late 1980s through 2012; and as of 2013, inferred mineral resources were estimated at 20.7 million tons, with a grade of 1.06 gram of gold per ton, with a cut-off grade of 0.50 gram per ton of gold. Thirty four exploration holes have been drilled on site. | TNR Gold Corp. 2013, EPA 2014 | **Yes—for further exploration.**<br>**No—for development.**<br>There is no indication that development of Shotgun would occur in the operations timeframe of the proposed Pebble Project.<br>The deposit is located on lands that have had mining claims and open to mineral development.<br>Mineral exploration has delineated inferred mineral resources, but to date have not been identified as measured or indicated.<br>The project is not currently subject to development permitting or in a planning document.<br>The project is closer to tidewater at Dillingham than the Pebble Project and would not likely use the project transportation system. |

**Table 4.1-1: Potential Reasonably Foreseeable Future Actions Evaluated for Cumulative Effects**

| Prospect, Project, or Activity | Description | Status | References | Reasonably Foreseeable? |
|---|---|---|---|---|
| Johnson Tract | Gold-rich poly-metallic deposit located roughly 80 miles east of the Pebble Project, owned by CIRI and subject to an exploration agreement with Constantine Metals Resources Ltd. CIRI has access rights through Lake Clark National Park and Preserve to a port site at Tuxedni Bay on Cook Inlet. | Discovered by Anaconda in 1982, 90 holes have been drilled but no exploration has occurred in more than 20 years. In 2018, Constantine Metals agreed to resume exploration and take the project to the point of evaluating feasibility of developing the mine. | Constantine 2019 | **Yes—for further exploration.**<br>**No—for development.**<br>There is no indication that development of Johnson Tract would occur in the operations timeframe of the proposed Pebble Project.<br>The deposit is located on private lands that have had mining claims and are open to mineral development.<br>Resource delineation has not progressed sufficiently with regard to identifying measured or indicated resources; a project is not subject to development permitting or in a planning document.<br>The project is closer to tidewater at Cook Inlet than the Pebble Project and would not likely use the project transportation system. |
| **Proposed Mining and Mineral Projects in Southwestern and Southcentral Alaska** | | | | |
| Donlin Gold | Open-pit hard rock mine in the Kuskokwim River watershed, 277 miles west of Anchorage. The proposed mine would have a total footprint of approximately 16,300 acres. Includes a 315-mile pipeline to carry natural gas from Cook Inlet to the mine site. | FEIS issued in April 2018. USACE and BLM have issued a JROD granting major federal permits. | USACE 2018 | **Yes—for further exploration.**<br>**Yes—for development.**<br>FEIS for the project has been completed, and the JROD was signed in August 2018. The project is considered reasonably foreseeable in the 78-year timeframe. |
| Diamond Point Rock Quarry | Granite quarry project near the convergence of Cottonwood and Iliamna bays on the western side of Cook Inlet. Project involves modification of shoreline to construct an access road, breakwater, barge landing, and solid fill dock. Dredging would be required in Cottonwood Bay. | The project has been developed as the first phase of a larger facility. | USACE 2010, USACE 2012b | **Yes—for development expansion.**<br>Reserves of quarry rock have been estimated and a permit was issued in 2012. Construction has begun. |

**Table 4.1-1: Potential Reasonably Foreseeable Future Actions Evaluated for Cumulative Effects**

| Prospect, Project, or Activity | Description | Status | References | Reasonably Foreseeable? |
|---|---|---|---|---|
| **Potential Oil and Gas Exploration and Development** | | | | |
| Alaska Stand Alone Pipeline Project (ASAP) | Proposed 737-mile natural gas pipeline from Prudhoe Bay to Point McKenzie, Alaska. The project involves the construction of an LNG extraction plant on the western side of Cook Inlet at Point McKenzie. | An FEIS was completed in 2018. A ROD was published in 2019. | ASAP JROD (USACE and BLM 2019) | **Yes—Because the project has a completed EIS and ROD, it is considered foreseeable for development.** However, it would not be built if the Alaska LNG project is funded for development. |
| Alaska LNG | Proposed 800-mile natural gas line from Prudhoe Bay to Nikiski, where the gas would be liquefied and shipped to foreign markets. Involves a natural gas pipeline crossing Cook Inlet and would result in increased marine traffic in Cook Inlet. | An FERC application has been filed. A DEIS was released in 2019; an FEIS is expected to be released in 2020. It is unknown if the project has funding to proceed. Construction would begin after 2020. | Alaska LNG DEIS (FERC 2019) | **Yes—Because the project has a permit application and is near completion of an EIS, it is considered foreseeable for development.** However, it might not be built if the ASAP project is funded for development. |
| Cook Inlet Oil and Gas Lease Sales | The ADNR is responsible for leasing oil and gas in state waters and the Bureau of Ocean and Energy Management is responsible for leasing oil and gas in federal waters.<br>Recent assessments by the USGS estimate that the Cook Inlet region (excluding the Outer Continental Shelf) contains mean values of 637 billion cubic feet of natural gas, 600 million barrels of oil, and 46 million barrels of natural gas liquids (from BOEM 2016).<br>There are 17 offshore production platforms in Cook Inlet state waters (ADNR 2019b; BOEM 2016). | ADNR released a preliminary best interest finding on the Cook Inlet Area-wide Oil and Gas Lease Sale in June 2018.<br>In 2017, Federal Lease 244 resulted in bids for 14 tracts in Cook Inlet. Federal Lease Sale 258 for Cook Inlet is scheduled for 2021.<br>Oil and gas exploration and development activities in Cook Inlet are ongoing and likely to continue. | ADNR 2019b, BOEM 2016 | **Yes—for exploration; oil and gas exploration has been subject to a 2016 EIS (federal waters) and a 2018 preliminary best interest finding (state waters).**<br>**Yes—for development.**<br>Although no new offshore platforms are currently scheduled for construction; work on and drilling from existing offshore platforms is likely to continue. |

**Table 4.1-1: Potential Reasonably Foreseeable Future Actions Evaluated for Cumulative Effects**

| Prospect, Project, or Activity | Description | Status | References | Reasonably Foreseeable? |
|---|---|---|---|---|
| | Exploration activities continue with future development anticipated. | | | |
| Hydrocarbon Exploration Licensing and Leasing Program | ADNR, LPB, Bristol Bay Borough, and Aleutians East Borough have signed a MOU in support of oil and gas lease sales and licensing on State land in the analysis area. Similar MOUs exist between ADNR and the Aleut Regional Native Corporation and Bristol Bay Native Corporation. | Exploration has historically occurred, but not resulted in development. | Bristol Bay Area Plan for State Lands (ADNR 2013a) | **Yes—for exploration. The State of Alaska has held lease sales, and additional exploration is considered reasonably foreseeable.**<br>**No—for development.**<br>Given the lack of previous oil and development in the region, development and production are not reasonably foreseeable. |
| **Transportation and Infrastructure** | | | | |
| LPB Transportation Projects | Several road improvement and new transportation corridors are currently being studied. Studies include the Williamsport-Pile Bay Road upgrade, Nondalton-Iliamna River Road Corridor and Bridge, and Kaskanak Road/ Cook Inlet to Bristol Bay (Igiugig). | Ongoing. | LPB Comprehensive Plan (LPB 2012) | **Yes—for development.**<br>These projects are in a published borough planning document. |
| LPB Community Development and Capital Improvement Projects | Village infrastructure development projects, including power plant upgrades, sewer and water improvement projects, transmission upgrades, and energy efficiency initiatives. | Ongoing. List of projects from LPB 2017 capital improvement projects. | LPB Comprehensive Plan (LPB 2012) | **Yes—for development.**<br>These projects are in a published borough planning document. |
| Rural Alaska Village Grant Program | US Department of Agriculture Rural Development program to improve rural sanitization. Grant money is used to improve water and sanitation services. | Ongoing. | USDA Rural Development 2019 | **Yes—for development.**<br>These projects are considered small-scale community improvements and could be approved for communities in the EIS analysis area. |

**Table 4.1-1: Potential Reasonably Foreseeable Future Actions Evaluated for Cumulative Effects**

| Prospect, Project, or Activity | Description | Status | References | Reasonably Foreseeable? |
|---|---|---|---|---|
| Williamsport Channel Dredging | Maintain a 150-foot by 500-foot channel and turning basin by annually dredging 2,250 cubic yards at the approach to the barge ramp. | Ongoing. | Department of Army permit, file number POA-2011-188 (USACE 2011b) | **Yes—for ongoing maintenance.** |
| **Energy and Utilities** | | | | |
| Lake and Peninsula Borough (LPB) and other regional Renewable Energy Initiatives | LPB and other communities and electrical generation cooperatives are studying renewable energy projects to help combat high fuel costs. Studies include wind, hydroelectric, river, and tidal energy alternatives. Igiugig has a permit for a removable in-river power generation facility in the Kvichak River. | Studies are ongoing. Igiugig has been installing its pontoon-mounted power generator annually in the Kvichak River.<br>The Tazimina Run of River Hydro Project upgrade has been completed 12 miles northeast of the village of Iliamna.<br>The village of Kokhanok has received funding to refurbish its existing wind diesel power plant. | LPB Comprehensive Plan (LPB 2012) | **Yes—for development.**<br>These projects are in a published LPB planning document. |
| Nushagak Electric Cooperative Village Intertie Project | The Nuyakuk Run of River Hydro Project would connect the communities of Dillingham, Levelok, New Stuyahok, Koliganek, Aleknagik, and Ekwok with power and fiber optics, with operation projected for 2024. | Nushagak Cooperative has submitted a preliminary permit application to the FERC for their hydro project on the Nuyakuk River in Wood Tikchik State Park. | US Department of Energy FERC (83 FR 15826) (FERC 2018) | **Yes—for development.**<br>This project is in the process of submitting permits for development. |
| Knutson Creek Hydroelectric Project | The Knutson Creek Hydroelectric Project is a proposed 200-kW run-of-river project located on Knutson Creek near the community of Pedro Bay. It would include a diversion and intake structure at river mile 2.6, a 7,080-foot-long penstock, a 9,900-foot-long buried power cable, and some additional roads and trails. | A feasibility study was prepared for the Pedro Bay Village Council in 2013 (Polarconsult Alaska 2013) and is expected to enter permitting in the foreseeable future. | (Polarconsult Alaska Inc. 2013) | **Yes—For development**<br>This project is expected to submit permits for development in the foreseeable future. |

**Table 4.1-1: Potential Reasonably Foreseeable Future Actions Evaluated for Cumulative Effects**

| Prospect, Project, or Activity | Description | Status | References | Reasonably Foreseeable? |
|---|---|---|---|---|
| Igiugig Hydrokinetic Project | The Igiugig Hydrokinetic Pilot Project is a proposed in-river 35 kW RivGen Power system turbine generator unit, 52-foot-long, 12-foot-high, 47-foot-wide placed in the Kvichak River in roughly 16 feet of water 100 feet off the river bank near Igiugig. The facility would be anchored and connected with a series of power/data monitoring cables to a prefabricated shore facility. Igiugig Village Council proposes maintaining between 3.5 and 7 feet of water over the top of the device. On expiration of the license, the project would be removed and the site restored. | Igiugig Village Council has applied for a 10-year pilot project license with the FERC. An Environmental Assessment was issued by FERC in 2019. | FERC 2019 | **Yes—For development**<br>This project is expected to receive permits for development in the foreseeable future. |
| **Commercial Fishing** | | | | |
| Bristol Bay—Nushagak and Naknek/Kvichak State Management Districts—Salmon<br>Lower Cook Inlet Management Area—Salmon and Herring | Continued stock assessment and allocation decisions under existing management plans. | Ongoing. Commercial fishing is anticipated to continue in the EIS analysis area. | ADF&G Commercial Fishing Management Reports 2018 (ADF&G 2018k) | **Yes—These actions will occur in response to annual stock assessments and direction from management plans.** |
| **Subsistence Activities** | | | | |
| Villages of Iliamna, Newhalen, Pedro Bay, Port Alsworth, Nondalton, Igiugig, Kokhanok, Koliganek, Levelock, New Stuyahok, King | Past, present, and foreseeable subsistence activities are described in Section 3.9, Subsistence, and Appendix K3.9. | Ongoing. Subsistence practices are anticipated to continue in the EIS analysis area. | See Section 3.9, Subsistence. | **Yes—Subsistence harvest of fish, wildlife, and plants will continue for the foreseeable future.** |

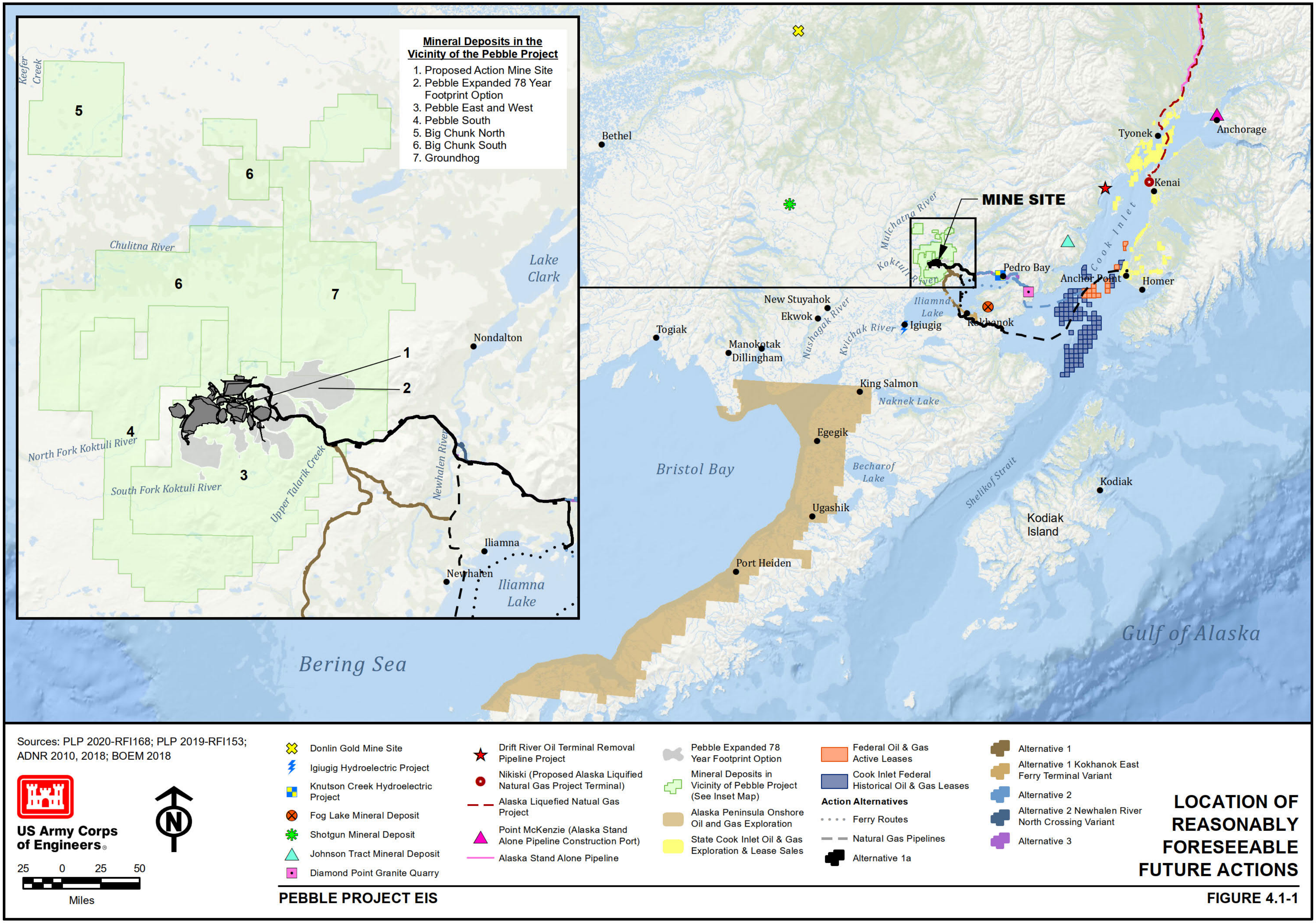
**Table 4.1-1: Potential Reasonably Foreseeable Future Actions Evaluated for Cumulative Effects**

| Prospect, Project, or Activity | Description | Status | References | Reasonably Foreseeable? |
|---|---|---|---|---|
| Salmon, Naknek, Aleknagik, Clarks Point, Manokotak, Dillingham, Ninilchik, and Seldovia | | | | |
| **Tourism, Recreation, Hunting, and Fishing** | | | | |
| National Parks and Preserves<br>Wildlife Refuges<br>State of Alaska Special Management Areas<br>Alaska Native Corporation Lands | Activities include hiking, camping, wildlife viewing, and photography. Sport fishing is the primary recreational activity that occurs in the EIS analysis area. Hunting, primarily for moose, caribou, and bear, is a major recreational activity in the region. | Activities are expected to continue in the EIS analysis area. | See Section 3.5, Recreation. | **Yes—Tourism, recreation, hunting, and fishing will continue for the foreseeable future.** |
| **Industrial Pollutants and Contaminated Sites** | | | | |
| Communities in project area | Sites with low levels of contamination have been identified in many Alaskan communities. Communities with site entries in the immediate vicinity of the project include Nondalton, Iliamna, Pedro Bay, Newhalen, and New Stuyahok. Many of the sites are associated with fuel storage tanks/power generation. | Many of the sites in the ADEC database have been cleaned up. The primary potential nexus with activities proposed by the project would be in communities where PLP proposes construction and operations support activities. | ADEC 2019a | **Yes—these projects would result in additional activities associated with clean-up of contaminated sites in communities in the EIS analysis area.** |

**Table 4.1-1: Potential Reasonably Foreseeable Future Actions Evaluated for Cumulative Effects**

| Prospect, Project, or Activity | Description | Status | References | Reasonably Foreseeable? |
|---|---|---|---|---|
| **Scientific Surveys and Research** | | | | |
| Federal, state, institutional, and private surveys and research | Scientific surveys and research conducted by government, institutional, and private parties have the potential to disturb wildlife, as well as interfere with subsistence and recreational activities and experience. | Although some agencies and organizations conduct annual surveys, others are difficult to forecast. | See Section 3.23, Wildlife Values and Section 3.24, Fish Values. | **Yes—There is a potential for airplane and helicopter traffic associated with surveys and research activities to disturb wildlife and for interaction with subsistence and recreational activities and experience.** |

Notes:
ADEC = Alaska Department of Environmental Conservation
ADF&G = Alaska Department of Fish and Game
ADNR = Alaska Department of Natural Resources
ASAP = Alaska Stand Alone Pipeline
BLM = Bureau of Land Management
CIRI = Cook Inlet Region, Incorporation
DEIS = Draft Environmental Impact Statement
EIS = Environmental Impact Statement
EPA = US Environmental Protection Agency
FEIS = Final Environmental Impact Statement
FERC = Federal Regulatory Energy Commission
JROD = Joint Record of Decision
LNG = liquified natural gas
LPB = Lake and Peninsula Borough
Ltd. = Limited
MOU = Memorandum of Understanding
NDM = Northern Dynasty Minerals
NEPA = National Environmental Policy Act
PLP = Pebble Limited Partnership
RFI = Request for Information
USACE = US Army Corps of Engineers
USDA = US Department of Agriculture
USGS = US Geological Survey




LOCATION OF REASONABLY FORESEEABLE FUTURE ACTIONS

PEBBLE PROJECT EIS

FIGURE 4.1-1

**Table 4.1-2: Assumptions for Pebble Project Expansion**

| Component | Assumptions |
|---|---|
| **Assumptions/Facilities Common to All Alternatives** | |
| General Project | **<u>Year and Activity Description:</u>**<br>**Year 0 to 20:** This time period refers to the proposed project operations for a 20-year period.<br>**Year 20 to 78:** This time period refers to expansion mining for a 58-year period.<br>**Year 78 to 98 or 118:** This time period refers to expansion milling for a 20- to 40-year period.<br>**<u>Assumptions:</u>**<br>• The current proposed project proceeds as outlined by EIS alternative for the first 20 years.<br>• After 20 years, mining continues for 58 years and mill throughput is expanded from 180,000 tons per day to 250,000 tons per day. This represents a 39% expansion in throughput compared to the proposed action.<br>• After mining stops (year 78), milling continues for an additional 20 to 40 years to process low-grade ore and PAG waste that is not backhauled to the pit. Bulk and pyritic tailings would be deposited directly into the pit.<br>• Concurrent reclamation would occur during mining, with the northern bulk TSF closed and reclaimed as soon as it is full, along with non-trafficked areas of waste rock facilities.<br>• Concurrent reclamation would occur during milling of low-grade ore/PAG material, with a dry closure of the southern bulk TSF, and final closure of NAG WRFs.<br>• After milling stops (year 98-118), all facilities and infrastructure not required for post-closure activities would be removed.<br>• Post-closure monitoring and water treatment would occur as proposed, but involving an expanded mine site.<br>• Estimates of permanent acreage, direct wetlands impact acreage, miles of direct stream impacts, and number of stream crossings associated with expansion of the Pebble mine have been estimated for each action alternative using GIS and are included in specific resource sections.<br>• Copper concentrate and diesel would be transported via pipeline to/from Iniskin Bay. Truck traffic would be 21 round trips per day to transport molybdenum concentrate, supplies, and other consumables. |
| Mine Site[4] | • The mine pit would be expanded starting in year 20.<br>• Reclamation of the pyritic TSF and placement of pyritic tailings and PAG rock from the first 20 years of mining would be postponed until year 78.<br>• Additional bulk tailings would be stored separately in a new southern bulk TSF with a flow-through embankment; additional pyritic tails would be stored in a new lined southern PAG TSF.<br>• With mine expansion, waste rock would increase and be stored in new northern and southern NAG WRFs. Low-grade ore and PAG waste rock would be stored on the western side of the northern WRF, which drains toward the pit. All runoff and seepage from the waste rock storage facilities would be captured and used in the process, or treated for release.<br>• An additional ore processing train would be added to the mill, and the power plant would be expanded to 375 megawatts, requiring 70 million standard cubic feet per day of natural gas. Water treatment plants would have throughput increased or additional treatment plants would be brought online.<br>• Water treatment plants would have throughput increased, or additional treatment plants would be brought online. For the purpose of this analysis, the increase in water required for production and treatment would increase by 39%, commensurate with the increase in production. |

[4] See response to RFI 062 [PLP 2018-RFI 062] for mine layout.

**Table 4.1-2: Assumptions for Pebble Project Expansion**

| Component | Assumptions |
|---|---|
| | • Two additional WRF water collection ponds would be constructed (one each for the northern and southern WRF), along with two additional TSF seepage collection ponds along with a TSF seepage recycle pond.<br>• The natural gas pipeline would remain the same size and route for each alternative (see additional compression at port sites under individual alternatives below).<br>• PLP has not ruled out that cyanide could be used for additional gold recovery during mine expansion. Therefore, it is assumed that sodium cyanide could be transferred in watertight sparge tank-tainers to the port as cargo and stored there until trucked to the mine site. A secure storage area with secondary containment could be constructed at the mine, and a cyanide solution would be prepared and applied in a leach process. After tailings leaching, processed tailings could be treated using sulfur dioxide to detoxify residual cyanide, and discharged to tailings storage. |
| Additional Concentrate Export Port Site | • A deepwater port facility would be constructed in Iniskin Bay for transport of copper concentrate via the concentrate pipeline. The pipeline would transport a copper/gold concentrate slurry; molybdenum concentrate would continue to be transported by truck.<br>• The concentrate handling, dewatering, and treatment facilities would be similar to those discussed at the Diamond Point port under the Alternative 3 Concentrate Pipeline Variant. |
| Additional Pipelines | • A concentrate pipeline would be constructed to the deepwater loading facility in Iniskin Bay.<br>• A small service road would be built along the pipeline extension to Iniskin Bay.<br>• A diesel pipeline would be constructed between the deepwater port in Iniskin Bay and the mine site, capable of carrying 100 million gallons annually, and parallel the concentrate pipeline. |
| **Assumptions Differing by Alternative** | |
| Alternative 1a | • The Amakdedori port and transportation system would continue to operate as proposed for the first 20 years.<br>• After 20 years, an additional natural gas compressor station would be constructed at Amakdedori to provide for increased power demand at the mine site; the port and transportation system, including the ferry, would continue to be used for transport of supplies and consumables, and bags of molybdenum concentrate.<br>• There would be less overall truck traffic between Amakdedori Port and the mine site with copper concentrate and diesel being transported via pipeline to/from Iniskin Bay.<br>• A road would be constructed along the concentrate pipeline from the Eagle Bay ferry terminal to the Williamsport-Pile Bay road to provide access for servicing the pipeline, but would not be used for regular traffic. This road would have a smaller footprint than roads constructed during the first 20 years to support concentrate truck traffic. |
| Alternative 1 | • The Amakdedori port and transportation system would continue to operate as proposed for the first 20 years.<br>• After 20 years, an additional natural gas compressor station would be constructed at Amakdedori to provide for increased power demand at the mine site; the port and transportation system, including the ferry, would continue to be used for transport of supplies and consumables, and bags of molybdenum concentrate.<br>• There would be less overall truck traffic between Amakdedori Port and the mine site with copper concentrate and diesel being transported via pipeline to/from Iniskin Bay.<br>• A road would be constructed along the concentrate pipeline from the mine site to Iniskin Bay to provide access for servicing the pipeline, but would not be used for heavy truck traffic, and would have a smaller footprint. |
| Alternative 2—North Road and | • The Diamond Point access road and north road would continue to operate as proposed for the first 20 years. |

**Table 4.1-2: Assumptions for Pebble Project Expansion**

| Component | Assumptions |
|---|---|
| Ferry with Downstream Dams | • After 20 years, an additional natural gas compressor station would be constructed at Diamond Point to provide for increased power demand at the mine site. A road would be constructed to connect the Eagle Bay and Pile Bay ferry terminals and the ferry would be discontinued. This road would need to accommodate regular truck traffic to port facilities and have a design similar to that proposed for Alternative 3.<br>• Diamond Point would continue to be used for transport of supplies and consumables, and bags of molybdenum concentrate.<br>• There would be less overall truck traffic between the mine and Diamond Point with copper concentrate and diesel being transported via pipeline to/from Iniskin Bay. |
| Alternative 3—North Road Only, Concentrate Pipeline Variant | • The Diamond Point access road and north road would continue to operate as proposed for the first 20 years.<br>• After 20 years, an additional compressor station would be constructed at Diamond Point to provide for increased power demand at the mine site.<br>• Diamond Point would continue to be used for transport of supplies and consumables, and bags of molybdenum concentrate.<br>• Under the Alternative 3 base case (i.e., no concentrate pipeline), expansion would build concentrate and diesel pipelines to Iniskin Bay. There would be 21 trucks per day during expansion, a reduction from the 35 trucks per day during the proposed project.<br>• Under Alternative 3 with the Concentrate Pipeline Variant, there would be 21 trucks per day during expansion, an increase from 18 during the proposed project. |

Notes:
GIS = geographic information system
NAG = non-acid generating
PAG = potentially acid-generating
PLP = Pebble Limited Partnership
TSF = tailings storage facility
WRFs = waste rock facilities

### 4.1.3 Issues Selected for Analysis

The USACE and cooperating agencies identified topics for further analysis, and eliminated others from evaluation, based on independent evaluation of topics and through scoping comments. Issues raised during scoping are documented as Statements of Concern in the Scoping Report (Appendix A). Issues selected for analysis include:

**Social science topics:**

- Socioeconomics
- Subsistence
- Traditional way of life
- Archaeological and cultural resources
- Land ownership, management, and use
- Transportation and navigation
- Recreation
- Environmental justice
- Public health and safety
- Visual resources
- Wilderness characteristics
- Food and fiber production

**Physical science topics:**

- Air quality
- Geology and seismic activity
- Surface and groundwater hydrology impacts
- Noise impacts
- Water quality and quantity

**Biological science topics:**

- Vegetation and ecosystems
- Fish and aquatic resources
- Wetlands and other waters and special aquatic sites
- Wildlife, birds, and mammals
- Endangered Species Act listed threatened and endangered species
- Invasive species

**Other topics:**

- Hazardous materials stored and transported to and from the mine site
- Tailings dams
- Fugitive dust
- Climate change
- Fuel spill risks and releases
- Natural gas supply
- Pipeline safety

### 4.1.4 Other Resources

NEPA provides the lead agency with discretion to determine, based on the scoping process, which categories of resources merit detailed analysis, and which categories do not. This determination and impacts to resources that did not warrant detailed analysis are briefly addressed in this section. This is particularly the case where the resource has relevance to USACE public interest review under Section 404 of the CWA (see Table 3.1-1 in Section 3.1, Introduction to Affected Environment, for a detailed list of resource categories and the section of the EIS where they are discussed). Note that affected environment for resources not specifically discussed in Section 3.2 to Section 3.26 is discussed in this section, along with environmental consequences.

#### 4.1.4.1 Conservation

Conservation is assessed in a regional context (USACE 2017). Beneficial and/or adverse impacts in terms of conservation for the proposed project are included in various sections of Chapter 4 in this context. Supporting discussions regarding impacts on the conservation of water supply, wetlands, wildlife, fish, aquatic resources, and vegetation are provided in appropriate sections of this EIS (see Section 3.1, Introduction to Affected Environment, for details on where each resource is discussed).

#### 4.1.4.2 General Environmental Concerns

General environmental concerns are assessed in a local, regional, state, national, and global context (USACE 2017). Beneficial and/or adverse impacts in terms of conservation for the proposed project are included in various sections of Chapter 4 in this context. Concerns with a large mineral resource extraction project are varied, interrelated, and complex. During the scoping period, concerns that did not fall into a specific social, physical, or biological science topic included: climate change, fugitive dust, hazardous materials storage and transportation to and from the mine site, tailings dams concerns, fuel spill risks and releases, natural gas supply, and pipeline safety.

Climate change: Climate change trends are discussed in Chapter 3 sections, and climate change impacts are discussed in Chapter 4 sections (effects of the project on climate change per greenhouse gas [GHG] emissions and effects of climate change on the project infrastructure). See the “Climate Change” subsection below. The framework for discussing climate change in this document is found in Section 3.1, Introduction to Affected Environment.

Fugitive dust is analyzed primarily in Section 4.10, Health and Safety; Section 4.18, Water and Sediment Quality; and Section 4.22, Wetlands and Other Waters/Special Aquatic Sites.

Hazardous materials storage and transportation to and from the mine site is discussed in Section 4.27, Spills.

Tailings dam concerns and fuel spill risks and releases: The probabilities and potential impacts of spills (unintended releases) from the project are analyzed for diesel fuel, natural gas, copper-gold ore concentrate, chemical reagents, bulk and pyritic tailings, and untreated contact water in Section 4.27, Spill Risk.

Pipeline safety is discussed in Section 4.27, Spill Risk.

Natural gas supply is addressed below under "Energy Needs."

#### 4.1.4.3 Energy Needs

Energy needs are assessed in terms of power supplies to the mine site and port facilities, from a local and regional context (USACE 2017). Beneficial and/or adverse impacts would not be expected in terms of energy needs for the proposed project in this context.

The project purpose is not to generate energy. The purpose of the natural gas pipeline from the Kenai Peninsula is to provide a long-term stable supply of natural gas to meet the energy needs of the project by connecting to the existing regional gas supply network. See Chapter 1, Purpose and Need, for an expanded discussion on project purpose and need. The proposed natural gas pipeline would be open access; more specifically, a contract carrier (a commercial entity carrying persons or property of certain customers only, rather than the goods of or the public in general). PLP has committed to providing community access to the gas pipeline during project operations. The natural gas pipeline would be maintained through operations to provide energy to the project site. If no longer required at closure, the pipeline would be pigged (the practice of using devices or implements known as "pigs" to perform pipeline maintenance services) and cleaned. It would then either be abandoned in place or removed, subject to state and federal regulatory review and approval at the decommissioning stage of the project. Open access users that may have used the supply of natural gas during operations would no longer have access to this energy source should the pipeline be abandoned in place or removed, and would need to find alternative sources at that time.

Due to the remote location and lack of current infrastructure, the project would be required to provide basic infrastructure in addition to support facilities typically associated with mining operations. The project would generate its own electricity using natural gas from the region and diesel fuel in back-up generators. This electricity would be used for ore extraction and processing. The peak electrical load for the project would be approximately 270 megawatts (MW). Various mine load centers would be serviced by a 69-kilovolt distribution system using a gas-insulated switchgear system located at the power plant. Waste heat from the power plant would be used to heat buildings and supply process heating to the water treatment plant, resulting in conservation of energy and reducing the amount of natural gas required to power ancillary facilities. The natural gas pipeline from the Kenai Peninsula will have an offtake to distribute natural gas to the port power generation facility. Natural gas pipeline infrastructure would include a compressor station on the Kenai Peninsula side. The concentrate and water return pipeline would require two electric pump stations, one at the mine site and one at an intermediate point; the intermediate one would require a power generation facility (1-2 MW range).

PLP proposes to purchase natural gas on the open market by linking with the existing pipeline system near Anchor Point, Alaska. Gas for the project would not be from a specific source. Potential sources at this time include any natural gas producer in Cook Inlet, Alaska.

#### 4.1.4.4 Mineral Needs

Executive Order 13817, A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals, is considered as an indication of the public's interest in mineral needs. Rhenium is a critical mineral listed in EO 13817 that is present at the Pebble deposit (PLP 2020d); however, copper, gold, and molybdenum are not mineral commodities considered to be critical based on EO 13817.

Mineral needs are assessed in terms of precious metals resource extraction in an international market and global context (USACE 2017). From the broad, macroeconomic scale, the stated project need is reflected in the demand for copper, gold, and molybdenum. The proposed project would result in a 20-year beneficial effect on the public's mineral needs for copper, gold, and molybdenum in this context. The proposed project would ultimately result in production of 7.4 billion pounds of copper, 36 million ounces of gold, and 398 pounds of molybdenum to meet global demand (see further details in the project description, Appendix N). The amount of rhenium is unknown at this time.

Copper is used in a variety of products and industries, including electrical and electronic products, industrial equipment, building construction, automobiles, and appliances. In 2019, the US consumed an estimated 2,039,276 tons of refined copper (USGS 2020c). The worldwide copper usage has tripled over the last 50 years and growth in the worldwide demand for copper is projected to continue (ICSG 2019).

Gold is used for the production of jewelry, electronics, and electrical components, official coins, and other uses (USGS 2005). In 2019, the US consumed an estimated 165 tons of gold. (USGS 2020d). Worldwide, 412 tons of gold was consumed in 2016 (USGS 2019). Worldwide consumption of gold grew by almost 8 percent per year between 1980 and 1999, and by an average of 2.8 percent per year between 1992 and 2002 (USGS 2005).

The most common use of molybdenum is the production of alloy steels and superalloys, enhancing hardness, strength, and resistance to corrosion. Examples of uses of these alloys include in food handling equipment, in automobile parts, in construction equipment, and in heavy construction (USGS 2010). The average reported amount of molybdenum used in the US between 2015 and 2018 was 18,602 tons. In 2019, the United States used an estimated 18,739 tons of molybdenum (USGS 2020e).

The production of copper, gold, and molybdenum would meet the Applicant's and the overall stated purpose and need. Project purpose and need is discussed in Chapter 1, Project Purpose and Need.

### 4.1.5 Traditional Ecological Knowledge

Information about traditional ecological knowledge (TEK) and the approach taken by the USACE to collect TEK is outlined in Section 3.1, Introduction to Affected Environment. The information collected is included in Appendix K3.1, Traditional Ecological Knowledge. Section 3.9, Subsistence, includes a discussion of TEK.

### 4.1.6 Climate Change

Chapter 3, Affected Environment, discusses climate change trends. Discussions are as follows:

- Section 3.1, Introduction to Affected Environment, provides a framework for discussion of climate change in the EIS, and the location of discussion of climate change.
- Section 3.9, Subsistence, discusses climate change in the context of traditional use change.

- Section 3.15, Geohazards and Seismic Conditions, discusses climate change trends on the potential for landslides and avalanches.
- Section 3.16, Surface Water Hydrology, discusses groundwater modeling incorporating cyclical and predicted climate data to account for changes in climate. Sea level changes are acknowledged.
- Section 3.17, Groundwater Hydrology, provides baseline details of water balance models to discuss trends and potential changes, including how climate variability is incorporated into recalibrated modeling.
- Section 3.18, Water and Sediment Quality, discusses climate trends and oscillations for temperature specifically.
- Section 3.20, Air Quality, provides detailed information about air quality and climate change in the context of estimated predicted future temperature and precipitation values.
- Section 3.22, Wetlands and Other Waters/Special Aquatic Sites, includes discussion of the potential impacts on wetlands and other waters in a changing climate. Section 3.26, Vegetation, provides similar discussion on trends, such as changes in phenology that may affect vegetation.
- Section 3.23, Wildlife, includes detailed analysis of potential impacts of climate change on terrestrial wildlife, birds, and marine mammals.
- Section 3.24, Fish Values, discusses climate change in the context of hydrological changes and potential large-scale shifts in populations.
- Section 3.25, Threatened and Endangered Species, includes discussion of climate change trends for Steller's eider.

Chapter 4, Environmental Consequences, discusses impacts of climate change from the proposed project, or contributions of the project to GHG emissions. These impacts are primarily discussed in the physical science sections. Discussions are as follows:

- Section 4.15, Geohazards and Seismic Conditions, describes the potential for increased landslide and related effects due to precipitation trends.
- Section 4.16, Surface Water Hydrology, provides analysis of water balance models specific to the project components and operations that incorporate climate variability.
- Section 4.17, Groundwater Hydrology, also discusses climate variability in the context of analyzing water flow and balance in project components such as the pit lake.
- Section 4.20, Air Quality, includes a detailed analysis of project-related GHG emissions.

### 4.1.7 Unavoidable Adverse Effects

The Council on Environmental Quality (CEQ) guidelines require agencies to evaluate "any adverse environmental effects which cannot be avoided should the proposal be implemented" (40 CFR Part 1502.16). Unavoidable adverse effects are those remaining after the project has complied with applicable stipulations and mitigation measures proposed by the Applicant (see Chapter 5). A detailed discussion of beneficial and/or adverse effects is presented for each resource in Section 4.2 through Section 4.26. A summary impacts subsection is presented at the end of each section. Additional mitigation may be possible, and additional mitigation measures under consideration are presented in Appendix M1.

### 4.1.8 Irreversible and Irretrievable Commitment of Resources

CEQ guidelines require an evaluation of "any irreversible or irretrievable commitments of resources which would be involved in the proposal should it be implemented" (40 CFR Part 1502.16). An irreversible or irretrievable commitment of resources refers to impacts on or losses to resources that cannot be recovered or reversed.

An irreversible commitment of a resource represents a loss of future options. This term applies primarily to the use of non-renewable resources, such as minerals, fossil fuels, or cultural resources, and to factors that are renewable only over long periods of time, such as soil productivity.

An irretrievable commitment of a resource represents opportunities that are foregone for the period of the proposed activities. This term applies primarily to the use of renewable resources, such as timber or human effort, or other utilization opportunities that are foregone in favor of the proposed activities.

Resources that would be irreversibly and irretrievably committed to the alternatives analyzed in this EIS include:

- **Cultural Resources and Historic Properties**—Any inadvertent effects to cultural resources or historic property would result in an irreversible commitment of resources.
- **Vegetation and Wetlands**—Ground disturbance, particularly due to project construction and operations, would cause irreversible impacts, including land to be permanently altered, soils and bedrock to be permanently displaced, vegetation to be permanently removed, and wetlands and other waters to be permanently altered or filled.
- **Aquatic Resources**—Irreversible changes to streamflows from permanent watershed alterations would eliminate aquatic habitat.
- **Aesthetics**—Development of infrastructure would create a visual contrast resulting in an irreversible commitment of resources in permanent fill areas, and an irretrievable commitment in areas subject to reclamation.
- **Resource consumption**—Irreversible consumption of renewable and non-renewable resources would be required for infrastructure development, including metals, aggregate, cement, wood, and other materials.
- **Soils and Geology**—Irretrievable and irreversible commitment of the use of copper, gold, and molybdenum ore resources.
- **Resource committal**—Non-renewable resources (e.g., gasoline, diesel, natural gas, and electrical power generated from these fuels) would be irreversibly committed for project construction, operations, and closure. Fuels would be required to operate aircraft, motor vehicles, barges, vessels, machinery, and mining equipment.
- **Funds and labor**—Funds and labor would be irretrievably committed for project permitting and development.
- **Water**—Water would be irretrievably committed for milling and processing.

## 4.2 LAND OWNERSHIP, MANAGEMENT, AND USE

The Environmental Impact Statement (EIS) analysis area for land ownership and management includes the project footprint (including material sites) and use of those and adjacent lands. Potential direct and indirect impacts include:

- Change in land ownership status if a lease was to be issued, an easement was to be altered or vacated, or if additional access were legally acquired
- Change in/or conflict with land management as a result of the project
- Change in land use from an existing or allowed land use

Indirect effects to lands adjacent to the project are discussed under specific resources, such as recreation in national parks.

The magnitude of impact is determined by the number of acres impacted or the distance (in miles) from the project components. The duration is described in relation to the phase of the project (construction, operations, closure, or post-closure). For example, long term is considered to be for the life of the project (i.e., years to decades), and short term would be for the construction phase (i.e., months to years). The likelihood that the project would have an impact, and the geographic extent of impacts, are discussed for land ownership, management, and use. Mitigation measures that would reduce project impacts are discussed in Chapter 5, Mitigation.

Scoping comments showed concerns regarding limiting access to State-owned lands for recreation and waterfront usage, ensuring consistency with land use plans and goals of the landowners, and addressing long-term patterns that could allow for additional development. Comments also requested that impacts to Native Allotments and Native corporation lands be disclosed. The following sections address these and other issues.

### 4.2.1 Summary of Key Issues

**Table 4.2-1: Summary of Key Issues for Land Ownership, Management, and Use**

| Impact Causing Project Component | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| **Mine Site** | | | | |
| Land ownership | The mine site would be entirely on lands owned by the State of Alaska, which can issue authorization for the life of the project. | | | |
| Land management | The mine site would be managed for multiple use, including habitat protection and mineral development. MCO 393 would be addressed by the State of Alaska during permitting. The LPB also issues permits and authorizations. | | | |
| Land use | Land use at the mine site would change from minimal disturbance from exploration and subsistence activities to intense industrial development. | | | |
| **Transportation Corridor** | | | | |
| Land ownership | 63% would be owned and managed by the State of Alaska<br>37% would be owned and managed by ANCSA village corporations | 63% State of Alaska<br>37% ANCSA village corporations | 40% State of Alaska<br>1% ANCSA regional corporations<br>57% ANCSA village corporations<br>2% Native Allotments | 30% State of Alaska.<br>>1% ANCSA regional corporations<br>70% ANCSA village corporations<br>1% Native Allotments |

**Table 4.2-1: Summary of Key Issues for Land Ownership, Management, and Use**

| Impact Causing Project Component | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | No variants | Kokhanok East Ferry Terminal Variant:<br>65% State of Alaska<br>35% ANCSA village corporations<br>Summer-Only Ferry Operation Variant:<br>64% State of Alaska<br>36% ANCSA village corporations<br>Pile-Supported Dock Variant would be the same as above | Summer-Only Ferry Operations Variant:<br>42% State of Alaska<br>1% ANCSA regional corporations<br>55% ANCSA village corporations<br>3% Native Allotments<br>Pile-Supported Dock Variant would be the same<br>Newhalen River North Crossing Variant:<br>44% State of Alaska<br>1% ANCSA regional corporations<br>53% ANCSA village corporations<br>2% Native Allotments | Concentrate Pipeline Variant would be the same as above |
| Land management | The State manages lands for multiple uses, including mineral development, which does not preclude a mine access road.<br>LPB and KPB also issue permits and authorizations.<br>Uses on surface and subsurface lands privately owned by Alaska Native corporations are subject to the approval of the landowners, including Native Allotments.<br>There would be no direct effects to federal lands, but indirect impacts from the project may result in modification of active management considerations. | | | |
| Legal access | R.S. 2477 ROWs: 2<br>17(b) easements: 3<br>Public access easements: 1 | R.S. 2477 ROWs: 0<br>17(b) easements: 1<br>Public access easements: 1 | R.S. 2477 ROWs: 1<br>17(b) easements: 2<br>Public access easements: 2 | R.S. 2477 ROWs: 1<br>17(b) easements: 2<br>Public access easements: 2 |
| Land use | The mine and port access roads would introduce a land use change from an undeveloped area primarily used for subsistence and recreation to an industrially used transportation system with trucks making 35 daily round trips.<br>The ferry would cause increased summer traffic and an additional use to the lake during winter, with the potential to interfere with other uses of the ice for local transportation and subsistence activities. | Impacts would be similar to those for Alternative 1a. | Impacts would be similar to those for Alternative 1a except for the Williamsport-Pile Bay Road, which would change from intermittent seasonal use to year-round industrial use with trucks making 35 daily round trips. | Impacts would be similar to those for Alternative 1a for the mine access road from Eagle Bay to the mine site, and similar to Alternative 2 from Diamond Point to Pile Bay. An access road would be developed along the Alternative 2 natural gas pipeline corridor, changing land use from previously undeveloped with some subsistence and recreational use associated with industrial truck traffic. |

**Table 4.2-1: Summary of Key Issues for Land Ownership, Management, and Use**

<table>
<tr><th>Impact Causing Project Component</th><th>Alternative 1a</th><th>Alternative 1 and Variants</th><th>Alternative 2 and Variants</th><th>Alternative 3 and Variant</th></tr>
<tr><td></td><td>No variants</td><td>Kokhanok East Ferry Terminal Variant would be the same as Alternative 1.<br>Summer-Only Ferry Operations Variant would have no impacts to use in the winter, but would have twice the amount of truck and ferry traffic in the summer.<br>Pile-Supported Dock Variant would be the same as Alternative 1.</td><td>Summer-Only Ferry Operations Variant would have no impacts to use in the winter, but would have twice the amount of truck and ferry traffic in the summer.<br>Pile-Supported Dock Variant would be the same as Alternative 2.</td><td>Concentrate Pipeline Variant would be the same as Alternative 3, but would have less truck traffic.</td></tr>
<tr><td colspan="5">Port Site</td></tr>
<tr><td rowspan="2">Land ownership</td><td colspan="2">100% State of Alaska</td><td>100% Native Allotments</td><td>58% ANCSA village corporations<br>42% Native Allotments</td></tr>
<tr><td>No variants</td><td>Pile-Supported Dock Variant would be the same as Alternative 1.</td><td>Pile-Supported Dock Variant would be the same as Alternative 2.</td><td>Concentrate Pipeline Variant would be the same as Alternative 3.</td></tr>
<tr><td>Land management</td><td colspan="2">Amakdedori port would be on lands owned by the State and managed with guidelines for waterfront development.</td><td colspan="2">Uses on surface and subsurface lands privately owned on Native Allotments are subject to the approval of the landowners.</td></tr>
<tr><td>Land use</td><td colspan="2">Amakdedori port would introduce artificial features to a previously undeveloped location, changing the land use from an undeveloped area used for subsistence and cultural uses to industrial ship traffic and storage activities</td><td colspan="2">At the Diamond Point port site, the area would change from active resource extraction to an industrial port. There would also be changes associated with industrial ship traffic in Iliamna Bay.<br>The Concentrate Pipeline Variant would have additional changes in Iniskin Bay.</td></tr>
<tr><td colspan="5">Natural Gas Pipeline—Onshore</td></tr>
<tr><td rowspan="2">Land ownership</td><td>16% State of Alaska<br>84% ANCSA village corporations<br>>1% Private</td><td>51% State of Alaska<br>48% ANCSA village corporations<br>1% Private</td><td>12% State of Alaska<br>7% ANCSA regional corporations<br>80% ANCSA village corporations<br>>1% Native Allotments<br>>1% Private</td><td>21% State of Alaska<br>57% ANCSA regional corporations<br>21% ANCSA village corporations<br>>1% Native Allotments<br>>1% Private</td></tr>
<tr><td>No variants</td><td>Kokhanok East Ferry Terminal Variant:<br>39% State of Alaska<br>60% ANCSA village corporations<br>1% Private</td><td>No variants</td><td>No variants</td></tr>
</table>

**Table 4.2-1: Summary of Key Issues for Land Ownership, Management, and Use**

| Impact Causing Project Component | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Land management | The pipeline would cross subsurface lands owned by Cook Inlet Region, Inc., and various village corporations. Uses on surface and subsurface lands privately owned by Alaska Native corporations are subject to the approval of the landowners. Lands managed by the State of Alaska would be the same as the transportation corridor. | | | |
| Land use | Effects on land use would be similar to the transportation corridor. The pipeline compressor station on the Kenai Peninsula would add to the existing industrial development. | Impacts would be the same as those for Alternative 1a. | Impacts would be the same as those for Alternative 1a except that the ROW from Pile Bay to the mine access road would introduce a land use change from a mostly undisturbed area to a utility corridor. | Impacts from the mine access roads and pipeline compressor station would be similar to those for Alternative 1a. The impacts to the Williamsport-Pile Bay Road and Diamond Point port would be similar to those for Alternative 2. |
| **Natural Gas Pipeline—Offshore Cook Inlet** | | | | |
| Land Management | The pipeline would cross the OCS of Cook Inlet. The BOEM has management authority over the Alaska OCS. The BSEE provides oversight of the OCS for safety, environmental protection, and conservation of resources. | | | |

Notes: See Section 3.2, Land Ownership, Management, and Use, for complete land ownership information.
% = percent
ANCSA = Alaska Native Claims Settlement Act
BOEM = Bureau of Ocean Energy Management
BSEE = Bureau of Safety and Environmental Enforcement
KPB = Kenai Peninsula Borough
LPB = Lake and Peninsula Borough
MCO = mineral closing order
OCS = outer continental shelf
ROW = right-of-way
R.S. = Revised Statute

## 4.2.2 No Action Alternative

Under the No Action Alternative, federal agencies with decision-making authorities on the project would not issue permits under their respective authorities. The Applicant's Preferred Alternative would not be undertaken, and no construction, operations, or closure activities specific to the Applicant’s Preferred Alternative would occur. Although no resource development would occur under the Applicant's Preferred Alternative, Pebble Limited Partnership (PLP) would retain the ability to apply for continued mineral exploration activities under the State's authorization process (ADNR 2018-RFI 073) or for any activity not requiring federal authorization. In addition, there are many valid mining claims in the area, and these lands would remain open to mineral entry and exploration by other individuals or companies.

It would be expected that current State-authorized activities associated with mineral exploration and reclamation, as well as scientific studies, would continue at levels similar to recent post-exploration activity. The State requires that sites be reclaimed at the conclusion of their State-authorized exploration program. If reclamation approval is not granted immediately after the cessation of activities, the State may require continued authorization for ongoing monitoring and reclamation work as it deems necessary.

Land use activities at the mine site, such as exploration or cessation of field activities, would occur in accordance with the requirements of the State of Alaska as the landowner. Such activities may result in a reversion of use (i.e., cessation of activity) or continuation of the existing use (i.e., exploration). Land ownership and management of the mine site, ports, and transportation and natural gas pipeline corridors would remain the same. Because the project would not be permitted as proposed, the No Action Alternative would have no new impacts on existing land ownership, management, and use.

### 4.2.3 Alternative 1a

#### 4.2.3.1 Land Ownership

For a description of land ownership under Alternative 1a, see Section 3.2, Land Ownership, Management, and Use. No land in the project footprint would be conveyed or sold, although an Uplands Mining Lease and associated authorizations may be acquired for mining activities and facilities on State lands. Temporary use permits (if issued), easements, and rights-of-way (ROWs) for the transportation corridor and natural gas pipeline corridor would be sought for State and Alaska Native Claims Settlement Act (ANCSA) Native corporation lands to construct and operate the project, if approved (see Appendix E, Laws, Permits, Approvals, and Consultations Required). This would result in a change in land status and an encumbrance on use at the mine site and along the route of the mine and port access roads, ferry terminals, and pipeline on both sides of Cook Inlet and including the alternative variants. The duration of the effect would be long term and the likelihood of the effect would be certain under Alternative 1a.

A tidelands lease would also be required by the State of Alaska for in-water facilities at the Amakdedori port site; this would include wetlands and other waters. These changes in land status constitute a direct impact, neither beneficial nor adverse, as there are no competing uses of encumbered lands at this time. The impact would last through the duration of the project, and after closure as long as the project components were in use. There would be no aspects of the project developed on federal- or municipal-owned lands.

#### 4.2.3.2 Land Management

**State Management**

**Mine Site**—The majority of the mine site would be on State-owned lands in units R06-05, R06-23, and R06-24 of the Bristol Bay Area Plan (BBAP). Additionally, a small portion of the bulk tailings storage facility embankment, a portion of the tailings storage facility main seepage pond embankment, and the north water treatment plant discharge would be in R06-30.

Lands encumbered by State of Alaska mining claims by PLP are managed under the Alaska Lands Act, which would be guided by the BBAP and further managed by the Alaska Reclamation Act, the Mine Operation Act, and the Alaska Administrative Code on mining reclamation. The State of Alaska made much of their land selections in the BBAP planning area because of its mineral potential (ADNR 2013a). The BBAP specifies that these lands are to be retained in public ownership and managed for multiple uses—including recreation, timber, minerals, and fish and wildlife—as well as natural scenic, scientific, and historic values. This does not preclude construction of the mine or related facilities. Mineral development may be authorized after a robust public process and with the appropriate stipulations or measures identified as needed to protect fish, wildlife, or their habitats (ADNR 2019-RFI 125). The project would generally be consistent with the plan's goals for the use of subsurface resources, which call for making metallic and non-metallic minerals available to contribute to the mineral inventory and independence of the US generally and Alaska specifically, while protecting the integrity of the environment and affected cultures. When potentially conflicting uses are designated in a management unit, the BBAP provides guidelines to allow various uses to occur without unacceptable consequences (ADNR 2019-RFI 125).

Unit R06-05 is managed for a variety of uses, including mineral exploration and development, protection of fish and wildlife resources, and dispersed recreation. Unit R06-24 consists of small portions of the upper North and South Fork Koktuli river corridors that flow through Unit R06-23 and Unit R06-30. Mineral development in Unit R06-24 as defined in the BBAP should be performed in such a manner as to ensure that impacts to the anadromous and high-value resident fish streams are avoided or reduced to levels deemed appropriate in the state and federal permitting processes related to mineral deposit development of the project. Specifically, such development should ensure the protection of the streams affected by MCO 393 and their associated riverine habitats, which includes the area within 100 feet of the ordinary high-water mark. The management intent for Unit R06-23 states that the habitat resources of those two stream corridors are to be managed like R06-24.

The BBAP acknowledged areas where mineral or habitat resources were known, taking such areas into consideration when establishing land use designations and, subsequently, classifications. If applications are submitted for this project, the State would adjudicate those applications based on statutes, regulations, and policies (ADNR 2019-RFI 125). Modification of active management for fish and wildlife protection would be necessary as a result of the project through the life of the mine and into post-closure. Potential conflicts between management plans and development of the project would be addressed and mitigated during the State permitting process and may require permit conditions to accommodate additional plan direction related to fish and wildlife management.

**Transportation Corridor and Pipeline**—Some of the transportation corridor and natural gas pipeline (and alternative variants) would be on State-owned lands managed under the guidance of the BBAP (see Section 3.2, Land Ownership, Management, and Use). The plan specifies that these lands are to be retained in public ownership and managed for a multiple use designation that does not preclude construction of the mine and port access roads. Modification of active management for fish and wildlife protection would be necessary in the immediate transportation and pipeline corridors and nearby McNeil River State Game Sanctuary and Refuge. The impact would be certain and long term, lasting through the life of the mine and into post-closure.

Iliamna Lake is managed as a navigable waterbody under the BBAP. The lake is co-designated for public recreation, dispersed tourism, and habitat. The designations allow for development to the extent that essential habitat and recreation values are maintained. These designations do not preclude construction and operations of the project's north and south ferry terminals, nor the ferry route across the lake.

**Amakdedori Port**—Amakdedori port, the southern end of the port access road, and the pipeline compressor station on the Kenai Peninsula would fall under the management of the State's Kenai Area Plan. The plan has management guidelines for the development of transportation and utilities that include protection of hydrologic systems and roads near wetlands or other waters. The plan also provides guidelines for waterfront development with regard to soil erosion and fuel storage (ADNR 2001). These guidelines would not preclude the development of Amakdedori port or the pipeline facilities on the Kenai Peninsula.

Because the project would not be counter to the State's planned land management of the area, project construction, operations, maintenance, or closure on State lands would not result in adverse direct or indirect effects on management of State lands. However, as described above, modification of active management may be necessary in some areas for the duration of the project and into post-closure.

## Borough Management

The mine site, the majority of the transportation corridor, and a portion of the natural gas pipeline corridor would be within the boundaries of the Lake and Peninsula Borough (LPB). The LPB issues development permits; however, no direct or indirect effects on land management in the LPB would occur outside of permit reviews and authorizations. Any permits from a borough would be issued with permit stipulations that would address potential land use conflicts as well as socioeconomic and fiscal impacts to residents and villages.

Amakdedori port and a portion of the transportation corridor and natural gas pipeline corridor on the western side of Cook Inlet would be located in the Kenai Peninsula Borough (KPB). The KPB Comprehensive Plan does not contain goals, objectives, or implementation actions specific to development of the project on lands in the KPB. However, the KPB does regulate development on the floodplain, in the coastal zone, and near certain anadromous fish streams throughout the borough. No direct or indirect effects on land management in the KPB would occur, outside of permit reviews and authorizations.

## Alaska Native Regional and Village Corporation Management

Portions of the mine and port access roads (including the Kokhanok spur road, and crossings of the Gibraltar and Newhalen rivers) would cross surface lands owned by Alaska Peninsula Corporation and Iliamna Natives Limited. The natural gas pipeline corridor would cross subsurface lands owned by Cook Inlet Region, Inc., and Bristol Bay Native Corporation. Uses on these surface and subsurface lands privately owned by Alaska Native corporations are subject to the approval of the landowners. Any activity would be conducted in accordance with lease and surface use agreements that PLP would establish with the landowners. Project construction, operations and maintenance, or closure would not result in adverse direct or indirect effects on management of these lands.

## Federal Management

Under this alternative, the Bureau of Safety and Environmental Enforcement (BSEE) has jurisdiction over the submerged lands seaward of State jurisdiction (3 nautical miles from shore); the pipeline would cross Cook Inlet over this federal jurisdiction. The natural gas pipeline would impact federal management on the outer continental shelf (OCS), which would factor into future decisions on oil and gas leasing. The Bureau of Ocean Energy Management (BOEM) has management authority over the Alaska OCS, and BSEE provides oversight of the OCS for safety, environmental protection, and conservation of resources.

The US Coast Guard (USCG) has authority over locations and clearances of bridges and causeways in or over navigable waters of the US. The USCG authorization is required for the bridges over the Gibraltar and Newhalen rivers and has set forth implementing regulations. The project would require permitting and federal oversight but would have no direct or indirect impact to federal management.

Besides the entities discussed above, no physical project-related infrastructure would be developed on any federal land or in other legislatively designated areas. Therefore, project construction, operations, or closure would not result in any direct effects on the management, ownership, or use of federal lands. However, project-related activities could indirectly and cumulatively affect the environment, resources, and visitor experience of four federal management units: Lake Clark National Park and Preserve, Katmai National Park and Preserve, Kachemak Bay National Estuarine Research Reserve, and the Alagnak Wild River. There is a small likelihood that adaptation in land management may be needed in response to potential adverse indirect impacts, such as noise and visual disturbance to recreationists and wildlife from project components or alternative variants. The indirect impact of displacement of visitors or disruption of the visitor experience would be low in intensity. These impacts would be distant from the project location for recreation and wildlife, but would be long term, lasting through construction and operations. These indirect impacts are discussed in relevant resource sections of this EIS. See Section 4.5, Recreation; Section 4.11, Aesthetics; Section 4.19, Noise; and Section 4.23, Wildlife Values, for discussions of impacts on those resources.

**Local Management**

Under Alternative 1a, no physical project-related infrastructure would be developed on lands that are in local jurisdiction under guidance of community plans. Therefore, project construction, operations, or closure would not result in any direct effects on the ownership, management, or use of local lands. However, project-related activities could indirectly affect the environment and resources of local communities. Those impacts are discussed in relevant resource sections of this EIS.

**Legal Access**

There is a Revised Statute (R.S.) 2477 ROW that runs from the community of Pile Bay to the community of Iliamna (RST 396). Alternative 1a project components would bisect the ROW at several locations (see Section 3.2, Land Ownership, Management, and Use). The natural gas pipeline would also cross RST 1641, between the northern shore of Iliamna and the mine access road. Where a R.S. 2477 ROW would be impacted from construction or operations of the project, alternate access or marked crossings would be provided as appropriate. The magnitude of land ownership changes, although certain and long term, would not be apparent due to very low existing levels of use of the easement. Most local residents travel on Iliamna Lake via boat or snowmachine and not on this ROW.

The project area encompasses several section line easements. These easements would not prohibit development of a pipeline ROW or access roads across the affected section lines. Access to the easements would not be prohibited, although any future use may need to account for the presence of the mine access road and pipeline, if permitted and constructed.

The port access road would intersect an ANCSA Section 17(b) easement on the southern shore of Iliamna Lake (EIN 17b C5). The road would not prevent access to the easement, and crossing points would be sign-posted, with appropriate traffic controls established to ensure public safety, if needed (PLP 2018-RFI 027). The mine access road would intersect EIN 15f C5, and the natural gas pipeline would intersect EIN 6b; the impacts would be the same as for the port access road.

One state public access easement exists (ADL 230875) along the pipeline route in Iliamna Lake (see Section 3.2, Land Ownership, Management, and Use); it is an easement for communication networks (there are fiber optic cables in Iliamna Lake) and other utilities. Development of the project would not prohibit access to the easement, although PLP would need to be in contact with easement holders to ensure that construction would not affect existing infrastructure. There would be no impact on access to the easement.

There are no R.S. 2477 ROWs, easements, or other legal access mechanisms in the mine site safety boundary.

### 4.2.3.3 Land Use

As discussed in Section 3.2, Land Ownership, Management, and Use, the prevalent land uses around the EIS analysis area are undisturbed landscape and natural habitat, low-intensity recreational activities, and subsistence activity. Land development in the Bristol Bay area is generally limited to the areas in and around geographically isolated communities, fish processing facilities, and small fishing and hunting lodges. Mining exploration activities have occurred in the project area and at other mineral deposits in the region.

Project construction, operations, and closure would not affect small-scale mining and exploration activities that may currently occur in the project vicinity. Residential and commercial uses in surrounding communities would not be directly affected by the project, but could expand based on employment and support service opportunities, an indirect effect. End land use and designation (post-closure) would be determined by the State.

**Mine Site**—The magnitude of impact to land use at the mine site would be in the change from minimal disturbance from exploration activities to intense industrial development. This would constitute an acute and obvious change that would last over the life of the project. The area affected would represent only a small portion of the total land area owned and managed by the State in the Bristol Bay watershed. Subsistence activity, cultural education, and recreation would be excluded from the vicinity of the mine site at the mine site safety boundary (PLP 2018-RFI 058) during construction and operations (see Section 4.5, Recreation; and Section 4.9, Subsistence). Land use would change again at closure of the mine, because the site would be restored as required by the State of Alaska and no longer used for mining. It could again be used for transportation and subsistence activities as resources once again become available.

**Transportation Corridor**—Construction of the mine and port access roads would introduce artificial features, vehicle traffic, and other activities to a previously undeveloped location, thereby changing land use. The magnitude of impact would be in the undeveloped locations that would now experience 35 daily round trips of industrial trucks along the transportation corridor. The access roads would be restricted to mine-related traffic and some controlled use by local residents and businesses and would not facilitate land use associated with non-resident recreation and tourism activities. These impacts would include the crossings of the Gibraltar and Newhalen rivers.

The ferry operating daily on Iliamna Lake would represent an addition to the watercraft currently used in open water; however, the ferry would present a new use of the lake during the winter, with the potential to interfere with other uses of the ice for local transportation and subsistence activities throughout the life of the project. The geographic extent would be the lake itself, and the likelihood of the impact would be certain when the lake is frozen. The road transportation corridor would remain in place upon project closure to support monitoring activities, although the ferry would cease operations and the intensity of use from the project would decrease. Depending on any agreements between the State and LPB with local input, some level of local use of the corridor may continue. These remaining features would constitute a permanent effect; the magnitude would be a moderate shift from an undisturbed landscape with low levels of intermittent use to transportation infrastructure supporting an industrial use.

**Natural Gas Pipeline Corridor**—The natural gas pipeline would be in the transportation corridor, extending from Amakdedori port to the south ferry terminal, crossing Iliamna Lake, coming ashore between Iliamna and Newhalen, and travelling north until co-locating with the mine access road to the mine site. There would be some land use changes in that segment between Iliamna Lake and the mine access road, although there is an existing road parallel so changes would be minimal. Any potential future use of the corridor would have to accommodate the presence of the pipeline. At the compressor station on the Kenai Peninsula, where the pipeline would connect to existing infrastructure, the land currently has some industrial development. The magnitude of impact would be in the additional development from construction of the compressor station, with restricted access lasting throughout the life of the project, but overall land use in that area would not change.

Where the pipeline would cross Iliamna Lake and Cook Inlet, it would introduce a new use to the lake and this portion of the inlet that would last for the life of the project. During construction, there may be some short-term disruption to current uses of these waterbodies; during operations, there would be minimal disruption to Cook Inlet uses due to pipeline maintenance and repairs. The pipeline would remain in place in post-closure; however, depending on agreements reached, service could extend beyond the life of the project.

**Amakdedori Port Site**—Construction at the port site would introduce an industrial port facility to a previously undeveloped location that is currently used for occasional subsistence and cultural education purposes. The magnitude of the impact would be the land use in the geographic area of the port that would change with the addition of industrial ship traffic, truck traffic, and storage activities. Because of security concerns, it is likely that any use of the physical footprint of the port site without coordination with PLP would be displaced (including cultural education at the specific site); adjacent use activities, such as commercial fishing, could be affected. However, current access to the port site is limited and existing use activities are intermittent; overall impacts would therefore be long term, lasting for the life of the project, but small in magnitude. Amakdedori port would remain in place until project closure, when the port would no longer be needed to support reclamation and monitoring activities. The likelihood of impacts to land use at the port site would be certain under Alternative 1a.

## 4.2.4 Alternative 1

### 4.2.4.1 Land Ownership

For a description of land ownership under Alternative 1, see Section 3.2, Land Ownership, Management, and Use. As with Alternative 1a, no land in the project footprint would be conveyed or sold, although an Uplands Mining Lease may be acquired, and associated authorizations permits may be sought for mining activities and facilities on State lands. Temporary use permits, easements, and ROWs for the transportation corridor and natural gas pipeline would be issued to construct and operate the project if approved. The magnitude of the impact on land ownership would be in the change in land status and an encumbrance on use along the routes of the mine, port access roads, and pipeline. The types of impacts would be the same as described under Alternative 1a, but would affect different areas, ANCSA village corporation owners, and communities along the mine access road. A new or amended tidelands lease may be sought from the State of Alaska. The impacts to land ownership would be long term in duration and would be certain under Alternative 1.

### 4.2.4.2 Land Management

Land management under Alternative 1 would be similar to Alternative 1a for state, borough, and local management; the impacts to land management would be similar to those discussed above, but would affect different areas, ANCSA village corporation owners, and communities along the mine access road.

#### Legal Access

There are no State-recognized R.S. 2477 ROWs in the footprint of Alternative 1.

The project area encompasses several section line easements from the mine site to Cook Inlet; impacts would be similar to Alternative 1a.

The port access road would cross the same ANCSA 17(b) easement (EIN 17b C5) and state public access easement (ADL 230875) in Iliamna Lake as Alternative 1a, although the number and locations of the crossings would be different. Impacts would be the same as discussed for Alternative 1a, and there would be no impact on access to the easements.

#### 4.2.4.3 Land Use

Impacts to land use at the mine site and the Kenai Peninsula pipeline compressor station would be the same as discussed under Alternative 1a.

The impact to the transportation corridor along the port road would be the same as Alternative 1a; impacts along the mine access road would be similar, although in a different location. Impacts to summer or winter transportation and subsistence use of Iliamna Lake would be the same as discussed for Alternative 1a.

As with Alternative 1a, the area at the Amakdedori port site would change from active resource extraction to an industrial port, with changes associated with an increase of project-related industrial ship traffic in Kamishak Bay. These impacts would be evident, certain, and would last for the duration of the project.

#### 4.2.4.4 Alternative 1—Kokhanok East Ferry Terminal Variant

The impacts to land ownership, management, and use would be same as described previously under Alternative 1a and Alternative 1. This variant would be on lands owned by the State of Alaska and Alaska Peninsula Corporation, although acreage would be different than Alternative 1. This variant would not impact additional easements or legal access.

#### 4.2.4.5 Alternative 1—Summer-Only Ferry Operations Variant

The impacts to land ownership and management would be same as previously described under Alternative 1a and Alternative 1, except that during winter there would be no new use of Iliamna Lake and there would be no impacts to other uses of the lake from the project. During the summer, the magnitude would be in the increased amount of truck traffic and ferry traffic, which would double on the access roads and lake, respectively, with increases in potential impacts to other users during that period. Conversely, there would be no truck and ferry traffic in the winter. In terms of duration, impacts would be every summer throughout the life of the project; the likelihood would be certain under this variant. Land ownership under this variant would not be different.

#### 4.2.4.6 Alternative 1—Pile-Supported Dock Variant

The impacts to land ownership, management, and use would be same as previously described under Alternative 1.

### 4.2.5 Alternative 2—North Road and Ferry with Downstream Dams

#### 4.2.5.1 Land Ownership

For a description of land ownership under Alternative 2—North Road and Ferry with Downstream Dams, see Section 3.2, Land Ownership, Management, and Use. The Diamond Point port would be on lands owned on Native Allotments. As with Alternative 1a, no land in the project footprint would be conveyed or sold, although an Uplands Mining Lease may be acquired, and associated authorizations permits may be sought for mining activities and facilities on State lands. Temporary use permits, easements, and ROWs for the transportation corridor and natural gas pipeline would be issued to construct and operate the project if approved. The magnitude of the impact on land ownership would be in the change in land status and an encumbrance on use along the routes of the mine, port access roads, and pipeline. The types of impacts would be the same as described in Alternative 1a, but would affect different areas, ANCSA village corporation owners, and communities along the transportation corridor and port site. Pedro Bay Native Corporation has stated that it will not grant access to PLP on their lands at this time. A new or amended tidelands lease may be sought from the State of Alaska. Impacts to land ownership would be long term in duration and would be certain to occur under Alternative 2.

#### 4.2.5.2 Land Management

State management at the mine site, transportation corridor, and on the Kenai Peninsula would be the same as Alternative 1a, but would affect different areas along the port access road. There would be no port facilities on State-owned lands. Although the route traverses different management units, the management intent is the same, and the impacts are the same as Alternative 1a.

As with Alternative 1a, the mine site, the majority of the transportation corridor, and a portion of the natural gas pipeline corridor would be in the LPB. The Diamond Point port and a portion of the transportation corridor and the natural gas pipeline corridor on the western side of Cook Inlet would lie in the KPB. Impacts for borough management in these locations would be similar to borough management for Alternative 1a.

Land use of surface and subsurface lands privately owned by Alaska Native corporations are subject to the approval of the landowners (including where the transportation corridor would cross the Newhalen River). Any activity would be conducted in accordance with lease and surface use agreements that PLP would establish with the landowners. Project construction, operations, maintenance, or closure would not result in long-term, adverse, direct, or indirect effects on management of these lands.

The Diamond Point port would be located on Native Allotments. The lands are held in trust by the federal government and generally require Bureau of Indian Affairs (BIA) oversight for sales, gift deeds, leases, permits, partitions, ROWs, and sand and gravel leases. Impacts on land use from development of the Diamond Point port would be minimally adverse changes to land management at the port site; however, there would be an increase in ship traffic. The changes would be certain to occur under Alternative 2 and would last for the life of the mine.

Federal land management under Alternative 2 would be similar to Alternative 1a in that project construction, operations, or closure would not result in any direct effects on the management, ownership, or use of federal lands. The Alternative 2 transportation corridor would be approximately 4 miles closer to Lake Clark National Park and Preserve than Alternative 1a, and project transportation activities may be more noticeable to park users; but it would be farther from both the Katmai National Park and Preserve and the McNeil River State Game Sanctuary and Refuge. Effects of project-related activities on the environment, resources, and visitor experience of the federal management units listed for Alternative 1a would be long term and certain under Alternative 2.

Management of BSEE jurisdiction would be the same as Alternative 1a. The USCG would have authority over the bridge crossing the Newhalen River. The project would require permitting and federal oversight, but would have no direct or indirect impact to federal management.

Under Alternative 2, no physical project-related infrastructure would be developed on lands that are in local jurisdiction. Impacts would be the similar to those under Alternative 1a.

The ferry route for Alternative 2 would cross near the islands on Iliamna Lake, where there is a conservation easement in place. Under the terms of the easement, there can be no development on those lands. The easement would not prevent the passage of vessels through those areas.

## Legal Access

Alternative 2 would cross the same R.S. 2477 ROW as Alternative 1a (RST 396), although the number and locations of crossings would be different and would occur primarily between Knutson Bay and Pile Bay.

The project area encompasses several section line easements from the mine site to Cook Inlet, and impacts would be similar to Alternative 1a.

The natural gas pipeline would intersect one Section 17(b) easement, on the northern shore of Iliamna Lake (EIN 30a C5 D1); the transportation corridor and natural gas pipeline would intersect one Section 17(b) easement, also on the northern shore of Iliamna Lake (EIN 15f C5). The project would not prevent access to the easements, and crossing points would be sign-posted, with appropriate traffic controls established to ensure public safety (PLP 2018-RFI 027). There would be no effect on legal access.

Alternative 2 would intersect the same public access easement in Iliamna Lake as Alternative 1a (ADL 230875). Although the number and locations of the crossings would be different, impacts would be similar. The natural gas pipeline and transportation corridor under Alternative 2 would intersect one additional public access easement (ADL 232949; see Section 3.2, Lands Ownership, Management and Use). The project would not prevent access to the easement, and crossing points would be sign-posted, with appropriate traffic controls established to ensure public safety (PLP 2018-RFI 027). Therefore, project effects on this and other easements would not occur.

### 4.2.5.3 Land Use

Impacts to land use at the mine site and the Kenai Peninsula pipeline compressor station would be the same as discussed under Alternative 1a.

Impacts to land use from the transportation corridor would be similar to Alternative 1a for the mine access road from the Eagle Bay ferry terminal to the mine site (including where the transportation corridor would cross the Newhalen River) and for the ferry use across Iliamna Lake, although they occur at different locations. The transportation corridor under Alternative 2 includes construction of a port access road in the vicinity of and in places overlapping the current Williamsport-Pile Bay Road, which is used for the summer season portage of fishing boats and some cargo from Cook Inlet to the Bristol Bay fishery. Construction could cause some disruption to pre-existing traffic, and pre-existing traffic would use the improved Williamsport-Pile Bay Road, which would have increased heavy industrial use. The change would be high intensity, certain under Alternative 2, and would last for the life of the project. After closure, the road would revert to the current level of use, although it may increase slightly. As a beneficial impact, an improved route with reduced grade could entice use by additional boat owners and lake cargo services.

At the Diamond Point port site, the magnitude of effects on land use would be in the change from active construction of a quarry to an industrial port. Changes associated with an increase of project-related industrial ship traffic in Iliamna Bay would occur, and truck traffic would increase along the road connecting Diamond Point to the Williamsport-Pile Bay Road. These adverse impacts would be noticeable and would last through the duration of the project.

The natural gas pipeline from Pile Bay to the mine access road from Eagle Bay ferry terminal would introduce a change in land use by converting a mostly undisturbed area to an area with a utility corridor. These impacts would be certain, low intensity, and last until the pipeline is decommissioned, which could extend beyond the life of the project depending on agreements reached.

#### 4.2.5.4 Alternative 2—Summer-Only Ferry Operations Variant

Impacts to land ownership and management would be same as described under Alternative 1, except at a different location. As with Alternative 1, during the winter, there would be no new project use of Iliamna Lake and there would be no impacts to other uses of the lake from the project. There would be no truck traffic along the access roads in the winter. During the summer, the magnitude of truck traffic and ferry traffic would double. The additional footprint for this variant would be entirely on lands owned by ANCSA village corporations and Native Allotments. The likelihood of impact would be certain under this variant, and the impact would be long term, lasting for the life of the project.

#### 4.2.5.5 Alternative 2—Pile-Supported Dock Variant

The impacts to land ownership, management, and use would be same as described under Alternative 1, except at a different location. The additional footprint for this variant would be entirely on lands owned by ANCSA regional and village corporations.

#### 4.2.5.6 Alternative 2—Newhalen River North Crossing Variant

The impacts to land ownership, management, and use would be same as described under Alternative 2.

### 4.2.6 Alternative 3—North Road Only

#### 4.2.6.1 Land Ownership

For a description of land ownership under Alternative 3—North Road Only, see Section 3.2, Land Ownership, Management, and Use. The Diamond Point port would be on lands owned on Native Allotments and ANCSA village corporations. As with Alternative 1a, no land in the project footprint would be conveyed or sold, although an Uplands Mining Lease may be acquired, and associated State authorizations may be sought for mining activities and facilities on State lands. Temporary use permits, easements, and ROWs for the transportation corridor and natural gas pipeline (including alternative variants) would be issued to construct and operate the project, if approved. The magnitude of the effect on land ownership would be in a change in land status and an encumbrance on use along the routes of the mine, port access roads, and pipeline. The types of impacts would be the same as described in Alternative 1a; they would affect roughly the same areas, ANCSA corporations, landowners, and communities as Alternative 2, but bridging the gap between ferry terminals with a road and natural gas pipeline corridor. Pedro Bay Native Corporation has stated that it will not grant access to PLP on their lands at this time. The access road would be in the same area as Alternative 2 and follow the Alternative 2 natural gas pipeline route. Long-term impacts on land ownership would be certain under Alternative 3.

#### 4.2.6.2 Land Management

Land management under Alternative 3 would be similar to Alternative 2 for state, borough, federal, and local management, except that the road would be co-located with the natural gas pipeline corridor and there would be no ferry operation. The transportation corridor would transect the same ANCSA native corporation lands as the transportation corridor and natural gas pipeline under Alternative 2 (including where it would cross the Newhalen River), and the impacts to land management would be similar to those of the transportation corridor under Alternative 1a and Alternative 2.

**Legal Access**

Under Alternative 3, the transportation corridor and natural gas pipeline would bisect the same R.S. 2477 ROW (RST 396), and Section 17(b) easements (EIN 30a C5 D1 and EIN 15f C5) as in Alternative 2, and the impacts would be similar. There would be no crossings of public access easements in Iliamna Lake, but the listed easement also crosses Cook Inlet at Iliamna Bay, and the impacts would be similar to Alternative 2.

The project area encompasses several section line easements from the mine site to Cook Inlet, and impacts would be similar to Alternative 1a.

### 4.2.6.3 Land Use

Impacts to land use at the mine site and the Kenai Peninsula pipeline compressor station would be the same as discussed under Alternative 1a.

The impact to the transportation corridor along the Williamsport-Pile Bay Road would be similar to Alternative 2, with the addition of road access and associated truck traffic along the natural gas pipeline route to Pile Bay. From Pile Bay to the mine site, impacts to the transportation corridor would be similar to Alternative 2 along the mine and port access roads, including where the transportation corridor would cross the Newhalen River. There would be no impacts to summer or winter transportation and subsistence use of Iliamna Lake, compared to Alternative 1a, Alternative 1, and Alternative 2.

At the Diamond Point port site, Alternative 3 would introduce additional industrial uses in an undeveloped area. There would be reconstruction of the Williamsport-Pile Bay Road and increased traffic levels. There would also be changes associated with an increase of project-related industrial ship traffic in Iliamna Bay. These impacts would be evident, certain, and would last through the duration of the project.

### 4.2.6.4 Alternative 3—Concentrate Pipeline Variant

The concentrate pipeline would be constructed adjacent to the natural gas pipeline; therefore, impacts to land ownership and management would be the same as described previously under Alternative 3. Under this variant, the magnitude of the increase in use of the Williamsport-Pile Bay Road would be lower because of less project-related truck traffic as concentrate would be shipped by pipeline.

## 4.2.7 Cumulative Effects

Potential cumulative impacts to lands include incremental change in land ownership, management, legal access, and land use. The magnitude of impact is determined by the number of acres impacted or the distance in miles from the project components. The cumulative effects analysis area for lands includes the EIS analysis area and encompasses the footprint of the project, including alternatives and variants, the expanded mine footprint (including road, pipeline and port facilities), and any other reasonably foreseeable future actions (RFFAs) in the vicinity of the project that would result in potential synergistic and interactive effects. In this area, a nexus may exist between the project and other past, present, and RFFAs that could contribute to a cumulative effect on lands and ownership.

Some of the actions identified in Section 4.1, Introduction to Environmental Consequences, are considered to have no potential of contributing to cumulative effects on land ownership and use in the analysis area. These include offshore-based developments; activities that may occur in the analysis area but are unlikely to result in any appreciable impact on land use (e.g., tourism, recreation, fishing, and hunting); or actions outside of the cumulative effects analysis area (e.g., Donlin Gold, Alaska LNG).

### 4.2.7.1 Past and Presents Actions

Past and present actions in the analysis area that have resulted in the land ownership pattern in the area include the Alaska Statehood Act, ANCSA, and the Alaska National Interest Lands Conservation Act. These include land status changes over time as lands selected under the Statehood Act and ANCSA are conveyed, and as additional easements and ROWs are developed. Land uses in the analysis area are primarily fish and wildlife habitat, low-intensity recreational activities, and subsistence. Outside of community settlements, some industrial and commercial land uses do exist in the analysis area, including those associated with mineral exploration and activity near the mine site and other mineral deposits; the Diamond Point port site, which is used for resource extraction; seasonal use of the Williamsport-Pile Bay Road; and commercial fishing in Cook Inlet. However, with the exception of these commercial and industrial land uses, the majority of the analysis area is characterized by low-intensity land uses; therefore, the area is generally in a natural state.

### 4.2.7.2 Reasonably Foreseeable Future Actions

The RFFAs identified in Section 4.1, Introduction to Environmental Consequences, that could contribute cumulatively to land ownership, use, or management impacts and are carried forward in this analysis include project expansion, exploration of mining claims, oil and gas development in Cook Inlet, road improvement projects, and continuance of recreation activities in the greater regional area.

The No Action Alternative would not contribute to cumulative effects on land ownership, management, legal access, or land use.

Collectively, the project alternatives with RFFAs' contribution to cumulative effects on land ownership, management, legal access, or land use are summarized in Table 4.2-2.

**Table 4.2-2: Contribution to Cumulative Effects on Land Ownership, Management, and Use**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Pebble Mine Expanded Development Scenario | **Mine Site:** The mine site footprint would have a larger open pit and new facilities to store tailings and waste rock and to manage water, which would contribute to land use changes and additional encumbrance of land. Cumulative effects to specific land uses, such as subsistence, recreation, and cultural resources, are discussed in those sections.<br>**Other Facilities:** The north access road would be extended east from the Eagle Bay ferry terminal to a new deepwater port site at Iniskin Bay. Diesel and concentrate pipelines would be co-located with the road. The ferry and port access road under Alternative 1a would continue to operate to transport freight. This would introduce vehicle and vessel transportation uses along the north access corridor and new port facility, although there would be a reduction in truck traffic along both road corridors. Pipeline construction would have potentially limited impacts on land use from trenching activities. The construction and operation of other facilities would add intensity to activities (more traffic) and potentially more infrastructure to the Iliamna Lake area.<br>**Magnitude:** The Pebble mine expanded development scenario project footprint would impact approximately 31,892 acres. It would affect more acres than either Alternative 2 or Alternative 3, given that two transportation corridors would be constructed and operated instead of one.<br>**Duration/Extent:** The duration/extent of cumulative impacts to land use would be incremental changes in ownership and intensity of use over the long-term | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** A north access road, and concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment, and extended to a new deepwater port site at Iniskin Bay.<br>**Magnitude:** Overall expansion would affect 32,418 acres, more acres than the other Alternatives. Impacts to land use from mine expansion would be similar to Alternative 1a.<br>**Duration/Extent:** The cumulative impacts to land use and ownership would be similar in duration and extent to Alternative 1a, although affecting more acres.<br>**Contribution:** The contribution to cumulative effects would be more than Alternative 1a, and more than Alternative 2 and Alternative 3. | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** The north access road would be extended east from the Eagle Bay ferry terminal to a new deepwater port site at Iniskin Bay. Concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay. This would introduce vehicle and vessel transportation uses along the new road-connected portion of the north access corridor and new port facility.<br>**Magnitude:** Overall expansion would affect fewer acres (31,528) than the other Alternatives, given that a portion of the north access road and all of the gas pipeline would already be constructed. Impacts to land use from mine expansion would be less than Alternative 1a.<br>**Duration/Extent:** The cumulative impacts to land use and ownership would be similar in duration to Alternative 1a, although affecting fewer acres, given | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** Overall expansion would use the existing north access road; concentrate and diesel pipelines would be constructed along the existing road alignment and extended to a new deepwater port site at Iniskin Bay. Truck traffic along the north access corridor would be reduced with operation of the concentrate pipeline.<br>**Magnitude:** Overall expansion would affect 31,541 acres, fewer acres than Alternative 1a and Alternative 1, given that the north access road and gas pipeline would already be constructed. Impacts to land use from mine expansion would be less than Alternative 1a.<br>**Duration/Extent:** The cumulative impacts to land use and ownership would be similar in duration and extent to Alternative 1a, although affecting fewer acres, given that only one transportation corridor would be constructed and operated. |

**Table 4.2-2: Contribution to Cumulative Effects on Land Ownership, Management, and Use**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | development and operation of the expanded mine scenario. Changes to land ownership, management, and use would occur in two transportation access corridors instead of one, increasing the geographic extent.<br>**Contribution:** Expansion would affect land management and ownership in ways similar to the combined effects of Alternative 1 and Alternative 3, due to the development of the north access road, and the Iniskin Bay/ Diamond Point and concentrate pipeline along the northern shore of Iliamna Lake to Iniskin Bay/Diamond Point, but over an operating life of 78 years followed by a period of closure. Effects of expansion would be similar to Alternative 3 with the Concentrate Pipeline Variant, minus the copper/gold concentrate truck traffic, and additive to the effects of Alternative 1. State permits and leases with the mine site would need to be amended and additional ROWs granted from State and ANCSA corporations. Additional tidelands leases might also be required. The proximity of expanded facilities to federal lands management units would be similar to a combination of Alternative 1 and Alternative 3 because the Pebble mine expanded development scenario would need to develop the Alternative 3 corridor for the concentrate export pipeline, and would need a port at Diamond Point and/or Iniskin Bay. The primary effects to the existing and surrounding land uses would be the expanded industrial use at the mine site and the introduction of industrial activities in two undeveloped areas over two transportation corridors instead of one over an extended timeframe. The effects would be | | that only one transportation corridor would be constructed and operated.<br>**Contribution:** Cumulative impacts from Alternative 2, combined with the mine expanded development scenario to land ownership, management, legal access, and use, would be of lesser magnitude and geographic extent than Alternative 1a because there would be no development at Amakdedori, and the Alternative 1 transportation corridor would not be used. Alternative 2, in combination with the mine expanded development scenario, would contribute to the slow transition toward a more developed land use scenario, with more prevalent industrial, commercial, and transportation land uses. However, these changes to land use patterns would occur over a smaller geographic area and affect fewer acres than under Alternative 1a. | **Contribution:** Under Alternative 3, project expansion would continue to use the existing Diamond Point port facility, would use the same natural gas pipeline, and would use the same north access road and Concentrate Pipeline Variant but extend diesel and concentrate pipelines to Iniskin Bay. The port site and associated facilities would be constructed at Iniskin Bay as discussed under Alternative 1a. Alternative 3, in combination with the mine expanded development scenario, would contribute to the slow transition toward a more developed land use scenario, with more prevalent industrial, commercial, and transportation land uses. Because the Pebble mine expanded development scenario would use the north access road system that would already be built under Alternative 3 and would not include any ferry operation, Alternative 3 combined with the expanded mine development scenario would have cumulative land ownership, management, legal access, and use |

**Table 4.2-2: Contribution to Cumulative Effects on Land Ownership, Management, and Use**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | partially offset with the construction of the concentrate pipeline, in that copper/gold concentrate truck traffic would be eliminated. The contribution of the expanded mine scenario to cumulative impacts would be the extended duration of mining land uses over an area and acreage roughly double the size of the proposed alternative. | | | impacts of lesser magnitude and geographic extent than Alternative 1a, Alternative 1, or Alternative 2. |
| Other Mineral Exploration Projects | **Magnitude:** Mining exploration activities would include additional borehole drilling, road and pad construction, and development of temporary camp facilities. Because they are currently permitted claims, mineral exploration is likely to continue in the analysis area for the mining projects listed above. Depending on the project, additional activity and infrastructure would be either continuation or a change in land use. Cumulative effects on specific land uses are discussed under subsistence, recreation, and cultural resources.<br>**Duration/Extent:** Exploration activities typically occur at a discrete location for one season, although a multi-year program could expand the geographic area affected in a specific mineral prospect. Table 4.1-1 identifies seven mineral prospects in the EIS analysis area where exploratory drilling is anticipated (four are in relatively close proximity to the Pebble Project).<br>**Contribution:** Exploration activities would continue to contribute to industrial uses in the analysis area. However, the magnitude of these activities would be generally sporadic, and summer-seasonal in duration. | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |

**Table 4.2-2: Contribution to Cumulative Effects on Land Ownership, Management, and Use**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Oil and Gas Exploration and Development | **Magnitude:** Onshore oil and gas exploration activities could involve seismic and other forms of geophysical exploration, and in limited cases exploratory drilling. Additional activity and infrastructure would create change in land use in areas where there is currently no development. Offshore activities would have little additional impact as a continuation of existing offshore activity.<br>**Duration/Extent:** Seismic exploration and exploratory drilling are typically single-season, temporary activities. The 2013 BBAP amended plan shows 13 oil and gas wells drilled on the western Alaska Peninsula, and a cluster of three wells near Iniskin Bay. It is possible that additional seismic testing and exploratory drilling could occur in the EIS analysis area, but, based on historic activity, is not expected to be intensive.<br>**Contribution:** Onshore oil and gas development in the area would contribute cumulatively to changes in land use and management, with the magnitude dependent on the level of on- and offshore oil and gas development. Port development and use at Amakdedori, combined with on- and offshore exploration activities in Cook Inlet, would both contribute to more industrial use in the area. | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |
| Road Improvement and Community Development Projects | **Magnitude**: Road improvement projects would take place in the vicinity of communities and have impacts through grading, filling, and potential increased erosion. Communities in the immediate vicinity of project facilities, such as Iliamna, Newhalen, and Kokhanok, would have the greatest contribution to cumulative effects. Some limited road upgrades could | Similar to Alternative 1a. | The footprint of the Diamond Point rock quarry in Alternative 1a coincides with the Diamond Point port footprint in Alternative 2 and Alternative 3. Cumulative impacts would likely be less under Alternative 2 due to | Similar to Alternative 2; less than Alternative 1a. |

**Table 4.2-2: Contribution to Cumulative Effects on Land Ownership, Management, and Use**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | also occur in the vicinity of the natural gas pipeline starting point near Stariski Creek, or in support of the previously discussed mineral exploration. Anticipated road improvement projects in the region include new transportation corridors currently being studied in the Lake and Peninsula Borough, such as the Williamsport-Pile Bay Road upgrade. Impacts would be similar to Alternative 3 because the road upgrade is in the same location as the north access road under Alternative 3.<br>The proposed Diamond Point rock quarry has the potential to intensify industrial land uses in the area. The estimated area that would be affected is approximately 140 acres (ADNR 2014a).<br>**Duration/Extent:** Disturbance from road construction would typically occur over a single construction season. Land use would be limited to the vicinity of communities and Diamond Point.<br>**Contribution:** Other community development and infrastructure projects would contribute to a slow land use change in the region, from undeveloped, generally natural landscapes to more development. The changes would be in or near communities and would have a small effect on the overall project area. Transportation, infrastructure, energy, and utility RFFAs would also contribute to the slow transition toward a more developed land use scenario, with more prevalent industrial, commercial, and transportation land uses. | | commonly shared project footprints with the quarry site. | |

**Table 4.2-2: Contribution to Cumulative Effects on Land Ownership, Management, and Use**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Other RFFAs | Other RFFAs described in Section 4.1, Introduction to Environmental Consequences, would change land ownership and management in the ways described above. There would be potential for some land conveyance and other changes in land ownership, such as encumbrance for an easement or a ROW, which might consequently cause changes to management actions. RFFAs that include current land uses (e.g., commercial fishing, subsistence, tourism, recreation, hunting and fishing, and scientific surveys and research) would continue along baseline trends. Increases in industrial and commercial land use could adversely affect some of these land uses, depending on measured and perceived changes in setting that affect the quality of resources and user experience. | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |
| Summary of Project Contribution to Cumulative Effects | Overall, the contribution of Alternative 1a to cumulative effects on land use and ownership, when taking other past, present, and RFFAs into account, would be an incremental change in ownership and intensity of use over the long-term development and operation of the expanded mine scenario. These incremental changes would be moderate in terms of magnitude, duration, and extent, given the limited acreage affected, but would be a change from existing undeveloped lands. | Similar to Alternative 1a, although slightly more acres would be affected by expansion of the Pebble Mine. | Similar to Alternative 1a, although slightly fewer acres would be affected by expansion of the Pebble Mine. | Similar to Alternative 1a, although fewer acres would be affected by expansion of the Pebble Mine than under either Alternative 1 or Alternative 2. |

Notes:
ANCSA = Alaska Native Claims Settlement Act
BBAP = Bristol Bay Area Plan
EIS = Environmental Impact Statement
RFFA = reasonably foreseeable future action
ROW = right-of-way

## 4.3 NEEDS AND WELFARE OF THE PEOPLE—SOCIOECONOMICS

This section addresses direct, indirect, and cumulative effects on the regional and state economy, education and infrastructure, cost of living, and population characteristics. Potential direct, indirect, and cumulative effects on commercial fishing and recreational tourism are discussed in Section 4.6, Commercial and Recreational Fisheries. Although subsistence activities are an indispensable component of the socioeconomic system of rural Alaska communities, this section addresses the monetized economy. Subsistence activity and the importance of subsistence as it relates to income and its support in stabilizing communities during economic downtimes are discussed in Section 4.9, Subsistence. Potential impacts to the socioeconomic environment include changes to economy and income, regional education and infrastructure, cost of living, and population. In addition, cultural ties to the area can impact the socioeconomic welfare of a community. The sociocultural dimensions are also discussed in Section 4.9, Subsistence.

The Environmental Impact Statement (EIS) analysis area for this section includes the state of Alaska, regions, and potentially affected communities where aspects of the monetized economy (including population, employment and income, government revenue, housing, and education) would likely be impacted by construction, operations, and closure of all components of each alternative of the project. Relevant effects on the state of Alaska are also discussed. The boroughs and communities included in the EIS analysis area for the socioeconomic analysis are:

- Lake and Peninsula Borough (LPB)
  - Igiugig
  - Iliamna
  - Kokhanok
  - Levelock
  - Newhalen
  - Nondalton
  - Pedro Bay
  - Port Alsworth
- Dillingham Census Area
  - Dillingham
  - Ekwok
  - Koliganek
  - New Stuyahok
- Kenai Peninsula Borough (KPB)
- Bristol Bay Borough
- Anchorage
- Alaska

Scoping comments related to socioeconomics focused on beneficial impacts of additional employment opportunities, economic benefits to the state of Alaska, and concerns regarding short-term benefits versus long-term risks. The following sections assess potential impact to these and other issues.

The magnitude of impact is discussed in terms of communities impacted or monetary implications (e.g., employment/income, potential revenue generated/lost, or cost of living). The duration and geographic extent of impacts would depend on the location and season in which the disturbance occurred. The potential of impacts is an assessment of how likely the impact would be.

Mitigation measures and actions designated to reduce or eliminate project impacts on socioeconomics are provided in Chapter 5, Mitigation.

## 4.3.1 Summary of Key Issues

**Table 4.3-1: Summary of Key Issues for the Socioeconomic Environment**

| Project Impact | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Population | Communities may see a small increase in population, especially communities near the project components (i.e., Newhalen, Iliamna, Nondalton, and Kokhanok), primarily due to new employment opportunities. | Same as Alternative 1a. | Same as Alternative 1a, except that impacts would be less likely to occur to Kokhanok because this community would not be on the transportation corridor and would instead occur in Pedro Bay.<br>There would be no difference in impacts from variants. | Same as Alternative 1a, except that impacts would be less likely to occur to Kokhanok and more likely to occur in Pedro Bay.<br>There would be no difference in impacts from the variant. |
| Economy and Income | This alternative would provide year-round employment, a positive impact that would help reduce the impacts of the seasonal fluctuations in employment. During construction, there would be an estimated 2,000 direct jobs, and during operations there would be an increase of direct employment by 850 people, plus indirect employment related to support services. Communities nearest the project components (i.e., Newhalen, Iliamna, Nondalton, and Kokhanok) would likely see the greatest impacts to employment and income. | Same as Alternative 1a.<br>The Summer-Only Ferry Operations Variant would result in less year-round employment and greater seasonal employment, with less income remaining in the potentially affected communities. | Same as Alternative 1a, except that impacts would be less likely to occur to Kokhanok and more likely to occur in Pedro Bay.<br>The impacts of the Summer-Only Ferry Operations Variant would be the same as those described for the variant for Alternative 1. | Same as Alternative 1a, except that impacts would be less likely to occur to Kokhanok and more likely to occur in Pedro Bay. The total number of employees needed during operations would likely be less.<br>The Concentrate Pipeline Variant would have fewer employment opportunities, which would decrease overall income. |
| Tax Revenue and Other Fiscal Effects | Alternative 1a would generate:<br>• $25 million annually in state taxes (in 2011 dollars) during construction<br>• $64 million annually from state corporate | Same as Alternative 1a. | Same as Alternative 1a. | Same as Alternative 1a.<br>The Concentrate Pipeline Variant would have greater impact on property taxes for KPB than Alternative 1a. |

**Table 4.3-1: Summary of Key Issues for the Socioeconomic Environment**

| Project Impact | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | taxes during the operations phase<br>• $20 million annually (2011 dollars) from state royalty payments during the operations phase<br>• $27 million annually in severance taxes for LPB<br>• Annual property taxes to the KPB based on the assessed value of project-related real property | | | |
| Cost of Living | Reduced transportation costs would likely lower the high cost of living for the communities near the transportation corridor (i.e., Newhalen, Iliamna, Nondalton, and Kokhanok). The natural gas pipeline would also provide opportunities for adjacent communities to lower their winter heating costs, a positive impact. | Same as Alternative 1a.<br>The Summer-Only Ferry Operations Variant would likely have less impact than Alternative 1 because transportation costs would only be reduced in the summer. | Same as Alternative 1a, except that impacts would occur to Pedro Bay and not to Kokhanok.<br>The Summer-Only Ferry Operations Variant would likely have less impact than Alternative 1 because transportation costs would only be reduced in the summer. | Same as Alternative 1a, except that impacts would occur to Pedro Bay and not to Kokhanok.<br>The Concentrate Pipeline Variant would be the same as Alternative 1a. except that impacts would occur to Pedro Bay and not to Kokhanok. |
| Regional Infrastructure | Alternative 1a would increase the infrastructure in the region. The impact of the transportation corridor depends on the access afforded to communities. Communities along the natural gas pipeline may also benefit from the infrastructure. | Same as Alternative 1a. | Same as Alternative 1a, except that impacts would be less likely to occur to Kokhanok and more likely to occur to Pedro Bay.<br>There would be no difference in impacts from variants. | Same as Alternative 1a, except that impacts would be less likely to occur to Kokhanok and more likely to occur to Pedro Bay.<br>There would be no difference in impacts from the variant. |

Notes:
KPB = Kenai Peninsula Borough
LPB = Lake and Peninsula Borough

## 4.3.2 No Action Alternative

Under the No Action Alternative, federal agencies with decision-making authorities on the project would not issue permits under their respective authorities. The Applicant's Preferred Alternative would not be undertaken, and no construction, operations, or closure activities specific to the Applicant's Preferred Alternative would occur. Although no resource development would occur under the Applicant's Preferred Alternative, Pebble Limited Partnership (PLP) would retain the ability to apply for continued mineral exploration activities under the State's authorization process (ADNR 2018-RFI 073) or for any activity not requiring federal authorization. In addition, there are many valid mining claims in the area, and these lands would remain open to mineral entry and exploration by other individuals or companies.

It would be expected that current State-authorized activities associated with mineral exploration and reclamation, as well as scientific studies, would continue at levels similar to recent post-exploration activity. The State requires that sites be reclaimed at the conclusion of their State-authorized exploration program. If reclamation approval is not granted immediately after the cessation of activities, the State may require continued authorization for ongoing monitoring and reclamation work as it deems necessary. Therefore, although there may be some decrease in the current level of economic activity generated by exploration of the project, exploration could continue; no changes in future direct or indirect effects to existing socioeconomics would be expected, and existing trends would continue.

### 4.3.2.1 Regional Setting

#### Regional Economy

The PLP employed approximately 100 to 150 local community members annually at the site during the pre-development phase of the project, which ended in 2012 (Loeffler and Schmidt 2017). Since then, PLP has had a minimal number of workers at the site for exploration and maintenance activities; this has supported some indirect jobs in the region. Under the No Action Alternative, it is anticipated that State-authorized activities associated with mineral exploration and reclamation, as well as scientific studies, would continue at levels similar to recent exploration activity. As a result, the current number of direct and indirect jobs would remain roughly the same and there would be no impact to the regional economy. Under the No Action Alternative, state and local government revenue sources, amounts, and fiscal characteristics would stay in the current range. Section 4.6, Commercial and Recreational Fisheries, addresses state and local government revenue associated with commercial fishing and tourism.

#### Cost of Living

The No Action Alternative is not anticipated to result in changes to the current activities, or to infrastructure associated with the Pebble deposit or regional infrastructure. As a result, the No Action Alternative would have no effect on the cost of living in potentially affected communities.

#### Regional Infrastructure

No additional impacts to the regional infrastructure would be anticipated as a result of the No Action Alternative. Because of the remoteness and small workforce, pre-development work has had little impact on the regional public infrastructure. The No Action Alternative would not affect the current or projected infrastructure trends; these trends would continue, including those related to education, health services, water, transportation, sewer, and solid waste operations.

#### 4.3.2.2 Potentially Affected Communities

It is anticipated that PLP would continue current activities in an effort to identify future opportunities under the No Action Alternative; therefore, the current number of direct and indirect jobs would not be expected to change. Under the No Action Alternative, population trends in communities would continue. Declining populations in some smaller communities could lead to school closures and other loss of services.

### 4.3.3 Alternative 1a

#### 4.3.3.1 Regional Setting

**Regional Economy**

Loeffler and Schmidt (2017) found that during the pre-development phase of the project (2009 to 2012), community members from the region accounted for about 43 percent of the project's seasonal workforce. Since then, PLP has had a minimal number of workers at the site for exploration and maintenance activities. Under Alternative 1a, the magnitude of the project's impact on local employment would be an increase of 2,000 direct hires during the construction phase, and 850 during the operations phase. The duration of these impacts would be short-term for construction employees and long-term for operations employees. PLP has stated that its objective is to maximize opportunities for local hire: first, directly to residents of the EIS analysis area, or those with close ties to the area; and second to Alaska residents in general. It is estimated that during operations, 250 employees would come from surrounding communities and the remaining 600 from Anchorage or Kenai. However, it is likely that during the construction phase, non-Alaskan labor would be required to fill the anticipated 2,000 jobs, potentially as high as 50 percent of hires (PLP 2018-RFI 027). In addition, indirect employment opportunities would increase from the services that would be needed to support construction and operations activities (e.g., air services, goods, and supplies). These activities could potentially create a large number of direct and indirect jobs in the region relative to the population, providing a measurable beneficial impact over both the short-term construction phase and the long-term operations phase of the project. Employment would decrease at mine closure.

Alternative 1a would provide year-round operations employment, which would help reduce the impacts of the seasonal employment fluctuations that are prevalent in the region. Depending on the construction schedule and nature of activities, some construction employment (although beneficial to the local economy) may be short-term and/or seasonal in nature.

Loeffler and Schmidt (2017) also found during the pre-development phase that communities near the mine site provided a much higher percentage of local labor than more distant communities, such as those in the Dillingham Census Area or other coastal communities. In addition, opportunities and incomes from other sources of employment (e.g., commercial fishing) were greater in distant communities. Therefore, the impact on employment and income during the exploratory phase had a much higher magnitude of impact on the communities closest to the mine site than on more distant communities. It can be anticipated that the same pattern would occur during the operations phase; communities near the mine site and ferry/port terminals would see a greater employment impact than communities farther away.

Because most of the state's professional and business service firms, including PLP's office, are based in Anchorage, the Anchorage region would be anticipated to see an increase in jobs. However, the increase would be minor in relation to the larger and more diverse economy of Anchorage (with approximately 130,000 employed workers in 2016). The extent of impacts from additional employment opportunities due to construction of the natural gas pipeline could reach to the Kenai Peninsula, with its oil services support industry. Similarly, services (particularly transportation and lodging) based in Iliamna and to a lesser extent in Homer, would also be anticipated to see an increase in jobs. These increases would be higher over the short-term construction phase, and would be expected to occur if the project is permitted and built.

Although the project would provide a more stable employment base in the region, it should be noted that the actual number of direct and indirect jobs in any given year could fluctuate based on economic conditions and/or business decisions.

## Cost of Living

As described in Chapter 2, Alternatives, Alternative 1a would result in construction of the mine and port access roads, spur roads, ferry terminals, and a port. Although some components are described as private, PLP has stated that they would work with all local communities to identify the best solutions for use of the access roads and ferry for community transportation (PLP 2018-RFI 027). Because the higher cost of living in rural areas is primarily associated with the high transportation cost of food, fuel, and other supplies (ADOL 2008, 2017a), Alternative 1a has the potential to reduce transportation costs to communities near the transportation corridor, should arrangements be made to allow controlled public use of the mine and port access roads and spur roads. It should be noted that state and local authorizations may affect final road alignment and uses. Reduced transportation costs would lower the high cost of living for the communities near the transportation corridor, specifically Kokhanok, Iliamna, Newhalen, and potentially Nondalton. This would be a beneficial long-term impact, lasting the life of the project or until roads are decommissioned. It is possible that PLP, landowners, and the LPB could agree on continued use of project transportation infrastructure after project closure and continue the beneficial contribution.

Communities adjacent to the natural gas pipeline (i.e., Kokhanok, Newhalen, and Iliamna) would have the opportunity to connect to the pipeline, depending on arrangements made with PLP. Natural gas would likely be less expensive than diesel heating oil. This impact could lower cost of living once community-based equipment (e.g., furnace, water heater) is converted to natural gas. However, communities would be responsible for funding the connections and conversions. After mine closure, the pipeline would be decommissioned and there would no longer be natural gas available for community use, unless otherwise negotiated between the communities and utility providers.

## Regional Infrastructure

The temporary construction and long-term operations camps used to house workers would be self-contained, and operated and maintained by PLP throughout the project. The work camps would be in remote areas, and employees would not have access to services in local communities. Therefore, local community services would not be adversely impacted by additional workforce population needs. In addition to housing facilities, the camps would be equipped with appropriate emergency medical facilities, electrical power generation, fuel storage, and facilities for sewage treatment and solid waste disposal and management. Potable water for the camps would be trucked in or sourced from on-site wells.

The direct effects of all phases of the project on public utilities in communities in the EIS analysis area would not be apparent, except for effects on communities along the corridor of the natural gas pipeline, which may develop infrastructure to take advantage of the supply of natural gas or experience reduced costs of goods and services through access to the project transportation system. However, local employment opportunities could offset current trends of outmigration in some communities and provide service fee revenue to maintain or even improve community infrastructure. These beneficial impacts would last the life of the project, decrease at mine closure, and extend to communities in the EIS analysis area.

The following sections address the direct and indirect impacts to the regional infrastructure from activities associated with Alternative 1a; however, these sections do not address changes in the regional infrastructure associated with potential decisions made by LPB or the State of Alaska related to the use of increased tax revenues. An increase in tax revenues may lead to an increase in spending on regional infrastructure, which would improve infrastructure for the population of the region.

### *Education*

The PLP has supported training and education programs in Alaska, such as the Alaska Native Science and Engineering Program, Teacher Industry Externship Program, and Alaska Resource Education (PLP 2018e). These activities would be anticipated to increase with Alternative 1a as the needs of the workforce expand. Conversely, some cultural education opportunities would be displaced, such as the current cultural activities and camps held at the site of the Amakdedori port, Groundhog Mountain, Frying Pan Lake, Upper Talarik Creek and Koktuli River watersheds, and a cultural site of cottonwoods (Alaska Heritage Resources Survey site ILI-00254) (NTC 2018). This would be an adverse impact, lasting the duration of the project if suitable alternatives cannot be found. The extent of impacts would be to communities in the EIS analysis area.

Although the project is not anticipated to result in an increased number of schools in the region, it may benefit educational opportunities for some communities through an increased revenue stream to the LPB and access to PLP-supported education programs. Because of declining population (i.e., out-migration) in some communities, schools are at risk of closing (LPB 2012). The project could reduce or eliminate this decline, allowing local schools to remain open and continue to serve local communities. It may also allow the school district to offer expanded services, such as the expansion of vocational education. The LPB's Large Project Ordinance would require that any expansion of school facilities due to the project be paid for by the project through increased tax revenues. Conversely, steady employment and income may provide some families with the ability to move to other areas, which may decrease the population of some communities.

### *Transportation*

Alternative 1a would expand transportation infrastructure in the region once the transportation corridor and ferry/port facilities are complete. Although the mine and port access roads and port are described as privately owned, it is expected that a road management agreement involving all of the landowners would allow controlled use of the access roads and ferry for community transportation needs (PLP 2018-RFI 027). This would help reduce the local cost of living, including the crossings of the Newhalen and Gibraltar rivers. The State of Alaska and Alaska Native Claims Settlement Act (ANCSA) corporation land owners may also provide conditions on permit approval for the portion of the transportation route on their lands. Access to the infrastructure would be limited to local residents and businesses; it would most likely consist of escorted, scheduled convoys for private vehicle transport, and require coordination with PLP for third-party commercial-haul traffic. Road traffic would be coordinated with scheduled third-party transportation by the ferry. When mining operations cease, the road would stay in place as needed for post-closure activities and would be reclaimed when it is no longer needed. Agreements may be made between relevant parties for the road to remain in place.

Because many of the workers and supplies would be transported to the region by air, the Iliamna Airport and local airfields would see increased use. Although no direct impacts are expected to airport infrastructure, the airport would likely see indirect impacts, such as an increase in fuel sales and maintenance activities related to increased air traffic. In turn, this could create additional indirect employment and economic activity at Iliamna and other airport hubs. The impacts would be long term, lasting for the life of the project, but would be greater during the construction phase. Section 4.12, Transportation and Navigation, describes the impacts to air, surface, and water transportation systems.

With port and ferry features removed at closure, only the access roads and shallow draft barge facilities would remain for use in transporting bulk supplies associated with the closure operations, unless an agreement could be reached for a third party to take over ferry operations. Access to the remaining infrastructure would likely be similar to that described above.

#### *Health Services*

The mine site would have on-site medical facilities to support workers. Many of the workers would be trained in emergency response and first aid. Most immediate care operations would be handled internally. Patients may be transported to a local clinic or airlifted to larger regional hospitals if needed. Therefore, existing health services are not anticipated to be directly impacted by the project. However, depending on the level of development associated with support services, there may be indirect beneficial or adverse impacts on these facilities. The extent of any indirect impacts would be anticipated in the communities nearest the mine site (i.e., Iliamna and Newhalen), which may have the highest level of indirect development to support the mining operations. In addition, an increased revenue stream to the LPB, along with stabilization of population levels attributable to employment opportunities, could result in improvements to community health care facilities throughout the borough.

#### *Water, Sewer, and Solid Waste*

The project would construct temporary water and wastewater facilities at various sites used for project construction camps, and at the mine site, ferry terminals, and Amakdedori port during operations. In addition, project-generated solid waste would be addressed on site or removed from the area. As a result, existing community water, sewer, and solid waste facilities would not be directly impacted by the project. However, depending on the level of indirect activity associated with support services, there may be indirect beneficial or adverse impacts on these facilities. The extent of indirect impacts would be the communities nearest the mine site. Similarly, an increased revenue stream to the LPB and stabilization of population levels attributable to employment opportunities could result in improvements to community water, wastewater, and solid waste services and facilities throughout the borough.

### 4.3.3.2 Potentially Affected Communities

Construction and operations would have direct and indirect impacts to local and regional socioeconomic conditions, described below.

### Population

As discussed in Section 3.3, Needs and Welfare of the People—Socioeconomics, the population of some of the potentially affected communities has been declining, particularly in the LPB. Much of this decline has been associated with the lack of employment opportunities in the communities and closing of schools.

Alternative 1a would result in direct creation of an estimated additional 2,000 jobs during the construction phase and 850 during the operations phase. It is estimated that during operations, 250 employees would come from surrounding communities, and a majority of the remaining 600 would be from Anchorage or Kenai (PLP 2018-RFI 027). Employment would decline after mine closure. Workers would be transported from multiple locations (including from local communities) to the mine site via aircraft or other approved transport such as local roads, and would stay in work camps during their shifts. Therefore, workers could live throughout the state or in other states and still have the ability to work at the mine. As a result, the local communities would not be anticipated to see a large increase in population from the project, particularly from in-migration. The largest impacts could occur in Iliamna, Kokhanok, Newhalen, and potentially Nondalton, which may see an increase in population related to any businesses that are developed to support the project.

Although a large in-migration of population is not anticipated, Alternative 1a may lead to changing population patterns in the region. The population in some potentially affected communities has been declining due to out-migration. The project could reduce or eliminate this population decline because of the increase in employment opportunities and indirect effects on education and infrastructure; it could also lead some prior residents to return to communities. Therefore, the population of some communities is anticipated to increase slightly. This anticipated small increase in population is consistent with a study conducted by LPB (InterGroup 2019) that forecasted a small increase in population in the EIS analysis area for the same reasons described previously. In addition, communities near the Red Dog Mine experienced small increases in population during the period from pre-mine into operations, primarily due to natural increases (Tetra Tech 2009). The Tetra Tech (2009) study found that there was no reason to believe that the population increase in Kotzebue (the rural hub serving as the gateway to the region and support for the Red Dog Mine) was the result of an influx of outside individuals related to the mine. Conversely, steady employment and income may provide some families with the ability to move to other areas, which may decrease the population of some communities. Therefore, the impacts on population for individual communities are difficult to anticipate.

## Economy and Income

Estimating how many local community members would obtain work through the project (or would be interested in obtaining work) is difficult, but any increase in the number of jobs would help the local communities. Loeffler and Schmidt (2017) found that during the pre-development phase of the project (2009 to 2012), community members from the region accounted for about 43 percent of the project's seasonal workforce. Communities near the mine site were found to provide a much higher percentage of local labor than more distant communities, where opportunities and incomes from other sources of employment (e.g., commercial fishing) were greater. Therefore, the impact on employment and income during the exploratory phase had a much higher magnitude of impact on the communities closest to the mine site than on more distant communities.

PLP has stated that its objective is to maximize opportunities for local hire; first, directly to residents of the EIS analysis area or those with close ties to the area; and second to Alaska residents in general. However, it is likely that during the construction phase, substantial labor from outside the region and outside Alaska would be required to fill the anticipated 2,000 jobs, potentially as high as 50 percent of hires (PLP 2018-RFI 027).

A majority of jobs would be taken by Alaskans during operations. PLP has estimated that 250 employees would come from the surrounding communities, with 50 of these employees coming from communities connected to the project site by road (PLP 2018-RFI 027). The majority of the remaining 600 employees would likely be from the Anchorage and Kenai areas. Therefore, the extent of beneficial impacts would reach beyond the communities in the EIS analysis area. A similar pattern of employment occurs at the Red Dog mine (Berman, Loeffler, and Schmidt 2020). Operations jobs would last for the life of the project.

The direct jobs created by the project would be attractive to many residents with the requisite skills. In general terms, developments like the project provide economic benefits to individuals, families, and communities in increased and steady income. Many of the communities in the region, especially those in the LPB, have a lower median household income and a higher unemployment rate than Anchorage or Alaska as a whole. Therefore, employment through the project would have an impact on income levels in the local communities.

The exploratory phase of the project revealed that the income earned by residents employed by the project was an important part of the total income earned in local communities, especially those communities close to the mine site (Loeffler and Schmidt 2017). The income earned by residents close to the mine working for PLP was greater than the income earned for commercial fishing, indicating that even the limited employment during the exploratory phase had large impacts on the communities. In communities that were farther from the mine site, commercial fishing was a larger part of total income. Indirect employment developed to support the construction and operations of the project would provide additional opportunities for community residents.

On average, wages for mining jobs are much higher than those for most industry categories. The average monthly wage in Alaska for the mining industrial classification in the third quarter of 2017 was $9,047, and mining support activities was $7,855, which was higher than the average for Alaska of $4,414 (ADOL 2017b). It should be noted that this average wage is likely for mine operations; construction wages would likely be lower. Because these figures are an average of all people employed in that classification, the monthly wage includes executives, specialized experts, and low-skill positions. Not all local residents would make the average wage. However, wages earned would likely be higher than the median household incomes of the potentially affected communities (see Section 3.3, Needs and Welfare of the People—Socioeconomics), which would be an improvement to the welfare of the community members. Similar income patterns are found at the Red Dog mine in western Alaska (Berman, Loeffler, and Schmidt 2020). For example, income from mining could be twice the median household income in the LPB of about $45,000. In addition, construction and operations of the mine would likely create opportunities for support services, creating indirect employment and income. This would most likely occur in support and transportation hubs, such as Iliamna and Port Alsworth, and in larger communities such as Anchorage and the KPB. McDowell (2018c) estimates that modeling an employment multiplier of approximately 2.0 accurately captures the magnitude of total direct and indirect employment of the mining industry in Alaska (McDowell 2018c).

Overall, the project would provide long-term beneficial impacts to the economy from employment and income in the region and state. Although the project would provide a more stable employment base, it should be noted that the actual number of direct and indirect jobs in any given year could fluctuate based on economic conditions and/or business decisions.

## Tax Revenue and Other Fiscal Effects

Project construction and operations would generate revenues for local governments and the state of Alaska. The revenue sources would potentially include mining license taxes, corporate income taxes, property taxes, sales taxes, borough severance taxes, and production royalty payments, depending on the nature of mining production, real property value, and taxation measures authorized by statute or ordinance. The duration of revenues to state and local governments would begin during the construction phase; it would escalate during the operations phase, when mining license taxes, production taxes, severance taxes, and corporate income taxes would become effective. At the time the mine ends operations/production, buildings, foundations, pipelines, and other infrastructure facilities would be removed or reclaimed and these revenues would end unless reuse of some of these facilities was negotiated with another party.

### *Mining License Tax and Corporate Income Tax*

Alaska levies a mining license tax and corporate income tax on net income received in connection with mining properties and activities in the state. The collection of mining license tax and corporate income tax on project net income would have a beneficial effect on state government revenues. The magnitude and extent of the state revenue were estimated based on analyses conducted by IHS (2013). The estimates from the IHS report were adjusted to the current design by scaling for the smaller workforce; however, the estimates were not adjusted for inflation and are in 2011 dollars. It is estimated that the proposed project could generate $25 million annually in state taxes during the construction phase, and an estimated $64 million annually in state corporate taxes during the operations phase. It was estimated that the operations phase could also generate $41 million annually from State mining license taxes (IHS 2013).

Corporate income tax may increase further through the indirect and induced impacts of mine construction and operations.

### *State Royalty Payments*

Alaska requires holders of State mining locations to pay a production royalty on all revenues received from minerals produced on State land, in accordance with the Production Royalty Law, which applies to all revenues received from minerals produced from a State mining lease (Section 38.05.212). The production royalty is 3 percent of net income generated (ADNR 2015).

The collection of state royalty payments on project net income would have a beneficial long-term effect (extending for up to decades over the life of the project) on state government revenues. Based on the same adjustments made to the IHS (2013) analyses as described above, the project could generate $20 million annually (in 2011 dollars) in state royalty payments during the operations phase.

### *Borough Severance Taxes*

Mining operations are subject to severance taxes on resource extractions in a taxing jurisdiction, which would be the LPB. Based on the same adjustments made to the IHS (2013) analyses as described above, the proposed project could generate $27 million annually (2011 dollars) in severance taxes paid to LPB during the operations phase. The estimated severance tax would represent a significant increase in revenue for LPB (>500 percent) compared to the estimated total revenue from external sources of approximately $5 million for fiscal year 2019 (LPB 2018d). Another potential source of revenue available to local governments is Payment in Lieu of Taxes (PILT), which is available to local governments as an alternative to property or severance taxes; the Northwest Arctic Borough currently receives PILT from the operation of the Red Dog mine.

### *Borough Property Taxes*

Real property can be subject to property taxes. The LPB does not have a property tax (LPB 2018d), but the KPB has a borough property tax of 4.7 mills[1], plus any other taxes assigned in accordance with the Tax Authority Group (e.g., hospital or road maintenance taxes). The mill rate for the KPB is 4.70, meaning that for every $1,000 of assessed taxable property value, the KPB receives $4.70 in revenue.

Real property, including the Amakdedori port facilities and any other infrastructure in the KPB, would be taxed at a rate of 4.7 percent of its assessed taxable value. This includes the assessed

[1] A mill represents 0.1 percent of $1, equal to $1 of tax revenue for each $1,000 of assessed taxable property value.

value of the infrastructure itself, as well as a portion of the assessed land value (subject to lease terms). Mill rates are set annually by the borough assembly, municipalities, and service area boards. Beneficial impacts of increased property taxes to all boroughs affected would last through the life of the project.

### *Right-of-Way Acquisition*

The right-of-way (ROW) for the transportation corridor connecting Amakdedori port to the mine site could be another fiscal element of the project. The State of Alaska would own 63 percent of the corridor, and 37 percent would be owned by ANCSA village corporations. Based on costs for a similar mine ROW and the value of State lands (ADNR 2008), a preliminary estimate of the magnitude of ROW costs for the transportation corridor ranged between $1 million and $1.5 million, which would be paid to the state government and to the Native corporations, creating a long-term beneficial economic effect.

The pipeline corridor would cross State and federal waters, as well as State and ANCSA village corporation lands. Historically, ROW costs account for approximately 7 percent of the total construction cost of a pipeline (Rui et al. 2011).

## Housing

Staff working at the mine would be housed in on-site facilities (i.e., work camps) and would follow a fly-in/fly-out or local road commute work arrangement. Therefore, there would not be an increase in housing demand in communities related to an influx of the direct employment of workers. However, employment opportunities could slow or reverse the decline in some communities, or encourage former residents to move back. This would affect the demand for local housing.

Communities closest to the mine and ferry terminals (i.e., Iliamna, Newhalen, Kokhanok, and potentially Nondalton) may see changes to the population as a result of support activities, which may lead to an increase in demand for housing. As described in Section 3.3, Needs and Welfare of the People—Socioeconomics, vacant housing units are available in these communities. Although the condition of the vacant units is not known, some of the units could accommodate at least a portion of any increase in population. Housing is also available in the larger communities in the region where workers may reside. Overall, adverse impacts to housing availability would not be expected.

## Education

Although the project is not likely to result in substantive demographic increases that would support an increase in the number or capacity of schools in the potentially affected communities, an increase in tax revenue to the LPB and the education programs supported by PLP could benefit schools and the student population. In addition, local employment opportunities associated with the project could reduce population decline in some communities, which could allow schools at risk of closing to remain open.

As with other mining operations in Alaska, employment at the mine would require at least a high school education or general education diploma (GED). Therefore, students may see employment opportunities provided by the mine as an incentive to complete at least a basic level of education, which could increase high school graduation rates in the potentially affected communities. Similar to the experience with other Alaska mining projects, it might also provide opportunities for participating in vocational training, particularly if PLP, the LPB, and Alaska Native organizations provide support.

#### 4.3.3.3 Changes in Sociocultural Dynamics

As discussed in Section 4.9, Subsistence, there is an interplay between socioeconomics and subsistence. Cash income (often from employment) is necessary to pay for subsistence equipment, supplies, and operating costs; increased incomes from project employment for local employees may be partially invested in subsistence activities. At the same time, subsistence activities are labor intensive and require large investments of time and effort. Many subsistence resources are available only at certain times of the year. To the extent that project-related employment reduces the time available for these employees to participate in subsistence activities and to pass on skills and knowledge to the next generation, harvest effectiveness may decline. Proposed shift-work schedules with 2 weeks at the project site and 2 weeks off in the community would likely reduce, but not eliminate, the conflict between project employment and subsistence activities.

Out-migration of mine project employees from local communities has been identified as an adverse sociocultural effect on subsistence and cultural continuity if high-harvesting households relocate. Similarly, increased availability of jobs for local residents could lead some prior residents to return to communities. Although a large in-migration or out-migration of population is not anticipated, Alternative 1a may lead to changing population patterns in the region. The population in some potentially affected communities has been declining due to out-migration. The project could reduce or eliminate the decline because of the increase in employment opportunities and indirect effects improving education and infrastructure.

At closure, both time commitments for and cash income from project employment would decline, depending on local employment opportunities associated with closure and monitoring activities. Households would have to adjust to reduced cash income to support the maintenance and operating costs of a subsistence lifestyle. Some residents may move away as job opportunities cease. The beneficial and adverse indirect effects of mine employment and income on subsistence practices would decrease. Some long-term impacts may include loss of subsistence knowledge and skills and/or decrease in participation during mine operations continuing after closure.

### 4.3.4 Alternative 1

#### 4.3.4.1 Regional Setting

**Regional Economy**

Although the alignment of the mine access road and natural gas pipeline would change, Alternative 1 would have the same overall impacts to the regional economy as Alternative 1a.

**Cost of Living**

For the region as a whole, the impacts on the cost of living of Alternative 1 would be largely the same as the impacts of Alternative 1a and would likely lower the high cost of living for the communities near the transportation corridor.

**Regional Infrastructure**

Although the alignment of the mine access road and natural gas pipeline would change, Alternative 1 would have the same overall impacts to the region as Alternative 1a.

### 4.3.4.2 Potentially Affected Communities

Although the alignment of the mine access road and natural gas pipeline would change, Alternative 1 would have the same overall impacts to socioeconomic indicators of the potentially affected communities as Alternative 1a.

Revenues from the ROW acquisition for the transportation corridor and the natural gas pipeline would be similar to Alternative 1a and would impact the State (which would own 63 percent of the corridor) and ANCSA village corporations (37 percent). Because of the different access routes on the northern side of Iliamna Lake, there would be some difference in Alaska Native corporation land ownership that would affect the specific distribution of ROW revenues.

### 4.3.4.3 Changes in Sociocultural Dynamics

Impacts to the sociocultural dimension of subsistence and the cash economy would be the same as discussed for Alternative 1a.

### 4.3.4.4 Alternative 1—Kokhanok East Ferry Terminal Variant

The Kokhanok East Ferry Terminal Variant would result in impacts similar to those described above for all project components. For this variant, the State would own 65 percent of the Kokhanok East Ferry Terminal Variant, and ANCSA village corporations would own 35 percent.

### 4.3.4.5 Alternative 1—Summer-Only Ferry Operations Variant

**Regional Economy**—Alternative 1 includes a variant for summer-only ferry operations, where the transportation corridor would only operate during the open water season (PLP 2018-RFI 065). As a result, more employment opportunities for truck drivers and ferry/terminal workers would be needed during summer operations, but fewer would be needed during winter operations, leading to less year-round employment opportunity and a larger number of seasonal employees. Therefore, this impact would be less beneficial than that described for Alternative 1 without the variant.

**Cost of Living**—Under the Summer-Only Ferry Operations Variant, communities that would rely on the project transportation system may opt to stockpile food, fuel, and other supplies or receive shipments via air when the ferry is not operating. Overall, the variant would likely lower the high cost of living for the communities near the transportation corridor, but not to the extent of the Alternative 1 year-round ferry operations.

**Economy and Income**—Under the Summer-Only Ferry Operations Variant, the transportation corridor would only operate during the open-water season. As a result, more employees (e.g., truck drivers or ferry/terminal workers) would be needed during summer operations, but fewer would be needed during winter operations (PLP 2018-RFI 065). This would lead to a smaller number of year-round employees and a large number of seasonal employees. Due to the small populations of the potentially affected communities, it is less likely that the communities would be able to meet all of the demand for the increased number of seasonal employees (in addition to the year-round employees), requiring more employees to come from outside the region for the seasonal work. In addition, other employment opportunities are available to local residents during the summer (e.g., construction, tourism and commercial fishing), whereas fewer opportunities exist during the winter months. Therefore, the variant would likely shift some of the positions held by community members from year-round to seasonal, which would also lower the overall income that is earned by community members and decrease the incentive to retain population in the region compared to year-round employment under year-round ferry operations.

#### 4.3.4.6 Alternative 1—Pile-Supported Dock Variant

The Pile-Supported Dock Variant would result in impacts similar to those described above for all components of Alternative 1 (without variants).

### 4.3.5 Alternative 2—North Road and Ferry with Downstream Dams

#### 4.3.5.1 Regional Setting

**Regional Economy**

Although the alignment of the transportation corridor and natural gas pipeline would change, Alternative 2—North Road and Ferry with Downstream Dams would have the same overall impacts to the regional economy as Alternative 1a, but would have a different level of effects on specific communities due to differences in transportation corridor routes. Impacts to specific communities are discussed below.

**Cost of Living**

For the region as a whole, the impacts on the cost of living under Alternative 2 would be largely the same as the impacts of Alternative 1a, and would likely lower the high cost of living for the communities near the transportation corridor. However, because of the different alignments of the transportation corridor and natural gas pipeline, Pedro Bay would likely experience greater beneficial impacts, while Kokhanok would likely see fewer beneficial impacts.

**Regional Infrastructure**

Although the alignment of the transportation corridor and natural gas pipeline would change, Alternative 2 would have the same overall impacts to the region as Alternative 1a. However, Pedro Bay would experience more direct impacts, and Kokhanok would be impacted to a lesser extent.

#### 4.3.5.2 Potentially Affected Communities

Although the alignment of the transportation corridor and natural gas pipeline would change, Alternative 2 would have the same overall impacts to the socioeconomic indicators of the potentially affected communities as Alternative 1a. However, Pedro Bay would experience greater impacts and Kokhanok would be less impacted.

Revenues from the ROW acquisition for the transportation corridor and the natural gas pipeline would be similar to Alternative 1a and would impact the State (which would own 40 percent of the transportation corridor), ANCSA village and regional corporations (57 percent and 1 percent, respectively), and Native Allotment owners (2 percent). Compared to Alternative 1a, there would be some difference in the specific land ownership by ANCSA village corporations, affecting where ROW revenue would accrue.

#### 4.3.5.3 Changes in Sociocultural Dynamics

Impacts to the sociocultural dimension of subsistence and the cash economy would be the same as discussed for Alternative 1a, except that potential effects would be more pronounced around Pedro Bay, and less around Kokhanok.

#### 4.3.5.4 Alternative 2—Summer-Only Ferry Operations Variant

**Regional Economy**—Alternative 2 includes a variant for summer-only ferry operations. The impacts of the variant would be similar to those described in the similar Alternative 1 variant, except that potential effects would be more pronounced around Pedro Bay, and less around Kokhanok.

**Cost of Living**—Alternative 2 includes a variant for summer-only ferry operations. The impacts of the variant would be the same as described in the similar variant for Alternative 1.

**Potentially Affected Communities**—Alternative 2 includes a variant for summer-only ferry operations. The variant would be the same as described for Alternative 2 without the variant.

#### 4.3.5.5 Alternative 2—Pile-Supported Dock Variant

The Pile-Supported Dock Variant would result in impacts similar to those described above for all project components.

#### 4.3.5.6 Alternative 2—Newhalen River North Crossing Variant

The Newhalen River North Crossing Variant would result in impacts similar to those described above for all project components.

### 4.3.6 Alternative 3—North Road Only

#### 4.3.6.1 Regional Setting

**Regional Economy**

Although the alignment of the transportation corridor and natural gas pipeline would change, and there would be no ferry operations on Iliamna Lake, Alternative 3 would have the same overall impacts to the regional economy as Alternative 1a. The distribution of effects between communities would be similar to Alternative 2.

**Cost of Living**

For the region as a whole, the impacts on the cost of living for Alternative 3 would be largely the same as the impacts of Alternative 1a; the magnitude of the impact would lower the high cost of living for the communities near the transportation corridor, similar to Alternative 2. However, because of the different alignments of the transportation corridor and natural gas pipeline, Kokhanok would likely experience less of a benefit, while Pedro Bay would likely experience more of a benefit over the long term.

**Regional Infrastructure**

Although the alignment and components of the transportation corridor and natural gas pipeline would change, Alternative 3 would have the same overall impacts to the region as Alternative 1a, except that there would be no ferry terminals. However, Kokhanok would experience fewer impacts, while Pedro Bay would experience more. One potential benefit of the alternative is that it would be more likely that regional governments and/or the State would maintain the access roads (the Williamsport-Pile Bay Road) for public use following closure of the mine.

#### 4.3.6.2 Potentially Affected Communities

Although the alignment and components of the transportation corridor and natural gas pipeline would change, Alternative 3 would have the same overall impacts to the socioeconomic indicators of the potentially affected communities as Alternative 1a. However, Kokhanok may experience fewer impacts, while Pedro Bay would experience greater impacts.

Revenues from the ROW acquisition for the transportation corridor and the natural gas pipeline would be similar to Alternative 1a and would impact the State (which would own 30 percent of the transportation corridor), ANCSA village and regional corporations (70 percent and >1 percent, respectively), and Native Allotment owners (1 percent). Compared to Alternative 1, there would be some difference in the specific land ownership by ANCSA village corporations, affecting where ROW revenue would accrue.

#### 4.3.6.3 Changes in Sociocultural Dynamics

Impacts to the sociocultural dimension of subsistence and the cash economy would be the same as discussed for Alternative 1a, except that Kokhanok may experience fewer impacts, while Pedro Bay would experience greater impacts.

#### 4.3.6.4 Alternative 3—Concentrate Pipeline Variant

**Regional Economy**—The magnitude of impacts of this variant would be decreased employment of truck operators and increased employment at the dewatering facility. Overall, the total number of employees needed during operations would likely decrease, which would decrease overall income and employment in the region. It could potentially increase property taxes for KPB more than Alternative 1, depending on final footprint and project specifics.

**Regional Infrastructure**—The magnitude of impact of this variant would be the construction of the pipeline(s) and a dewatering facility near the port, which would likely be of no value and/or benefit to the potentially affected communities or the region as a whole, other than potential property tax revenue.

**Potentially Affected Communities**—The magnitude of impacts of this variant would be decreased employment of truck operators and increased employment at the dewatering facility. Overall, the total number of employees needed during operations would likely decrease, which would decrease the overall income and employment in the potentially impacted communities. However, the KPB would receive an increase in property taxes levied on the assessed value of the portion of the concentrate pipeline located in the borough.

### 4.3.7 Cumulative Effects

Potential impacts to the socioeconomic environment include changes to economy and income, regional education and infrastructure, cost of living, and population. In addition, cultural ties to the area can impact the socioeconomic welfare of a community. Potential cumulative effects on commercial fishing and recreational tourism are discussed in Section 4.6, Commercial and Recreational Fisheries. Subsistence activity and the importance of subsistence as it relates to income and its support in stabilizing communities during economic downtimes are discussed in Section 4.9, Subsistence. The sociocultural dimensions are discussed in Section 4.7, Cultural Resources, and Section 4.9, Subsistence.

The cumulative effects analysis area includes the region around the potentially affected communities, and to a lesser extent, the state of Alaska. Similar to the project, opportunities would also exist for employment for people living across a broad area of Alaska. Potential cumulative effects could occur on the regional and state economy, infrastructure, cost of living, government revenue, and population characteristics.

All of the actions identified in Section 4.1, Introduction to Environmental Consequences, are considered to have the potential to contribute to cumulative effects on the needs and welfare of the people of Alaska.

### 4.3.7.1 Past and Present Actions

The categories of past and present actions that have contributed to the existing socioeconomic conditions of potentially affected communities include commercial and subsistence harvest of fish and wildlife, commercial recreation and tourism, community development and infrastructure, mining exploration activities, the Williamsport-Pile Bay Road, and the Diamond Point Quarry. Changes in fishing technology and the variability of fish returns have changed the regional economy from year to year. The trend of declining local ownership of fishing permits has decreased the amount of local employment and income in some parts of the region, notably the area around Iliamna Lake. Fluctuations in oil prices have affected the availability of state and local revenue, affecting capital improvement projects and services in the region. When major projects are developed, there is often high employment associated with construction cycles, which then drops during operation cycles. In addition, seasonal employment fluctuation exists at the regional level, largely due to seasonality of the commercial fishing, construction, and tourism industries. Limited transportation infrastructure keeps cost of living high, which is offset somewhat by subsistence hunting and fishing. Declining population in some communities of the LPB have resulted in school closures when the number of students drops below 10, the state minimum to keep a school open.

### 4.3.7.2 Reasonably Foreseeable Future Actions

The reasonably foreseeable future actions (RFFAs) identified in Section 4.1, Introduction to Environmental Consequences, that could contribute to the regional and state socioeconomic cumulative impacts are carried forward in this analysis in Table 4.3-2.

The No Action Alternative would not contribute to adverse or beneficial cumulative effects on the regional and state economy, infrastructure, cost of living, and population characteristics. Although there may be some decrease in the current level of economic activity generated by exploration of the Pebble Project, exploration activities could continue.

Collectively, the Project Alternatives with RFFAs' contribution to cumulative effects on the socioeconomic environment are summarized in Table 4.3-2.

**Table 4.3-2 Contribution to Cumulative Effects on Socioeconomics**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Pebble Project expansion Scenario | **Mine Site:** The Pebble Project expansion scenario would likely increase the beneficial and adverse impacts realized from the project. Mineral processing is estimated to increase nearly 40 percent. Employment and income opportunities realized from the expansion, as well as tax revenue and cost of living reductions, would continue and potentially increase through the 78-year expansion period. If a severance tax on production was imposed by the LPB, increased production would generate additional local tax revenue.<br>**Other Facilities:** A north access road, concentrate pipeline, and diesel pipeline would be constructed along the Alternative 3 road alignment from Eagle Bay to a new deepwater port site at Iniskin Bay. Pipeline construction would provide additional employment opportunities. Construction of the port and north access road would also provide an additional route to ship goods into the region and contribute to reductions in transportation costs. The new deepwater port and pipeline facilities would generate additional tax revenue for the KPB. Due to the proximity of the new transportation corridor, the community of Pedro Bay would benefit more, and Kokhanok less.<br>**Magnitude.** The operation of the mine during the extended period would have socioeconomic impacts similar to those from operation of the proposed project. With the transition for trucking concentrate to shipment via concentrate pipeline, there could be fewer long-term employment opportunities associated with truck drivers, but additional construction, and potentially operations employment, with mine expansion.<br>**Duration/Extent**: The duration/extent of cumulative impacts to Socioeconomics would vary from temporary (e.g., jobs created during construction) to long term (e.g., jobs created during operations). Effects on | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** Alternative 1 would be similar to Alternative 1a, except that the portion of the access road from the Eagle Bay ferry terminal to the existing Iliamna area road system would not already be constructed. The complete north access road would be constructed from the mine site to the Pile Bay terminus of the Williamsport-Pile Bay Road. Concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay.<br>**Magnitude:** The magnitude of cumulative impacts to socioeconomics would be similar to that under Alternative 1a.<br>**Duration/Extent:** The cumulative impacts to socioeconomics would be similar in duration and extent to Alternative 1a.<br>**Contribution:** The contribution to cumulative effects would be slightly more than under | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** The north access road would be extended east from the Eagle Bay ferry terminal to Iniskin Bay. Concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay.<br>**Magnitude:** Beneficial cumulative impacts to income and infrastructure from Alternative 2, combined with those from the Pebble Project expansion scenario, would be less than those under Alternative 1a because the south transportation system/ferry would not be in place.<br>**Duration/Extent:** The cumulative impacts to socioeconomics would be similar in duration and extent to Alternative 1a.<br>**Contribution:** Employment opportunities would be lower because employees would not be required at two transportation corridor/port locations, and the additional | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** Overall expansion would use the existing north access road; concentrate and diesel pipelines would be constructed along the existing road alignment and extended to a new deepwater port site at Iniskin Bay.<br>**Magnitude:** Cumulative tax revenue generation and reduction in cost of living would be similar to those under Alternative 2. Beneficial cumulative impacts to employment, income and infrastructure from Alternative 3, combined with those from Pebble Project expansion scenario, would be less than under the other alternatives because no ferry operation would be in place, and the north access road system used for the Pebble Project expansion scenario would already be built under Alternative 3.<br>**Duration/Extent:** The cumulative impacts to socioeconomics would be |

**Table 4.3-2 Contribution to Cumulative Effects on Socioeconomics**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | regional population (such as reduction of out-migration and any in-migration associated with job opportunities) and reductions in cost of living would be extended during mine expansion. Generation of state and local revenue would also be extended over the life of operations.<br>**Contribution:** Additional and extended employment opportunities could affect regional population; impacts to cost of living, housing, community services and generation of state and local revenue would be anticipated to remain the same as experienced during operation of the project, but would extend for the longer period of expansion. However, Pedro Bay would experience beneficial impacts from use of the transportation corridor under the Pebble Project expansion scenario than under the project as proposed. | Alternative 1a, but less than under Alternatives 2 and 3. | facilities would not generate taxable income. | similar in duration and extent to Alternative 1a.<br>**Contribution:** Employment opportunities associated with the south access road and truck traffic would be lower because employees would not be required at those locations, and the facilities would not generate additional taxable income. |
| Other Mineral Exploration and Development Projects | **Magnitude:** The RFFAs related to continuing mining exploration activities would provide some additional employment and support service activities during exploratory phases, primarily through direct employment and support service activities.<br>Although the proposed Donlin Gold Project could potentially create statewide demand for skilled workers, it would be in a different region and would have little contribution to the regional socioeconomic effects. From a statewide perspective, both the Donlin Gold Project and the Pebble Project expansion could create a competing need for support services and secondary/indirect jobs associated with such services.<br>**Duration/Extent:** Exploration activities typically occur at a discrete location for one season, although a multi-year program could expand the geographic area affected in a specific mineral prospect. (See Section 4.1, Introduction to Environmental Consequences, which identifies seven mineral | Similar to Alternative 1a.<br>**Contribution:** Because most mineral exploration activities would be limited to summer, the contribution to cumulative effects would be greater with the Summer-Only Ferry Operations Variant. | Similar to Alternative 1a.<br>**Contribution:** Because most mineral exploration activities would be limited to summer, the contribution to cumulative effects would be greater with the Summer-Only Ferry Operations Variant. | Similar to Alternative 1a. |

**Table 4.3-2 Contribution to Cumulative Effects on Socioeconomics**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | prospects in the EIS analysis area where exploratory drilling is anticipated [four are in relatively close to the Pebble Project].)<br>**Contribution:** The combination of projects would contribute to the seasonal work imbalance and further increase the demand for summer employees. This would likely require more employees from outside the region for seasonal work. | | | |
| Oil and Gas Exploration and Development | **Magnitude:** Oil and gas exploration and development would likely create some measurable cumulative effects to the socioeconomic characteristics of the potentially affected communities during the exploratory phases. Effects of onshore and offshore exploration would be seasonal and geographically limited. If offshore projects are developed, they could create a competing need for direct employees, support services, and secondary/indirect jobs associated with such services, but offshore exploration and operations activities would be supported both within and outside of the KPB, where there is a mature oil support service industry.<br>**Duration/Extent:** Seismic exploration and exploratory drilling are typically single-season, temporary activities. Offshore resources would constitute a southern extension of existing offshore production for roughly 10 to 20 years if they were developed.<br>**Contribution:** Any continuing onshore oil and gas exploration on the Alaska Peninsula would be small in scale and supported out of King Salmon rather than Iliamna Lake communities. Any offshore development in Cook Inlet would likely extend existing oil industry employment and generate state revenue during the period of production, with operations support out of Anchorage and the KPB. | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |

**Table 4.3-2 Contribution to Cumulative Effects on Socioeconomics**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Road Improvement and Community Development Projects | **Magnitude:** Transportation and infrastructure improvements, as well as renewable resource energy projects, could have an impact on the potentially affected communities. The projects could create small-scale construction and operations employment opportunities, improve services, and potentially lower the cost of living. It is possible that such projects would support additional business development, taking advantage of the infrastructure and energy improvements. Community construction projects are a particularly important source of seasonal employment and income for small communities.<br>Continued operation of the Diamond Point rock quarry has the potential to provide additional employment opportunities and generate revenues for the village corporation landowner.<br>Development of two proposed community hydroelectric projects (Knutson Creek and Igiugig) would create some short-term construction employment opportunities and lower the cost of power generation during operations.<br>**Duration/Extent:** Disturbance from road construction would typically occur over a single construction season. Geographic extent would be limited to the vicinity of communities and Diamond Point; however, labor could come from a greater distance.<br>**Contribution:** Cumulative impacts from project road construction would be anticipated to be greater if the project is implemented, which could increase development as support-related businesses take advantage of the additional employment and service opportunities provided by the mine. | Similar to Alternative 1a and Alternative 2; greater than Alternative 3. | The footprint of the Diamond Point rock quarry under Alternative 1a coincides with the Diamond Point port footprint in Alternative 2 and Alternative 3. Cumulative impacts would likely be less under Alternative 2 due to commonly shared project footprints with the quarry site. | Similar to Alternative 2; less than Alternative 1a. |

**Table 4.3-2 Contribution to Cumulative Effects on Socioeconomics**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Summary of Project contribution to Cumulative Effects | Overall, the contribution of Alternative 1a to cumulative effects on socioeconomics, taking other past, present, and reasonably foreseeable future actions into account, would be minor to moderate in terms of magnitude, duration, and extent, given the jobs and tax revenues generated by the project. | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |

Notes:
EIS = Environmental Impact Statement
KPB = Kenai Peninsula Borough
LPB = Lake and Peninsula Borough
RFFA = reasonably foreseeable future action

## 4.4 ENVIRONMENTAL JUSTICE

As described in Section 3.4, Environmental Justice (EJ), Executive Order 12898 requires federal agencies to identify and address "disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations," including Alaska Native communities. Furthermore, Executive Order 12898 also requires the protection of populations with differential patterns of consumption of fish and wildlife. The Council on Environmental Quality (CEQ) defines this as differences in rates or patterns of subsistence consumption by minority, low-income, and Indian tribes, as compared with rates and patterns of consumption by the general population (CEQ 1997).

The CEQ's "Environmental Justice: Guidance Under the National Environmental Policy Act" (1997) and the US Environmental Protection Agency's (EPA's) *Promising Practices for EJ Methodologies in NEPA Reviews* (2016a) were developed to provide agencies with a process for identifying environmental justice communities and addressing potential impacts on those communities. According to these guidance documents, the basic components of an environmental justice assessment should include:

- A demographic assessment of the affected communities to identify minority and low-income populations that may be present
- An integrated assessment to determine whether any adverse impacts would disproportionately affect minority or low-income populations, including Alaska Native communities
- An opportunity for the public to participate in the process, including community, minority, low income, and tribal participation

CEQ guidance indicates that when determining whether natural and physical effects on the environment are "high and adverse," agencies are to consider if environmental effects are significant (as that term is defined by the National Environmental Policy Act [NEPA] lead agency), and if those significant effects are or may have an adverse impact on minority populations, low-income populations, or Indian tribes that appreciably exceeds or is likely to appreciably exceed those on the general population or other appropriate comparison group (CEQ 1997).

CEQ guidance also indicates that when determining whether human health effects, which may be measured in risks and rates, are high and adverse, agencies are to consider if those risks and rates are above generally accepted levels (CEQ 1997).

In addition, the EPA recommends considering the following factors in the determination of disproportionately high and adverse human health effects (EPA 2007, 2016a):

- Proximity and exposure to chemical and other adverse stressors, including impacts commonly experienced by "fence-line" communities
- Unique exposure pathways, including subsistence fishing, hunting, or gathering
- Multiple or cumulative impacts, including exposure to several sources of pollutions or pollutants from single or multiple sources
- Physical infrastructure, including inadequate housing, roads, or water supplies in communities
- Non-chemical stressors, including chronic stress related to environmental or socioeconomic impacts

The project's potentially affected population includes those who live, work, subsist, visit, or recreate in the Environmental Impact Statement (EIS) analysis area. The EIS analysis area for this section corresponds to an area that could be affected by the mine site, transportation corridor, and natural gas pipeline for each alternative through changes in economic, subsistence, and health resources and activities. This includes the six Iliamna Lake communities that would be most impacted by the project economically and through subsistence resources, and regional communities in Bristol Bay who may experience some small economic impacts from the project. Section 3.4, Environmental Justice, presents racial and ethnic characteristics and poverty status for the populations of the six Iliamna Lake communities in the EIS analysis area that would be affected during construction and operations of the project. In the EIS analysis area, Igiugig, Iliamna, Kokhanok, Newhalen, Nondalton, and Pedro Bay, all of which are communities in the Lake and Peninsula Borough (LPB), meet the CEQ definition of minority and/or low-income communities (see Section 3.4, Environmental Justice). Many of the potential physical, environmental, and social effects would be experienced more frequently and intensely by residents of those communities, given their proximity to multiple project components and their use of the area and nearby areas for subsistence harvests.

Impacts to affected communities and the population in the EIS analysis areas for these resources are described in Section 4.3, Needs and Welfare of the People—Socioeconomics; Section 4.9, Subsistence; and Section 4.10, Health and Safety. This environmental justice analysis considers information presented in those sections; considers the distribution of adverse and beneficial impacts throughout the EIS analysis area; and concludes whether there may be disproportionately high and adverse effects to minority or low-income communities. Potential impacts include:

- Changes in job opportunities, employment, recreational opportunities, income, and the cost of living
- Changes in access to and competition for subsistence resources and resource availability
- Changes in sociocultural conditions
- Changes in health and well-being, including the risk of exposure to hazardous chemicals and bioaccumulative compounds, and non-chemical stressors

Impacts are discussed in terms of magnitude, duration, extent, and potential or likelihood. The magnitude of impact is discussed in terms of the communities impacted; the duration of impacts would be short-term, lasing only though the construction phase or months to years; or long-term, lasting throughout the life of the project (decades). The geographic extent of impacts depends on the location and proximity to the affected community; and the potential of impacts is how likely the impact would be. For this analysis, impacts would be expected to occur as described if the project or alternatives are permitted and constructed.

Scoping comments were received related to disproportionate, adverse impacts to low-income and minority communities as a result of the project. Commenters requested that the EIS identify low-income, minority, and Alaska Native communities that may be impacted by the project. Concerns should be addressed regarding food security and subsistence resources, health impacts from pollution and exposure to increased industrial activities and noises, increased risk of injury and exposure to hazardous materials, increased exposure to outsiders and the cascading social and psychological effects.

## 4.4.1 Summary of Key Issues

**Table 4.4-1: Summary of Key Issues for Environmental Justice**

| Impact | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Socioeconomics | Economic benefits to minority and low-income communities. This alternative would increase job opportunities, create year-round employment, and provide steady income. Minority and low-income communities nearest the project components (i.e., Newhalen, Iliamna, Nondalton, and Kokhanok) would likely see the greatest impacts in employment and income.<br>Reduced transportation costs would likely lower the high cost of living for the communities near the transportation corridor (i.e., Newhalen, Iliamna, Nondalton, and Kokhanok). The natural gas pipeline could also provide opportunities for adjacent communities to lower their cost of living. | Same as Alternative 1a.<br>The Summer-Only Ferry Variant would create more seasonal employment and less year-round employment.<br>Impacts from the Kokhanok East Ferry Terminal Variant and the Pile-Supported Dock Variant would be the same as Alternative 1. | Same as Alternative 1a, except that Kokhanok would see fewer cost-of-living benefits, but Pedro Bay would experience greater benefits from reduced transportation costs that would lower the cost of living.<br>The Summer-Only Ferry Operations Variant would create more seasonal employment and less year-round employment.<br>Impacts from the Pile-Supported Dock Variant and the Newhalen River North Crossing Variant would be the same as Alternative 2. | Same as Alternative 2.<br>The Concentrate Pipeline Variant would have less employment and income. There would still be economic benefits to minority and low-income communities from job opportunities, year-round employment, and steady income, but to a lesser extent. |
| Subsistence | Changes in resource availability would be adverse for minority and low-income communities.<br>Impacts to access of subsistence resource harvest areas for minority and low-income communities would not be high or adverse because of access to alternate subsistence resource harvest areas.<br>Employment opportunities could provide additional revenue to support subsistence activities. | Same as Alternative 1a, except that the ferry and transportation corridor would cause less disruption of access to subsistence resource areas for freshwater seals, and more disruption of access to the Upper Talarik Creek area for residents of Iliamna, Newhalen, Pedro Bay, Igiugig, and Kokhanok.<br>Impacts from variants would be the same. | Same as Alternative 1a, except that the transportation corridor and ferry would cause more disruption of access to subsistence resource areas for residents of Iliamna, Newhalen, and Pedro Bay, and less disruption of access for residents in Igiugig and Kokhanok.<br>Impacts from variants would be the same. | Same as Alternative 1a for resource availability and access to subsistence resources.<br>Access to subsistence resource use areas would be similar to Alternative 2 for residents of Iliamna, Newhalen, Pedro Bay, and Nondalton.<br>Impacts from variants would be the same. |

**Table 4.4-1: Summary of Key Issues for Environmental Justice**

| Impact | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Health and Safety | Alternative 1a would provide economic benefits and improvements to the overall health and well-being of residents, especially those in the Lake and Peninsula Borough.<br>Beneficial and adverse impacts on minority and low-income communities from psychosocial and family stress, unintentional injuries (e.g., falls, poisoning).<br>Beneficial and adverse impacts on minority and low-income communities related to access to and quantity of subsistence resources and food security.<br>Adverse impacts from potential increased transportation/navigation accidents and potential increase in suicide rates.<br>Potential for increased risk of exposure to hazardous chemicals in air, soil, groundwater, surface water, sediment, and bioaccumulative compounds would be low, and imperceptible from baseline. Real or perceived impacts could cause additional stress for local residents harvesting salmon for subsistence, commercial fishing, and recreational fishing purposes. | Same as Alternative 1a.<br>Impacts from variants would be the same. | Same as Alternative 1a.<br>Impacts from variants would be the same. | Same as Alternative 1a.<br>The Concentrate Pipeline Variant would provide the same economic benefits and improvements to the overall health and well-being of residents as described for Alternative 3, but to a lesser extent. |
| Environmental Justice Rating | No high or adverse impacts related to socioeconomics.<br>Potential adverse impacts related to subsistence.<br>Potential adverse impacts related to human health. | Same as Alternative 1a. | Same as Alternative 1a. | Same as Alternative 1a. |

### 4.4.2 No Action Alternative

Under the No Action Alternative, federal agencies with decision-making authorities on the project would not issue permits under their respective authorities. The Applicant's Preferred Alternative would not be undertaken, and no construction, operations, or closure activities specific to the Applicant’s Preferred Alternative would occur. Although no resource development would occur under the Applicant's Preferred Alternative, Pebble Limited Partnership (PLP) would retain the ability to apply for continued mineral exploration activities under the State's authorization process (ADNR 2018-RFI 073) or for any activity not requiring federal authorization. In addition, there are many valid mining claims in the area, and these lands would remain open to mineral entry and exploration by other individuals or companies.

It would be expected that current State-authorized activities associated with mineral exploration and reclamation, as well as scientific studies, would continue at levels similar to recent post-exploration activity. The State requires that sites be reclaimed at the conclusion of their State-authorized exploration program. If reclamation approval is not granted immediately after the cessation of activities, the State may require continued authorization for ongoing monitoring and reclamation work as it deems necessary.

PLP has employed local community members at the site during the exploratory phase of the project. In particular, the communities closest to the exploration area in the LPB, likely including Nondalton, Iliamna, and Newhalen, provide the greatest proportion of the local workforce. These communities are identified as minority and/or low-income communities. Similarly, these communities and others harvest caribou, large land mammals, and other subsistence resources in the vicinity of project components. Therefore, although there may be some decrease in the current level of economic activity generated by exploration of the project, exploration could continue; no changes in additional future direct or indirect effects to existing socioeconomics, subsistence resources, or access to subsistence resources would be expected; and existing socioeconomic and habitat and resource trends would continue.

#### 4.4.2.1 Needs and Welfare of the People—Socioeconomics

Under the No Action Alternative, although there may be some decrease in the current level of economic activity generated by exploration of the project, exploration could continue, and no changes in additional future direct or indirect effects to the regional economy, cost of living, or current or projected infrastructure would be expected; existing trends would continue. As a result, the current number of direct and indirect jobs would remain the same, and there would be no impact on income, economic stability, or social integrity in minority and low-income communities.

#### 4.4.2.2 Subsistence

The extent of effects on subsistence would be limited to the exploration area. No construction, operations, or closure activities would occur; however, permitted resource exploration activities currently associated with the project may continue (ADNR 2018-RFI 073).

Resource availability would not change from the conditions present during exploration activity and environmental studies at the mine site; therefore, no additional future direct or indirect effects to subsistence resources or access to subsistence resources would be greater than existing conditions, and existing habitat and resource trends discussed in Section 3.9, Subsistence, would continue, including displacement of current subsistence activities from exploration activities. Existing exploration activities associated with the project provide some local employment and income, which could contribute to pursuit of subsistence activities. There is no guarantee that such employment would continue to be available, which could affect minority and low-income communities in the vicinity of the exploration area disproportionately, because these communities may rely more heavily on subsistence activities. Existing trends in subsistence resources and uses would be expected to continue, and these communities would continue to harvest subsistence resources; the effects of the No Action Alternative would not be high or adverse.

#### 4.4.2.3 Health and Safety

Although the current number of direct and indirect jobs would remain roughly the same (see Section 4.3, Needs and Welfare of the People – Socioeconomics), human health impacts associated with any potential loss of employment opportunities (and subsequent decrease in household income) primarily concern increases or decreases in social determinants of health (SDH), such as income, psychosocial stress, substance abuse, violent crime, and family stress and stability. Any potential SDH impacts would be relatively small in magnitude, relative to baseline conditions, and would largely be confined to communities closest to the mine site (Nondalton, Iliamna, and Newhalen). There would be no impact to more distant communities in the lower Bristol Bay watershed, such as Dillingham, other than removing uncertainty about the fate of this project. Other health factors would likely be similar to current conditions (i.e., baseline), such as potential rates of accidents and injuries, communicable and non-communicable diseases, exposure to hazardous constituents, and access to healthcare services (see Section 4.10, Health and Safety).

Human health impacts from the No Action Alternative would not be perceptible, or those impacted would be able to adapt with ease and not require medical intervention. Direct effects would be largely similar to baseline levels of health. Current health conditions and trends, as described in Section 3.10, Health and Safety, would continue in the EIS analysis area (see Section 4.10, Health and Safety). In addition, a decision not to permit the project may relieve some stress in affected communities associated with concerns regarding project development and perceived impacts on salmon.

### 4.4.3 Alternative 1a

This section presents the potential for Alternative 1a to result in high and adverse effects on minority and low-income populations. Both adverse and beneficial effects are summarized below.

#### 4.4.3.1 Needs and Welfare of the People—Socioeconomics

As discussed in Section 4.3, Needs and Welfare of the People—Socioeconomics, Alternative 1a would provide economic benefits to individuals, families, and communities in the form of increased incomes, year-round employment, and steady income, and would reduce the impacts of the seasonal fluctuations in employment. Under Alternative 1a, in terms of magnitude of impacts, the number of employees would increase to about 2,000 during the 4-year construction phase, and 850 during the 20-year operation of the mine. For the construction phase, PLP has estimated that 250 employees (out of 2,000) would come from the surrounding communities, with 50 of these employees coming from communities connected to the project site by road (PLP 2018-RFI 027).

The communities closest to the mine site include Nondalton, Iliamna, and Newhalen, and Kokhanok on the southern shore of Iliamna Lake; these communities are also proximal to the transportation corridor. These communities meet the definition of minority and low-income communities. Although PLP has generated exploration-related employment for residents of villages throughout the LPB and broader Bristol Bay region over the past decade, the communities surrounding Iliamna Lake and connected by road have provided the greatest proportion of the local workforce. It would be anticipated that residents of the communities surrounding Iliamna Lake would continue to provide the majority of the local workforce for construction and operations of the project. An increased revenue stream and stabilization of population levels attributable to employment opportunities could result in improvements to community health care facilities throughout the borough, including minority and low-income communities. Therefore, employment through the project would have beneficial economic effects on minority and low-income communities. These effects would last through the life of the project.

The LPB is not connected by road to the rest of the state, and has few roads, contributing to an extremely high cost of living. As described in Section 4.12, Transportation and Navigation, Alternative 1a would result in the construction of roads and ports. Although the road and port would have limited access, PLP has stated that they would work with all local communities to identify the best solutions for controlled-access use of the road and ferry for community transportation (PLP 2018-RFI 027). Additional access would be coordinated between the State of Alaska, the LPB, PLP, and landowners. In terms of magnitude and extent, Alternative 1a has the potential to reduce transportation costs of materials and goods to the transportation corridor area's potentially affected communities (Kokhanok, Iliamna, Newhalen, and potentially Nondalton). Reduced transportation costs would lower the cost of living for these communities, many of which are minority and low income. These benefits may cease if the roads are reclaimed at the end of the project.

Communities adjacent to the natural gas pipeline (Kokhanok, Newhalen, and Iliamna) would have the opportunity to connect to the pipeline. For heating buildings, natural gas would likely be less expensive than diesel heating oil, which could lower the cost of living once equipment (e.g., furnace, water heater) is converted to natural gas; however, communities would be responsible for funding the connections and conversions. These benefits may cease if the pipeline is reclaimed at the end of the project. No other impacts to public utilities would be apparent.

The increase in job opportunities, year-round or seasonal employment, steady income, and lower cost of living described above would have beneficial impacts on the EIS analysis area, especially for communities in the LPB, during construction and operations of the project. Therefore, the effects of Alternative 1a on the needs and welfare of the people would not be "high or adverse."

Although the project would provide a more stable employment base, it should be noted that the actual number of direct and indirect jobs in any given year could fluctuate based on economic conditions and/or business decisions.

### 4.4.3.2 Subsistence

As discussed in Section 4.9, Subsistence, communities closest to project infrastructure would be the most affected by changes in resource availability. These include the minority and/or low-income communities of Iliamna, Newhalen, Pedro Bay, Igiugig, Nondalton, and Kokhanok. Communities in the Nushagak River drainage and the Kvichak River drainage below Iliamna Lake would experience little to no impact on resource availability or access to resources during routine operations because they use areas that are distant from the project area.

Project construction (and to a lesser extent, operations) would impact the availability and abundance of traditional and subsistence resources through habitat loss; behavioral disturbance to resources from increased noise and human activity; fugitive dust deposits on vegetation; concerns about contamination of resources; avoidance of subsistence harvest areas; wildlife injury and mortality, and increased costs and times for traveling to more distant areas. In terms of magnitude and extent of impacts, there would be a potential for a small population increase in communities closest to the mine site, which could introduce a small amount of resource competition to the area. Adaptive strategies for the harvest of resources could maintain harvest levels for affected communities, but with the burden of additional expenditures of time and money needed to harvest subsistence resources. This could impact retention and transmission of traditional knowledge and practices related to the areas affected by project activities. In general, the impacts of subsistence resource availability on minority and low-income communities would potentially be adverse.

Construction and operations of the project would result in changes in access to subsistence resources. During the construction period, access to resources in the immediate vicinity of project components would be inhibited or restricted. In terms of extent, this would impact the communities near project infrastructure that use this land for subsistence fishing, hunting, gathering, education of youth on subsistence traditions, and other cultural and customary practices. Construction of linear features, such as the roads, pipeline, and ice-breaking ferry corridor, could interrupt travel to resources or communities on the other side of the linear features. Safety considerations and presence of project equipment and personnel may restrict hunting activities in proximity to construction activities and facilities, resulting in adverse effects on those minority and low-income communities. Additionally, specific individuals and families that own Native Allotments near project infrastructure and transportation facilities would be disproportionately impacted if project construction and operations activities reduced the availability or value of subsistence resources on or surrounding the Native Allotments.

Once constructed, in terms of magnitude, the natural gas pipeline corridor right-of-way and the transportation corridor roads would likely have a positive impact on minority and low-income communities by providing access to subsistence resources, because these cleared routes would facilitate overland all-terrain vehicle and snowmachine travel under approved conditions. During operations, PLP has stated it would work with local communities to identify safe, practicable ways for residents to use the access roads, such as scheduled, escorted convoys for private vehicle transport; however, crossing at designated points or avoidance of barge traffic may add travel time and expense for subsistence users. The Iliamna Lake ice-breaking ferry could disrupt winter travel over the frozen lake by potentially adding to travel time, complicating travel logistics, increasing the risk of accident and injury, and increasing fuel and maintenance expenditures. This could potentially result in adverse effects on minority and low-income communities that rely on winter travel over the lake. In addition, the open water in the ferry's wake would present a safety hazard for subsistence users. PLP has stated it would work with communities (and supply funding) to provide for the marking and maintenance of snowmachine trails between communities across Iliamna Lake when lake ice would be thick enough to support such traffic (see Chapter 5, Mitigation).

In terms of extent, impacts on access to subsistence resource harvest areas would occur for the minority and/or low-income communities closest to the project components: Nondalton, Iliamna, Newhalen, Pedro Bay, Igiugig, and Kokhanok. In terms of magnitude, impacts associated with access around the mine site for subsistence use and harvest would be most concentrated near the mine site area, and would diminish with distance. The magnitude, duration, and extent of impacts of the transportation corridor and associated uses of areas would vary depending on the activity of the user and the location of the use area in relation to the transportation corridor. The effects would be limited in geographic extent, and subsistence users would be able to access other areas for harvest of resources, based on overlapping areas shown in Section 4.9, Subsistence. The duration of impacts from the transportation corridor and associated uses would be intermittent to long term over the 24-year period of project construction and operations, and extend beyond the life of the mine. Although impacts would be long-term, there would be other accessible areas for subsistence hunters, although there may be increased time and resources spent to harvest. Therefore, the impacts of access to subsistence resource harvest areas for minority and low-income communities would not be "high and adverse" (see Section 4.9, Subsistence, for a detailed discussion of impacts related to changes in access of subsistence resource harvest areas for the communities of Nondalton, Iliamna, Newhalen, Pedro Bay, Igiugig, and Kokhanok).

In terms of magnitude and extent, project construction and operations would be expected to increase employment opportunities for local residents, particularly for those living in communities surrounding Iliamna Lake. Many subsistence activities depend on cash income to pay for the tools, ammunition, equipment, maintenance, and fuel used to harvest, process, and store subsistence resources. When cash incomes increase, subsistence production often increases as a result (Wolfe et al. 2010). Therefore, new employment opportunities that would last throughout the life of the mine would benefit minority and low-income communities.

Changes in harvest participation are a leading indicator of cultural changes. The level of participation may be affected by changes in resource abundance and quality, season and bag limits, changes in physical access, real or perceived changes in cultural perceptions of resources (e.g., fish and animals seen as tainted/contaminated, or water seen as polluted) and the times and funds available for subsistence activity change. Year-round and rotational employment could reduce the opportunity for subsistence users to harvest and process resources, as well as reduce their ability to pass on skills and knowledge to the next generation. Households and communities would need to adjust to new roles of subsistence labor, changes in sharing networks, and to possible changes in harvest levels. Project employment or related regional out-migration could cause the reduction or loss of subsistence production from high-harvesting households. In typical communities, 30 percent of households harvest 70 percent of the resources, and there is a high level of sharing that occurs among households (Wolfe et al. 2010).

The loss of high-harvesting households and a reduction in sharing could result in less availability of traditional foods, thereby having adverse impacts on minority and low-income communities. If high-harvesting members of “super households” find project-related employment and have less time for subsistence activities, the rest of the community and households in other communities could end up receiving less wild food through sharing and trading relationships. Therefore, the impacts would be long-term, lasting through mine closure. However, the effects could be reduced with planned periods of leave options during subsistence harvest periods.

#### 4.4.3.3 Health and Safety

Section 4.10 and Appendix K4.10, Health and Safety, describe impact ratings for the health effects category under Alternative 1a. These effects determinations take into account impact-reducing design features proposed for the project. Although eight health effect categories (HECs) were considered, the primary focus of the health assessment were HECs 1 through 4, including SDH, accidents and injuries, exposure to hazardous materials, and food, nutrition, and subsistence activity. The relevance to the project of the remaining HECs (5 through 8) is expected to be low, and they are not summarized below, but are presented in Section 4.10 and Appendix K4.10, Health and Safety, for completeness.

The project would increase household incomes, employment rates, and education attainment during construction and operations phases, and those economic benefits would likely result in an improvement to the overall health and well-being of residents living in the communities from which the workforce for the project would be employed. Many of the communities that would experience these beneficial effects are minority and low-income communities. Economic benefits to these communities would also likely result in increased dietary options, lower regional food costs, and increased income for purchasing subsistence-related equipment. The benefits would be more apparent in the small, rural LPB communities, where even minor changes in their economies could have a measurable impact on their overall health and well-being.

Impacts on psychosocial health, family stress, other unintentional injuries (e.g., falls, poisoning), and food security (relative to impacts to cost of living/food and subsistence resources) would be both beneficial and adverse. In terms of magnitude and extent, beneficial effects could include increased funding for the borough to maintain or improve community health services, and increased financial security for community members employed by the project. Adverse health consequences may be related to fear of changes in lifestyle and cultural practices, depression and increased substance abuse, land encroachment, impact to the environment, and real or perceived impacts on food security and quality associated with both commercial and recreational fishing, and with subsistence activities. The project could result in an increase of transportation/ navigation accidents and injuries for mine workers and the public at surface access road crossings (at a minimum) if alternate safe routes or mitigation measures were not taken. In addition, the project could potentially result in increased intentional injury (suicide) due to increases in psychosocial stress and any decreases in family stability. However, it is difficult to predict changes in the direction and magnitude of impacts to suicide rates because it is influenced by complex, multi-dimensional contributing factors.

Impacts on access to and quantity of subsistence resources could be both adverse and positive to health; and in terms of magnitude and extent, many of these effects would be most noticeable to communities in close proximity to the mine site, including material sites, and the transportation corridor. Potential negative impacts could be from actual or perceived decreases in access to, availability, and/or quality of subsistence resources, which could also adversely impact food security, community health/well-being, and cultural identity. Subsistence users would likely adjust the resource use areas and species composition of harvest resources to target resources that would be less affected by project activities. Although these adaptive approaches would likely sustain harvest levels for affected communities, they may increase expenses and time needed to harvest subsistence resources, and add to psychosocial stress and anxiety. However, benefits may also occur, because increased incomes and employment can positively affect subsistence harvest levels and participation, including making procurement of hunting and fishing equipment more affordable, which in turn could positively affect food security.

The magnitude of health impacts related to unanticipated project spills may include psychosocial stress and anxiety regarding the possible or actual occurrence of spills; potential temporary releases of hazardous chemicals to air, water, and soil; and possible exposures to chemicals by subsistence resources that are ultimately consumed by humans. Planned measures to address these potential impacts include prompt measures for spill containment, rapid community outreach and notifications, as well as testing and monitoring of environmental media such as air, water, and subsistence food resources (see Section 4.27, Spill Risk).

Other adverse key health outcomes considered are the potential for increased risk of exposure to hazardous chemicals in air, soil, groundwater, surface water, and sediment from the project construction, operations, and closure activities. Exposure to hazardous chemicals could occur through inhalation, physical (i.e., dermal) contact, and direct or indirect ingestion (e.g., direct exposure through incidental soil ingestion or indirect exposure through ingestion of subsistence foods that have the potential to bioaccumulate chemicals of potential concern [COPCs]). Recreational and subsistence activity users are expected to be the most frequent visitors to the areas affected by project-related chemicals; in terms of impact extent, these users may be drawn from the potentially affected communities identified in the EIS analysis area, particularly those in closest proximity: Nondalton, Iliamna, and Newhalen, each approximately 17 miles from the mine site; and Kokhanok, which would be approximately 2 miles from the port access road and pipeline route, and would have a spur road to the community. Specific project sources of hazardous materials, the media in which they might occur, and the magnitude and extent of impacts on potentially affected communities are summarized below. The duration of potential impacts from exposure would be long-term. See Section 4.10 and Appendix K4.10, Health and Safety, for a discussion of modeling criteria used to determine health risks associated with exposure to metals, COPCs, and hazardous air pollutants (HAPs).

- **Air Exposure Pathways—**Project air emissions resulting from stationary sources (e.g., turbines, generators, boilers), mobile sources (e.g., vehicle and mobile equipment exhaust), and fugitive sources (e.g., air particulates from blasting, drilling, vehicle road dust, and wind erosion) could potentially be inhaled by residents in the affected communities, subsistence receptors, and recreational users. Quantitative and qualitative air emission evaluations conducted for this EIS determined that the air inhalation exposure pathway from all project components would not be expected to impact the health of the affected communities, including residents, subsistence receptors, and recreational users. In addition, with implementation of dust mitigation measures, the potential localized and near-field air quality fugitive dust impacts from the project would be further reduced. Within the limits of its regulatory authority, the Alaska Department of Environmental Conservation can require an assessment of ambient air quality to verify whether fugitive dust is causing or significantly contributing to concentrations of particulate matter above ambient air standards.
- **Soil Exposure Pathways—**Mine site fugitive dust emissions from material and handling activities (mined ore, quarry rock, overburden, and waste rock) could result in wet and dry dust deposition of metals onto soils, waterbodies, and vegetation (e.g., berries) due to the concentration of heavy metals found in orebody materials. Mine site fugitive dust deposition modeling indicates that this could result in negligible increased concentrations of HAP metals and non-HAP metals above baseline outside of the mine site. Because it is expected that concentrations of HAP and non-HAP metals in soils would be almost indistinguishable from current baseline concentrations, they would not result in any new exceedances of health-based criteria (beyond those that already exceed baseline concentrations). The transportation corridor, Amakdedori port, and natural gas pipeline fugitive emissions also have the potential to result in dust deposition. However, because only existing soils with baseline levels of naturally occurring metal concentrations would be disturbed during construction, and local non-potentially acid-generating rock sources would be used for construction of the roadway, dust deposition would not be expected to increase metal concentrations above baseline conditions. Overall, dust deposition impacts to soil would not be expected to impact the health of the affected communities, including subsistence receptors and recreational users, through direct exposure relative to baseline conditions.
- **Water Exposure Pathways—**Affected communities could be exposed to mine site surplus water, inadvertent release of vehicle- or ferry-related materials (e.g., fuel, oil, and lubricants) during transportation corridor operations, and mine site fugitive emissions that could result in dust deposition of metals to surface waterbodies or to soil, and subsequent leaching to groundwater. Mine site surplus water (e.g., non-contact stormwater runoff and contact water) would be collected separately on site and discharged to downstream drainages during operations and closure after treatment under permits. Because mine site effluent would be treated to meet permitting requirements (if permits are issued) prior to discharge, the mine site effluent would not be expected to result in impacts to surface water quality, and would be presumed to be protective of human health, even for the most intensive uses, such as potable use and household water supply.

  Mine site material and handling activities would result in fugitive emissions that could result in wet and dry dust deposition of metals to surface waterbodies. Expected concentration increases in surface water and sediment at the end of mine site operations are negligible relative to baseline and future risk/hazards for metal concentrations. Therefore, the surface water and sediment exposure pathways from dust deposition would not be expected to impact the health of the affected communities above baseline conditions, including subsistence receptors and recreational users.

The health evaluation used future media concentrations expected immediately outside the mine, which would be protective of existing drinking water protection areas near the project and the potentially affected communities. Iliamna, Newhalen, and Nondalton have community drinking water wells east of the mine site. Mine site groundwater would be expected to be captured by the seepage collection systems or contained in the open pit cone of depression, remaining within the mine site boundaries, and would not be expected to impact the mine drinking water wells of these communities. Metals deposited on soil from mine site fugitive emissions may subsequently leach to groundwater, representing a potential source of increased metals to groundwater. Any dust deposition impacts to soil and subsequently groundwater would be greater for those communities in close proximity to the mine site boundary, and would be less for other potentially affected communities farther away. Because dust deposition impacts to soil would be expected to result in negligible increases from baseline soil, there would not be groundwater exceedances of health-based criteria (beyond those that already exceed baseline concentrations). Therefore, dust deposition impacts to soil and subsequent potential migration to groundwater would not be expected to impact the health of the affected communities relative to baseline groundwater conditions.

- **Subsistence Food Exposure Pathways—**Exposure to project-related chemicals through food may occur through consumption of food resources that dust-containing chemicals have deposited directly on (e.g., berries and other plant produce), or consumption of food that has taken up project-related chemicals from the surrounding environmental media by bioaccumulation (e.g., uptake of metals by edible fish from sediments, water, or invertebrate prey items, or by plants from soils). Affected communities consuming a subsistence diet may be exposed to higher levels of bioaccumulative compounds because subsistence foods may compose a very large portion of daily dietary intake.

  Consumption of terrestrial plant foods impacted by mine site dust deposition may be seasonal, because dust would be washed off of the vegetation/berries surrounding the project during winter months, or can occur throughout the duration of project activities. The geographic extent of effects to vegetation from fugitive dust would be areas adjacent to the construction activities, active mine site, and roads with vehicle traffic or in unpaved surface areas, with the highest concentrations of dust closest to the source. Fugitive dust impacts would be expected to discourage subsistence users from harvesting resources near the areas affected by the mine site and the transportation corridor. Therefore, potential dietary exposure to plant foods impacted by dust deposition would be anticipated to be low for subsistence users.

  Vegetation has the potential to be ingested by wildlife, which may subsequently be harvested and consumed by subsistence users. Caribou and moose would be expected to avoid areas impacted by dust deposition, and subsistence users may avoid harvesting resources near the mine site and transportation corridor due to air/dust deposition concerns. In addition, increases on or in terrestrial wildlife (upland game) at the end of project operations would be expected to be negligible to slight, given the predicted negligible increases of HAP and non-HAP metals in abiotic media at the end of project operations. Therefore, potential dietary exposure to terrestrial wildlife impacted by dust deposition would be anticipated to be low for subsistence users.

Mine site fugitive emissions would result in direct dust deposition to surface waterbodies. In addition, mine site activities would create new areas of standing water in the mine site that may attract waterbirds, including various freshwater storage impoundments, the tailings pond, and the pit lake. Edible fish have the potential to uptake bioaccumulative metals from water, sediments, or invertebrate prey items; and waterbirds have the potential to uptake bioaccumulative metals in water and aquatic prey items. The edible fish and waterbirds may then be harvested and consumed by subsistence users. However, surface water concentrations outside the mine site are expected to be below water quality criteria protective of the environment and human health. Increases of all bioaccumulative metals in fish in surface waterbodies outside the mine site at the end of operations would be expected to be negligible to slight. Bioaccumulation potential would be expected to be low for migratory waterfowl because they would not be expected to have sufficient exposure to the mine site water storage features, including the pit lake. Impacts to wildlife from all aspects of the project, including around the pit lake, would be minimized or mitigated through PLP's development and implementation of a Wildlife Management Plan. Therefore, potential dietary exposure to bioaccumulative chemicals from fish and waterbirds would be anticipated to be low for subsistence users.

### 4.4.4 Alternative 1

This section presents the potential for Alternative 1 to result in high and adverse effects on minority and low-income populations. Both adverse and beneficial effects are summarized below.

#### 4.4.4.1 Needs and Welfare of the People—Socioeconomics

The magnitude, duration, extent, and likelihood of impacts of Alternative 1 on employment and income would likely be the same as the impacts of Alternative 1a. The impacts on the cost of living of Alternative 1 would be largely the same as the impacts of Alternative 1a, and would likely lower the high cost of living for the communities near the transportation corridor. Although the alignment of the mine access road and natural gas pipeline would change, Alternative 1 would have the same overall impacts to the socioeconomic indicators of the potentially affected communities as Alternative 1a. Overall, environmental justice determinations would be the same.

#### 4.4.4.2 Subsistence

The magnitude, duration, extent, and likelihood of impacts from the changes in resource availability, access to subsistence resources, and the sociocultural dimension of subsistence under Alternative 1 would be the same as Alternative 1a, except for differences described below. As described above for Alternative 1a, these impacts could result in both beneficial and adverse effects on minority and low-income communities.

Changes in resource availability along the transportation corridor and the natural gas pipeline would be similar to Alternative 1a for the port access road, but the natural gas pipeline impacts would likely have a somewhat smaller geographic extent during construction because there would be no deviation of the natural gas pipeline away from the mine access road. Individual mortality, behavioral disturbance, and displacement of subsistence resources would occur at approximately the same levels as described under Alternative 1a.

In terms of magnitude, the mine access road would cause less disruption of access to subsistence resource areas for residents of Nondalton, Iliamna, Newhalen, Pedro Bay, Igiugig, and Kokhanok than Alternative 1a, with the exception of the Upper Talarik Creek areas. Ferry operations would also result in a smaller-magnitude impact to resource availability for seals compared to

Alternative 1a from ferry operations. Magnitude of impacts would vary from year-to-year, depending on location of subsistence resources during any given year. Therefore, the impacts of access to subsistence resource harvest areas for minority and low-income communities would not be "high and adverse," and would be offset to some degree by the availability of alternate resources.

#### 4.4.4.3 Health and Safety

Alternative 1 would have the same or similar magnitude, duration, extent, and likelihood of health and safety impacts on communities as those for Alternative 1a, with few exceptions. The area of Iliamna Lake used for the ferry would be different, because it would travel to the north ferry terminal instead of the Eagle Bay ferry terminal. The mine access road alignment would be different; however, accidents and injuries due to transportation would be the same as Alternative 1a. Overall environmental justice determinations would be the same.

#### 4.4.4.4 Alternative 1—Kokhanok East Ferry Terminal Variant

The Kokhanok East Ferry Terminal Variant would have the same magnitude, duration, extent, and likelihood of impacts to socioeconomics, subsistence, and health and safety in the context of environmental justice as discussed above.

#### 4.4.4.5 Alternative 1—Summer-Only Ferry Operations Variant

The Summer-Only Ferry Operations Variant would have the same magnitude, duration, extent, and likelihood of impacts to health and safety in the context of environmental justice as discussed above. Impacts from socioeconomics and subsistence would be the same, except that for socioeconomics, it would likely shift some of the positions held by community members from year-round to seasonal, which would also lower the overall income earned by community members that stays in the region compared to year-round ferry operations, and would have fewer beneficial impacts than Alternative 1 without the variant. For subsistence, this variant would not have impacts to lake travel and associated harvest activities in the winter. Overall, there would be tradeoffs, but environmental justice determinations would be the same.

#### 4.4.4.6 Alternative 1—Pile-Supported Dock Variant

The Pile-Supported Dock Variant would have the same magnitude, duration, extent, and likelihood of impacts to socioeconomics, subsistence, and health and safety in the context of environmental justice as discussed above.

### 4.4.5 Alternative 2—North Road and Ferry with Downstream Dams

This section presents the potential for Alternative 2 to result in high and adverse effects on minority and low-income populations. Both adverse and beneficial effects are summarized below.

#### 4.4.5.1 Needs and Welfare of the People—Socioeconomics

The magnitude, duration, extent, and likelihood of impacts of Alternative 2 on employment and income would be expected to be the same as the impacts of Alternative 1a. It would be anticipated that residents of the communities surrounding Iliamna Lake would continue to provide the majority of the local workforce for construction and operations of the project under Alternative 2. The increase in job opportunities, year-round employment, and steady income under Alternative 2 would have the same beneficial impacts on minority and low-income communities as Alternative 1a. However, Pedro Bay would primarily experience more of these impacts instead of Kokhanok.

The impacts on the cost of living of Alternative 2 would likely be the same as the impacts of Alternative 1a for the communities of Nondalton, Iliamna, and Newhalen. However, because the mine and port access roads and ferry route would be at the northern end of the lake around Pedro Bay as opposed to the mid-lake region, Kokhanok would likely see fewer cost-of-living benefits under Alternative 2; however, Pedro Bay, which is considered a minority community, would likely experience greater beneficial impacts from reduced transportation costs that would lower the high cost of living.

### 4.4.5.2 Subsistence

The magnitude, duration, extent, and likelihood of impacts from the changes in resource availability, access to subsistence resources, and the sociocultural dimension of subsistence under Alternative 2 would be the same as Alternative 1a, except for the differences described below. As described for Alternative 1a, impacts could result in both beneficial and adverse effects on minority and low-income communities.

Changes in resource availability along the transportation corridor and the natural gas pipeline for Alternative 2 would be similar to Alternative 1a. Disturbance to and displacement of subsistence resources would occur at approximately the same levels. The primary difference is that there are fewer communities using the area between Pile Bay and Williamsport for subsistence; therefore, the magnitude of the impact would be less than Alternative 1a.

Under Alternative 2, there would be an overland pipeline right-of-way from Pile Bay to Eagle Bay. This could introduce some competition to subsistence users from recreational sport hunting and fishing; although because of the relatively low recreational use of the area, the magnitude of the effects on minority and low-income communities from competition for subsistence resources would be expected to be small.

In terms of extent of impacts under Alternative 2, the mine and port access roads and ferry terminals would be at the northern and eastern ends of the lake, as opposed to the mid-lake region. In terms of magnitude, the transportation corridor and ferry would cause more disruption of access to subsistence resource areas for residents of Nondalton, Iliamna, Newhalen, and Pedro Bay; less disruption of access for residents in Kokhanok; and no impacts to residents of Igiugig. In addition, there would be a higher number of overlapping use areas along the road and pipeline corridors of Alternative 2 from Pedro Bay to the mine site, and the magnitude of the impact would be slightly greater than Alternative 1a. Ferry operations would also result in a higher-magnitude impact to resource availability for seals compared to Alternative 1a, due to impacts from ferry operations. However, similar to Alternative 1a, there would be availability of alternate areas in traditional subsistence areas for activities for these communities. Magnitude of impacts would vary from year-to-year, depending on location of subsistence resources during any given year.

Therefore, the impacts of access to subsistence resource harvest areas for minority and low-income communities would not be “high and adverse,” and would be offset to some degree by the availability of alternate resources.

### 4.4.5.3 Health and Safety

Alternative 2 would have the same magnitude, duration, extent, and likelihood of health and safety impacts on minority and low-income communities as Alternative 1a. Alternative 2 would provide the same economic benefits and improvements to the overall health and well-being of residents; would have the same beneficial and adverse impacts on psychosocial health, family stress, and unintentional and intentional injuries; and would have the same beneficial and adverse impacts on access to and quantity of subsistence resources as described above for Alternative 1a.

Alternative 2 would have the same magnitude and duration potential for increased risk of exposure to hazardous chemicals in air, soil, groundwater, surface water, sediment, and bioaccumulative compounds as Alternative 1a. However, this alternative includes a natural gas pipeline along the Alternative 3 north road alignment, which eliminates any potential transportation/navigation hazards and impacts at the Iliamna Lake segment during the construction phase under Alternative 1a. In terms of geographic extent, under Alternative 2, the communities that would be impacted are those closest to the transportation corridor: Iliamna, Newhalen, Nondalton, and Pedro Bay.

See Section 4.10, Health and Safety, for information on risk of exposure.

#### 4.4.5.4 Alternative 2—Summer-Only Ferry Operations Variant

The Summer-Only Ferry Operations Variant would have the same magnitude, duration, extent, and likelihood of impacts to socioeconomics, subsistence, and health and safety in the context of environmental justice as discussed above, and as for this variant in Alternative 1.

#### 4.4.5.5 Alternative 2—Pile-Supported Dock Variant

The Pile-Supported Dock Variant would have the same magnitude, extent, duration, and likelihood of impacts to socioeconomics, subsistence, and health and safety in the context of environmental justice as discussed above.

#### 4.4.5.6 Alternative 2—Newhalen River North Crossing Variant

The Newhalen River North Crossing Variant would have the same magnitude, duration, extent, and likelihood of impacts to socioeconomics, subsistence, and health and safety in the context of environmental justice as discussed above.

### 4.4.6 Alternative 3—North Road Only

This section presents the potential for Alternative 3 to result in high and adverse effects on minority and low-income populations. Both adverse and beneficial effects are summarized below.

#### 4.4.6.1 Needs and Welfare of the People—Socioeconomics

The magnitude, duration, extent, and likelihood of impacts of Alternative 3 on employment and income would likely be the same as the impacts of Alternative 1a. It would be anticipated that residents of the communities surrounding Iliamna Lake would continue to provide the majority of the local workforce for construction and operations of the project under Alternative 3. The increase in job opportunities, year-round employment, and steady income under Alternative 3 would have the same beneficial impacts on minority and low-income communities as Alternative 1a. There would be no interference with winter access across Iliamna Lake, because there would be no ferry operations under Alternative 3.

The impacts on the cost of living of Alternative 3 would likely be the same as the impacts of Alternative 1a for the communities of Nondalton, Iliamna, and Newhalen. However, because the north access road would be at the northern end of the lake around Pedro Bay as opposed to the mid-lake region, the cost-of-living benefits provided to Kokhanok under Alternative 1a would not be provided under Alternative 3; however, Pedro Bay, which is considered a minority community, would benefit from reduced transportation costs that would lower the high cost of living.

#### 4.4.6.2 Subsistence

The magnitude, duration, extent, and likelihood of impacts from the changes in resource availability, access to subsistence resources, and the sociocultural dimension of subsistence under Alternative 3 would be the same as Alternative 1a, except for differences described below. As described above for Alternative 1a, these impacts could result in both beneficial and adverse effects on minority and low-income communities.

In terms of magnitude and extent, changes in resource availability along the transportation corridor and the natural gas pipeline corridor for Alternative 3 would be similar to Alternative 1a, but would occur over a different geographic area. Disturbance to and displacement of subsistence resources would occur at approximately the same levels. The primary difference is that there are fewer communities using the area between Pile Bay and Williamsport for subsistence (Iliamna, Newhalen, Nondalton, and Pedro Bay). However, there are many overlapping use areas along the road corridor of Alternative 3 from Pedro Bay to the mine site for Iliamna and Pedro Bay, so the magnitude of the impact to those communities would be slightly higher than Alternative 1a.

Under Alternative 3, the north access road would connect Pile Bay to the mine site. In terms of magnitude of impacts, this road could introduce some competition to subsistence uses of resources from recreational sport hunting and fishing. The port access road beyond Pile Bay would have similar controlled access as described under Alternative 1a; therefore, the magnitude of effects would be similar.

Access to subsistence resource use areas would be similar to Alternative 2 for residents of Nondalton, Iliamna, Newhalen, Pedro Bay, Igiugig, and Kokhanok. Similar to Alternative 1a, there would be availability of alternate areas in traditional subsistence areas for activities for these communities; however, magnitude of impacts would vary from year-to-year, depending on location of subsistence resources during any given year. There would be no ferry operations, and therefore no impacts to winter seal hunting or access on Iliamna Lake. Therefore, the impacts of access to subsistence resource harvest areas for minority and low-income communities would not be “high and adverse.”

#### 4.4.6.3 Health and Safety

Alternative 3 would have the same or similar magnitude, duration, extent, and likelihood of health and safety impacts on communities as Alternative 1a. Alternative 3 would provide the same economic benefits and improvements to the overall health and well-being of residents; would have the same beneficial and adverse impacts on psychosocial health, family stress, and unintentional and intentional injuries; and would have the same positive and adverse impacts on access to and quantity of subsistence resources as described above for Alternative 1a.

In terms of likelihood of impacts, Alternative 3 would have the same potential for increased risk of exposure to hazardous chemicals in air, soil, groundwater, surface water, sediment, and bioaccumulative compounds as Alternative 1a. In terms of magnitude, this alternative includes a natural gas pipeline along the north road, which eliminates any potential transportation/navigation hazards and impacts at the Iliamna Lake segment during the construction phase under Alternative 1a. Communities closest to the transportation corridor are the same as Alternative 2. See Section 4.10, Health and Safety, for information on risk of exposure.

Because Alternative 3 does not involve operation of a ferry across Iliamna Lake, there would be no potential safety hazards to winter transportation by local residents across Iliamna Lake compared to Alternative 1a, Alternative 1, and Alternative 2.

#### 4.4.6.4 Alternative 3—Concentrate Pipeline Variant

The Concentrate Pipeline Variant would have the same duration, extent, and likelihood of impacts to subsistence in the context of environmental justice as discussed above. In terms of magnitude, for socioeconomics and health and safety, the impacts of the variant would likely be a decrease in employment of truck operators and increased employment at the dewatering facility. Overall, the total number of employees needed during operations would likely decrease, which would decrease the overall income and employment in the potentially affected communities. However, the variant would still provide some economic benefits to minority and low-income communities by providing job opportunities, year-round employment, and steady income to a lesser extent than Alternative 3. Overall, environmental justice determinations would be the same.

### 4.4.7 Cumulative Effects

Impacts to environmental justice are those high and adverse human health or environmental effects that affect a minority or low-income population at a greater rate than the general population as a whole. The cumulative effects analysis area consists of the geographic area of those who live, work, subsist, or recreate in the EIS analysis area and the broader region that would be affected by the reasonably foreseeable future actions (RFFAs). These areas include the communities in the LPB and Dillingham Census Area, which are considered minority and low-income communities (see Section 3.4, Environmental Justice). There could be some cumulative effects on minority and low-income residents in the Kenai Peninsula Borough (KPB), Bristol Bay Borough, and Municipality of Anchorage, which are not considered minority or low-income communities as a whole. Past, present, and RFFAs in the cumulative impact analysis area have the potential to cumulatively contribute to disproportionately high and adverse effects on minority and low-income communities.

This cumulative analysis considers information presented in Section 4.3, Needs and Welfare of the People—Socioeconomics; Section 4.9, Subsistence; and Section 4.10, Health and Safety. These sections took into consideration RFFAs as identified Section 4.1, Introduction to Environmental Consequences. Because the broader region of Alaska is considered in this analysis, there are no actions identified in Section 4.1, Introduction to Environmental Consequences, that are considered to have no potential of contributing to cumulative effects on environmental justice.

#### 4.4.7.1 Past and Present Actions

**Needs and Welfare of the People—Socioeconomics**

Past and present actions that have contributed to the existing socioeconomic conditions of potentially affected communities include commercial and subsistence harvest of fish and wildlife, commercial recreation and tourism, community development and infrastructure, mining exploration activities, the Williamsport-Pile Bay Road, and the Diamond Point quarry. Changes in fishing technology and the variability of fish returns have changed the regional economy from year-to-year. Local employment and income associated with commercial fishing has been decreasing around Iliamna Lake, but remains the economic mainstay of portions of the Bristol Bay Borough and Dillingham Census Area. Commercial recreation and mineral exploration have created employment opportunities for local residents. Fluctuations in oil prices have affected the availability of state and local revenue, affecting capital improvement projects and services in the region. Employment fluctuates due to construction cycles of major projects and seasonal employment associated with commercial fishing, construction, and tourism industries. Limited transportation infrastructure keeps the cost of living high, which has contributed to the population outmigration in some LPB communities. Subsistence has remained a cultural and economic foundation of communities in the project area.

## Subsistence

Past and present actions have caused noticeable effects to subsistence resources. Such activities include subsistence activities themselves, sport fishing and hunting, mining exploration, and non-mining-related projects, such as transportation, oil and gas development, or community development actions. There have been observations of aircraft disturbance to wildlife and localized restriction of access to subsistence activities associated with mineral exploration activities, including the project.

## Health and Safety

Past and present actions such as sport fishing and hunting, mining exploration, and non-mining-related projects, such as transportation, oil and gas development, or community development actions, have all influenced health and safety conditions for minority and low-income communities in the cumulative effects analysis area. Community development and transportation infrastructure projects have generally improved human health and safety on project area communities. A certain amount of psychosocial stress has resulted from the variability in salmon runs and fish prices, affecting participants in commercial fishing. Past and present mineral exploration has also created stress with regard to concerns about potential mining development in the Bristol Bay watershed.

### 4.4.7.2 Reasonably Foreseeable Future Actions

As noted above, because the broader region of Alaska is considered in this analysis, all categories of actions identified in Section 4.1, Introduction to Environmental Consequences, are considered to have a potential of contributing to cumulative effects on environmental justice. These projects include the following categories: Mineral Exploration and Mining Projects, Oil and Gas Exploration and Development projects, Transportation and Infrastructure Projects, and Energy and Utilities Projects.

The No Action Alternative would not contribute to cumulative effects on the regional and state economy, infrastructure, cost of living, population characteristics, changes to resource availability, access to resources, competition for resources, or health and safety. Although there may be some decrease in the current level of economic activity generated by exploration of the project, exploration activities could continue. If there are fewer local employment opportunities associated with future exploration of the Pebble deposit, there could be less income that could contribute to support subsistence activities. However, that could be offset by exploration of other nearby mineral deposits.

Collectively, the project alternatives and RFFAs that contribute to cumulative effects on environmental justice are summarized in Table 4.4-2.

**Table 4.4-2: Contribution to Cumulative Effects for Environmental Justice**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| **Pebble Project Expansion Development Scenario** | **Mine Site:** The mine site footprint would have a larger open pit and new facilities to manage water and store tailings and waste rock. The Pebble Project expansion development scenario would continue, and likely increase, the beneficial and adverse impacts that would be realized from the project on socioeconomics, subsistence, and health and safety characteristics.<br>**Other Facilities:** The north access road would be extended east from the Eagle Bay Ferry Terminal to a new deepwater port site at Iniskin Bay. Construction and operation of a second road access corridor would have both beneficial and adverse effects on socioeconomics, subsistence, and health and safety through increased access opportunities and increased disturbance of subsistence resources.<br>**Magnitude:** The Pebble Project expansion development scenario would create some additional local employment and revenue opportunities over a longer period of time, but likely increase and extend stress and concerns about contamination resulting from the project. An increased area around the mine site and second access corridor would be restricted for subsistence activities, including portions of Upper Talarik Creek, with potential losses in harvest and cultural activities.<br>**Duration/Extent:** Beneficial and adverse effects of mining would be extended over an additional 78 to 98 years. Pedro Bay would experience greater impacts under the Pebble Project expansion development scenario with the development of the second transportation access corridor.<br>This additional habitat loss associated with the mine site and second transportation corridor would not be expected to have population-level effects on fish and wildlife; however, noise, access to resources, and | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** Similar to Alternative 1a, except that the portion of the access road from the north ferry terminal to the existing Iliamna area road system would not already be constructed. Concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay.<br>**Magnitude:** Impacts to environmental justice from mine expansion would be similar to Alternative 1a regarding local employment and revenue, contamination concerns, and subsistence access.<br>**Duration/Extent:** The duration and extent of cumulative impacts to environmental justice would be similar to the duration and extent of Alternative 1a.<br>**Contribution:** The contribution to cumulative effects would be slightly more than Alternative 1a, Alternative 2, and Alternative 3. | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** Same as Alternative 1a.<br>**Magnitude:** Impacts to environmental justice from mine expansion would be similar to Alternative 1a regarding local employment and revenue and contamination concerns. There would be a smaller magnitude of impacts on access to subsistence resources because there would be one mine access route instead of two.<br>**Duration/Extent:** The duration and extent of cumulative impacts to environmental justice would be similar to the duration and extent of Alternative 1a, although affecting a smaller amount of acreage over a smaller geographic area with one road access corridor.<br>**Contribution:** Beneficial cumulative impacts from Alternative 2, combined with the Pebble Project expansion development scenario to income and infrastructure for minority and low-income communities would be less than Alternative 1a because the north ferry operation | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** Overall expansion would use the existing north access road; concentrate and diesel pipelines would be constructed along the existing road alignment and extended to a new deepwater port site at Iniskin Bay.<br>**Magnitude:** Impacts to environmental justice from mine expansion would be similar to Alternative 1a, although affecting a smaller amount of acreage over a smaller geographic area with one road access corridor.<br>**Duration/Extent:** The duration and extent of cumulative impacts to environmental justice would be similar to the duration and extent of Alternative 1a, Alternative 1, and Alternative 2, although affecting a smaller amount of acreage and geographic area.<br>**Contribution:** Expanded mine site development and associated contributions to cumulative impacts would be the same as Alternative 1a. Cumulative cost-of-living |

**Table 4.4-2: Contribution to Cumulative Effects for Environmental Justice**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | the quality and cultural experience of subsistence activities could be affected. The cumulative impacts would be long-term over extended operations, and decrease in magnitude as closure is implemented.<br>The Pebble Project expansion development scenario has the potential to result in increased beneficial and adverse health impacts, especially from increased impact durations, possible increased releases into the environment, and affected community exposure to potentially hazardous materials over an additional 78 years. The geographic exposure would combine the footprints of Alternative 1a and Alternatives 3, with two operating ports and transportation corridors.<br>**Contribution:** The Pebble Project expansion development scenario would continue, and likely increase, the beneficial (additional employment and income opportunities) and adverse (potential exposure) impacts to socioeconomic conditions for minority and low-income communities. It would contribute to impacts on subsistence activities as described above. The expanded development scenario has the potential to add to the beneficial and adverse cumulative health impacts of minority and low-income communities in areas with pre-existing industrial pollutants and contaminated sites. It would be expected that mitigation measures would be used to minimize or mitigate exposure. | | would be discontinued, and the south transportation system/ferry would not be in place. Therefore, employment opportunities would be lower, because employees would not be required at those locations. Expanded mine site development and associated contributions to cumulative impacts would be similar to but of lesser magnitude than Alternative 1a, because the Amakdedori port and connecting transportation infrastructure would not be built. As a result, potential beneficial and adverse cumulative impacts to Kokhanok would also be less under this alternative, particularly those associated with road access and lower costs for goods and services. | benefits would be similar to Alternative 2. Beneficial cumulative impacts from Alternative 3, combined with the Pebble Project expansion development scenario to income and infrastructure would be less than Alternative 1a, Alternative 1, and Alternative 2 because no ferry operation would be in place. With the concentrate pipeline, employment opportunities for minority and low-income communities associated with truck traffic would be lower.<br>Potentially affected minority and low-income communities would be similar to Alternative 2. |
| **Other Mineral Exploration Projects** | **Magnitude:** Mining exploration activities would include additional borehole drilling, road and pad construction, helicopter support, and development of temporary camp facilities. Actions that expand mineral exploration near the Pebble deposit and around Iliamna Lake contribute to landscape-level effects, including additional impediments to the movement of people and animals in the immediate vicinity of exploration activities; increased noise, vibration, and atmospheric pollution; and increased | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |

**Table 4.4-2: Contribution to Cumulative Effects for Environmental Justice**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | numbers of people to the area. This, in combination with the Pebble Project, could result in increased stress associated with fear of changes in lifestyle and cultural practices, changes in land use, degradation to the environment, and real or perceived impacts on food security and quality.<br>There could be greater beneficial impacts to socioeconomic indicators such as employment and community services.<br>**Duration/Extent:** Exploration activities typically occur at a discrete location for one season, although a multi-year program could expand the geographic area affected in a specific mineral prospect.<br>**Contribution:** The RFFAs related to continuing mining exploration activities would likely induce some measurable cumulative effects to the socioeconomic characteristics of minority and low-income communities during the exploratory phases, primarily through limited employment and support service activities.<br>Actions that expand mineral exploration near the Pebble deposit and around Iliamna Lake contribute to landscape-level effects; site-specific impediments to the movement of people and animals; increased seasonal noise, vibration, and atmospheric pollution; and increased numbers of people to the area. This could lead to similar effects to resource availability, access to resources, competition for resources, and sociocultural conditions described above for the Pebble mine expanded development scenario, but on a smaller scale.<br>The Donlin Gold Project would contribute to regional economic benefits similar to those of the Pebble Project. Employees would likely come from the city of Bethel, as well as other parts of the Bethel Census Area, the Kusilvak Census Area, and the Yukon-Koyukuk Census Area. Therefore, these | | | |

**Table 4.4-2: Contribution to Cumulative Effects for Environmental Justice**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | benefits would not directly contribute to economic benefits for minority and low-income communities in the cumulative effects analysis area. From a statewide perspective, both the Donlin Gold Project and the Pebble Project could create a need for support services and secondary/indirect jobs associated with such services in the region. | | | |
| **Oil and Gas Exploration and Development** | **Magnitude:** Onshore oil and gas exploration activities could involve seismic and other forms of geophysical exploration; and in limited cases, exploratory drilling. Potential impacts would be similar to mining exploration.<br>Offshore oil and gas exploration and development has been ongoing in Cook Inlet for 6 decades. Employment opportunities for project area residents would be extremely limited and would have negligible interaction with project marine subsistence activities. Offshore exploration and development could be intermittently noticeable to local residents, and could add to cumulative stress associated with landscape-level resource development.<br>**Duration/Extent:** Seismic exploration and exploratory drilling are typically single-season temporary activities. Offshore development could result in installation of additional production platforms and marine support activities on a long-term basis. These activities would occur in Cook Inlet north of the project area.<br>**Contribution:** If the RFFAs related to oil and gas exploration and development are developed, they could create a need for direct employees, support services, and secondary/indirect jobs associated with such services, but offshore exploration activities would be supported out of the KPB, where there is a mature oil support service industry. Any continuing onshore oil and gas exploration on the Alaska | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |

**Table 4.4-2: Contribution to Cumulative Effects for Environmental Justice**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | Peninsula would be small in scale and supported out of King Salmon, rather than minority or low-income Iliamna Lake communities.<br>As indicated above, direct interactions with subsistence and health would be limited, but could contribute to stress associated with resource development. | | | |
| **Road Improvement and Community Development Projects** | **Magnitude:** Road improvement projects would take place in the vicinity of communities and have positive economic impacts through reduction in transportation costs and lowering the cost of living for minority and low-income communities. These transportation projects would increase access to the area, which could improve access to subsistence resources, but also introduce additional disturbance to and competition for resources, affecting all minority and low-income communities in the cumulative effects analysis area.<br>Local hydroelectric projects such as Knutson Creek and Igiugig would create beneficial socioeconomic effects through renewable power generation. There could be some construction and operations effects on subsistence resources, but federal and state permitting would require mitigating adverse impacts. Renewable energy could also have modest beneficial impacts on health by reducing reliance on fossil fuels.<br>**Duration/Extent:** Disturbance from road and hydroelectric construction would typically occur over a single construction season. Geographic extent would be limited to the vicinity of communities and Diamond Point.<br>**Contribution:** The RFFAs related to transportation and infrastructure improvements could have a beneficial cumulative impact on potentially affected communities by reducing high transportation and power costs, and lowering the cost of living for | Similar to Alternative 1a and 2; greater than Alternative 3. | Cumulative impacts in terms of employment opportunities would likely be less under Alternative 2 due to commonly shared project footprints with the quarry site. | Similar to Alternative 2; less than Alternative 1a. |

**Table 4.4-2: Contribution to Cumulative Effects for Environmental Justice**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | minority and low-income communities in the LPB. In combination with the Pebble Project, there could be some adverse impacts to resource availability, access to resources, and competition for resources, which would increase for minority and low-income communities in the cumulative effects analysis area.<br>The capital improvement–related RFFAs and rural development projects have the potential to improve road access to many affected minority and low-income communities (e.g., road improvement and increased safety) in the EIS analysis area, improving safety and access to healthcare.<br>The Diamond Point rock quarry would be near the convergence of Cottonwood and Iliamna bays. This project could increase job opportunities and provide steady income to minority and low-income communities. | | | |
| **Summary of Project Contribution to Cumulative Effects** | Overall, the contribution of Alternative 1a to cumulative effects to Environmental Justice when taking other past, present, and RFFAs into account, would include both beneficial (socioeconomics) and adverse (health and subsistence) effects on low-income and minority communities, and vary in terms of magnitude, duration, and extent. | Similar to Alternative 1a, although slightly more acreage would be affected by expansion of the Pebble Project. | Similar to Alternative 1a, although slightly less acreage/geographic area would be affected by expansion of the Pebble Project, reducing both beneficial and adverse effects. | Similar to Alternative 1a, although less acreage would be affected by expansion of the Pebble Project than either Alternative 1a, Alternative 1, or Alternative 2, reducing both beneficial and adverse effects. |

Notes:
EIS = Environmental Impact Statement
KPB = Kenai Peninsula Borough
LPB = Lake and Peninsula Borough
RFFA = Reasonably foreseeable future action

# 4.5 RECREATION

The Environmental Impact Statement (EIS) analysis area for recreation is defined as the area from Lake Clark National Park and Preserve south to Katmai National Park and Preserve, and from the Nushagak River east to the western Kenai Peninsula (see Figure 3.5-1). Potential impacts include:

- Adverse effects to recreation opportunities and experiences for recreationists participating in hunting, fishing, wildlife viewing, boating, camping, backpacking, beach combing, clamming, and picnicking activities
- Displacement of recreationists participating in hunting, fishing, wildlife viewing, boating, camping, backpacking, beach combing, picnicking activities, and snowmachine use
- Adverse effects to recreation experiences for visitors flying over the EIS analysis area.
- Increased access to recreational areas
- Changes to recreational settings

The magnitude of impact from the project depends on the level of current recreation use that would be impacted, the extent to which the recreation setting, opportunities, and experiences are altered, as well as the ability of recreationists to relocate to another area with similar recreation opportunities, settings, and experiences. The duration and geographic extent of impacts depends on the location and season in which the disturbance occurs during construction, operations, or closure, as well as the audibility and visibility of any changes to the recreation setting. Duration would be considered long term if the effect lasted throughout the life of the project (i.e., years to decades). A short-term effect would be expected to last only though the construction phase (i.e., months to years). The potential for impacts is related to how likely the project would be to alter the recreation setting, opportunities, experiences, and use level.

## 4.5.1 Summary of Key Issues

**Table 4.5-1: Summary of Key Issues for Recreation**

| Category | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Permanent Loss of Area Available for Recreation (all components) | Loss of 9,611 acres | Loss of 9,600 acres<br>Kokhanok East Ferry Variant: 9,635 acres<br>Summer-Only Ferry Operations Variant: 9,661 acres<br>Pile-Supported Dock Variant: 9,589 acres | Loss of 9,763 acres<br>Summer-Only Ferry Operations Variant: 9,819 acres<br>Pile-Supported Dock Variant: 9,753 acres<br>Newhalen River North Crossing Variant: 9,783 acres | Loss of 10,130 acres<br>Concentrate Pipeline Variant: 10,132 acres |
| Recreation Experience | Project-related noise and activities, lasting from construction through operations and closure may adversely affect recreation experiences for recreationists by changing the recreation setting and displacing wildlife | Same as Alternative 1a, except there would be no impacts to visitors of the Lake Clark park unit. | Same as Alternative 1a, but would particularly affect visitors to lodges in the Pedro Bay area. Recreation experiences for visitors to the Lake Clark park unit would be more | Same as Alternative 2 |

**Table 4.5-1: Summary of Key Issues for Recreation**

| Category | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | and fish throughout the EIS analysis area.<br>Adverse effects on recreational experiences for visitors within visual and auditory distance may displace visitors that prefer a quiet, undisturbed recreation setting.<br>Recreation experiences for visitors to the Lake Clark park unit may be impacted by the increased sight of human-made development from the roadway and ferry terminal.<br>Recreation experiences impacted for visitors accessing the McNeil River State Game Refuge at Chenik Creek by the site of port facilities and vessel traffic.<br>These impacts would last throughout the life of the project. | | impacted due to the increased sight of human-made development from construction of the pipeline.<br>There would be no impacts to visitors to McNeil River State Game Refuge. | |
| Recreation Setting | Recreationists flying over project components would be adversely impacted, as the project would be visible from planes.<br>The recreational setting from Iliamna Lake would be impacted by ferry traffic and terminals.<br>Vessel traffic may intermittently affect the recreational setting of McNeil River Camp. The port may be visible from a small number of areas near the northern borders of Katmai National Park and McNeil River Game Refuge and from National Wildlife Refuge islands.<br>There would be changes to the recreational setting for visitors to Roadhouse Mountain.<br>These impacts would last throughout the life of the project. | Same as Alternative 1a, except it would not change the recreational setting for visitors to Roadhouse Mountain. | Impacts would be similar to Alternative 1a, except it would not affect the McNeil River State Game Refuge or Katmai National Park, but may affect views from some areas of the Alaska Maritime National Wildlife Refuge. | Same as Alternative 2, except there would be no ferry terminals and no impacts to recreation on Iliamna Lake. |

**Table 4.5-1: Summary of Key Issues for Recreation**

| Category | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Recreation Activities | There would be adverse effects on wildlife viewing, hunting, and fishing opportunities and experiences from displacement of wildlife and fish.<br>Boating and snowmachine use on Iliamna Lake could be displaced or altered.<br>These impacts would last throughout the life of the project. | Same as Alternative 1a. | Same as Alternative 1a, except that more guided fishing opportunities would be impacted.<br>There would also be adverse effects to activities in Ursus Cove and Cottonwood Bay during construction. | Same as Alternative 2, except with additional adverse effects on fishing opportunities and experiences at road river/stream crossings, particularly at Newhalen and Iliamna rivers. There would be no adverse effect to recreation on Iliamna Lake. |
| Recreation Use | Potential for increase in recreation use due to increase in full-time resident population and potential for additional recreation use along the pipeline ROW.<br>These impacts would last throughout the life of the project. | Similar to Alternative 1a. No additional opportunities or use associated with the pipeline ROW due to the presence of a private road. | Same as Alternative 1a and potential for additional recreation use due to recreation equipment being more readily available and/or less expensive. Additional potential for increased recreation use along the pipeline ROW though motorized use may affect wilderness-type recreation experiences. | Similar to Alternative 1a. No additional opportunities or use associated with the pipeline ROW due to the presence of a private road. |

Notes:
EIS = Environmental Impact Statement
ROW = right-of-way

## 4.5.2 No Action Alternative

Under the No Action Alternative, federal agencies with decision-making authorities on the project would not issue permits under their respective authorities. The Applicant's Preferred Alternative would not be undertaken, and no construction, operations, or closure activities specific to the Applicant's Preferred Alternative would occur. Although no resource development would occur under the Applicant's Preferred Alternative, Pebble Limited Partnership (PLP) would retain the ability to apply for continued mineral exploration activities under the State's authorization process (ADNR 2018-RFI 073) or for any activity not requiring federal authorization. In addition, there are many valid mining claims in the area, and these lands would remain open to mineral entry and exploration by other individuals or companies.

It would be expected that current State-authorized activities associated with mineral exploration and reclamation, as well as scientific studies, would continue at levels similar to recent post-exploration activity. The State requires that sites be reclaimed at the conclusion of their State-authorized exploration program. If reclamation approval is not granted immediately after the cessation of activities, the State may require continued authorization for ongoing monitoring and reclamation work as it deems necessary.

Noise and disturbance from activities such as drilling and aircraft overflights could still occur under the No Action Alternative. The magnitude of helicopter traffic related to exploration activities would remain at the same level it has over the past 10 years, or decrease slightly from current activity. The mine site itself is generally not used for recreation, but helicopter traffic would be noticeable to recreation users of the Newhalen River and the northern shoreline of Iliamna Lake near Iliamna. Any decreases in human-made noise and disturbance would benefit the recreation setting and enhance recreation experiences in these areas by increasing the natural setting. While these activities would also cause noise and disturbance, reclamation would benefit the recreational setting.

### 4.5.3 Alternative 1a

The following sections describe anticipated project impacts on recreation. This alternative would result in the direct loss of 9,611 acres of area available for recreation activities, including 2,175 acres of wetlands and other waters. This includes the mine site, transportation corridor, port, and natural gas pipeline components. The impact would be long term, lasting through the life of the project and would be certain to occur if this alternative is permitted and built.

Scoping comments related to recreation focused on potential disruption to recreational hunting and fishing near the mine, along river systems, and in the transportation/pipeline corridor during construction and operations. Impacts to lodges in the Iliamna and Lake Clark areas were specifically noted. The following sections consider the potential project impacts on guided hunting and fishing activities, increased access for additional recreationists, and displacement of wildlife viewing, specifically in the McNeil State Game Refuge. For economic impacts related to commercial and recreational fishing, see Section 4.6, Commercial and Recreational Fisheries.

#### 4.5.3.1 Mine Site

Recreational use at the mine site is estimated to be low; use consists of some sport hunting, sport fishing, and occasional snowmachining. Flights taking recreationists to various destinations in the region may pass over the mine site. For potential impacts to subsistence hunting, see Section 4.9, Subsistence.

The extent of impacts on recreation at the mine site would be the alteration and physical removal of 8,391 acres of land (i.e., size of the mine site footprint including material sites) currently available for recreation. This would include the loss of 2,113 acres of wetlands and other waters, which support the fish and wildlife that attract anglers and sport hunters. The impacts would be permanent and certain if the mine is permitted and built. The acres directly impacted do not see much recreational use and the magnitude of impacts would be measured by the small number of users that would be displaced to other nearby state or federal lands where similar recreation opportunities and settings exist.

Construction, operations, and closure at the mine site would affect sport hunting, fishing, and other recreation activities on lands surrounding the EIS analysis area. Project-related activities that generate noise, such as blasting and operation of heavy equipment and helicopters, would adversely affect the recreational experience for hunters, anglers, and other recreationists. Recreation would not be allowed in the mine site safety boundary (see Chapter 2, Alternatives). The boundary would be demarcated by signage at regular intervals and at logical locations such as the mine access road and waterways. The boundary would be reduced during the post-closure phase of the project (PLP 2018-RFI 058). The magnitude of the effects would be to change the setting from the current low level of summer exploration activities to a developed year-round industrial area in visual and auditory distance of the mine site. The effects would be certain if the mine is permitted and built and would be long term, lasting throughout the life of the project.

The magnitude and geographic extent of increase in noise from construction and operations at the mine site would be 10 decibels (dBA) higher than the ambient noise level up to 2.3 to 2.4 miles away from the mine site. Based on human perception, an increase of 10 dBA would sound "twice as loud" as the current ambient noise level. Project construction and operations noise would exceed a 30 dBA equivalent noise level up to 3.3 and 3.5 miles from the mine site, respectively. Above this 30 dBA noise level, the project would risk causing sleep disturbance to recreationists sleeping outdoors on lands considered "wilderness ambient." These adverse effects to recreation experiences generally within 3.5 miles of the mine site would be certain if the project is permitted and built, and may result in minimal displacement of visitors to other areas for the duration of the project. For further analysis, see Section 4.19, Noise.

The noise generated by project construction, operations, and closure activities would also displace wildlife and fish from the immediate mine site area, and likely from lands immediately surrounding the EIS analysis area. The magnitude of this effect would reduce hunting and fishing success close to project components. Therefore, hunters, anglers, or guides who currently use the immediate vicinity would be displaced to other areas during construction, operations, and closure activities. This effect would be certain if the mine is permitted and built (see Section 4.23, Wildlife Values, for further analysis). However, the mine site and immediate surrounding area is not popular for sport hunting, fishing, and other recreation uses, and potential users would be displaced to other state lands in the area with similar habitat.

The removal of acreage at the mine site would impact trout habitat downstream of the project area. It is possible that as habitat changes, trout would be displaced to other areas. The anglers targeting these trout would also be displaced. However, due to the natural dynamic nature of habitat, the change may not be noticeable to recreationists.

Visibility of the mine site would generally be limited to high-elevation areas on Sharp Mountain and Groundhog Mountain, and the upper Stuyahok River Valley. The extensive development at the mine site and contrast of the mine site with the surrounding area would alter the recreation setting. Visual contrast is expected to attenuate to a weak level at a distance of about 20 miles from the mine. There is a lack of existing night lighting in the analysis area and mine facility lighting would result in a strong contrast from high elevation locations. The quality of the night sky would also be impacted in areas where there are no direct views of the mine site by brightening the night sky and reducing the visibility of stars and other astronomical observations. Impacts would be of high magnitude within 8 miles of the mine site and decrease with distance; low magnitude impacts could occur at distances of up to 70 miles from the mine site. Night sky impacts would be less noticeable in the summer months when there is longer daylight. These impacts would occur if the mine is permitted and built. Changes to the recreation setting due to visibility of the mine would alter recreation experiences for visitors within view of the mine for daytime impacts, and further for impacts to night sky. The impacts would last for the duration of the project and after project closure, and may result in displacement of recreation visitors to areas where the mine site is not visible. Displacement of recreation visitors would affect recreation use by potentially decreasing use in areas near the mine site and increasing use in other areas (where the mine site is not visible). For further analysis, see Section 4.11, Aesthetics.

The mine site would be approximately 15 miles from the border of Lake Clark National Park and Preserve, the nearest well-known regional recreation destination and use area to the mine site. Project-related noise and activities would not result in meaningful, direct effects on recreational settings or activities in the park unit. The geographic extent of the impact of the coarse ore stockpile at the mine site would be limited because it would only be visible from high elevations in the southwestern corner of the park near Roadhouse Mountain, which is a small portion of the total park unit (see Section 4.11, Aesthetics, and figures in Appendix K4.11). Visibility from this distance would be low; therefore, the magnitude of impacts to recreation settings and experiences from increased development in a primitive setting would be low. This impact would be long term to permanent and would occur if the mine is permitted and built.

Mine site construction and operations noise would not affect sensitive receptors in the park unit. Recreational berry-picking, fishing, and drinking water collection in Lake Clark National Park and Preserve would not be affected due to the distance between the mine site and the park unit. The geographic extent of long-term fugitive dust impacts on vegetation, water quality, aquatic ecosystems, and berry-picking would be limited to the area around the mine site and within 330 feet of the mine and port access roads. Therefore, magnitude of impacts from fugitive dust to recreational activities would be low because recreational activities are limited that close to the mine site. These effects would be certain if the mine is permitted and built, but implementation of dust suppression, on-site water treatment processes, and enforcement of slow speed limits at all stream crossings would minimize dust-related impacts to vegetation, water quality, and aquatic ecosystems (see Chapter 5, Mitigation, for additional mitigation for fugitive dust, and Section 4.24, Fish Values, for impacts to fish).

Activities at the mine site would be visible to visitors flying over the area. The presence of the mine, a large industrial facility in an otherwise generally primitive area, would adversely affect the recreational experience for visitors flying over the mine site by causing a change in the recreational setting. Given the mine site's location relative to nearby lodges and airstrips/airports, some unscheduled recreational flight paths would cross the mine site itself. Although the number of visitors flying into the area is relatively low, their experience would be affected by the presence of the project, and the magnitude of impact would be high. Therefore, project construction, operations, and closure are likely to have a noticeable adverse effect on the recreational experience for flightseeing visitors. The mine site may be visible to recreationists taking flightseeing tours in Lake Clark National Park and Preserve, but these tours are not likely to fly over the mine site itself.

Outdoor recreation by construction and operations staff would not be expected to occur because site rules would prohibit hunting, fishing, or gathering on site to minimize impacts on local subsistence resources. The mine would operate on a fly-in, fly-out basis; therefore, non-resident staff members would not likely contribute to an increase in recreational use. However, they may occasionally stay in the area or participate in recreational trips to nearby destinations. Operation of the mine is not expected to generate a large increase in the number of full-time residents (see Section 4.3, Needs and Welfare of the People—Socioeconomics). Therefore, a small increase in recreational use would likely occur during project construction, operations, and closure due to a small increase in the full-time residential population, and local residents may notice slightly more people participating in recreation activities. However, it is not anticipated that the small increase in the number of full-time residents or employees who may use recreational resources would eliminate any existing recreation opportunities or experiences, but may decrease opportunities for solitude. These impacts would be of low to medium magnitude and could occur anywhere in, and potentially beyond, the EIS analysis area.

#### 4.5.3.2 Transportation Corridor

The transportation facilities would directly impact 809 acres of land, including 59 acres of wetlands and other waters, and would remove it from use for recreation opportunities. These impacts would occur for the duration of the project through closure and would be certain if the project is permitted and built. The direct loss of these acres would negatively impact recreational opportunities and experiences as discussed below.

Near the transportation corridor there is recreational use of Roadhouse Mountain to the northeast of Iliamna, as well as use of some all-terrain vehicle (ATV) trails around the Iliamna area for transportation, subsistence, and recreation. Recreation opportunities also exist in the Gibraltar River and Gibraltar Lake portions of the port access road corridor, where some local lodges advertise guided fishing, hunting, and sightseeing trip options (Haugen, Bush, and Rice 2003). Recreational sport hunting and snowmachine use may occur occasionally in this road corridor. Some boating takes place (motorized and non-motorized) at Iliamna Lake, both as an activity and as a means of accessing other recreation opportunities, primarily fishing, which is the main recreation activity at Iliamna Lake along with boating (ADNR 2013a). Due to its current inaccessibility and location of nearby recreation opportunities, recreational use of the port access road corridor and the Kokhanok spur road is likely low and would have low magnitude impacts.

Noise and activities along the transportation corridor during project construction, operations, and closure would affect the recreation setting and experiences for sport hunting, fishing, and other recreational activities in and surrounding the EIS analysis area by generating potential noise and visual impacts. Those lodges, guides, and clients that use the immediate area in the vicinity of the transportation corridor would experience an adverse effect on the quality of recreation experience. This effect would be long-term and certain if the transportation system is permitted and built. Roadway truck traffic of up to 35 round trips per day would result in noise-related impacts to the recreation setting about 1 to 2 miles from the roadway (see Section 4.19, Noise, for more information). Impacts on recreation opportunities and experiences in this area would be similar to those described above for the mine site but would last beyond the life of the project until the roads are decommissioned and reclaimed.

In addition to roadway traffic, operations would increase aviation traffic at both the Iliamna and Kokhanok airports as discussed in Section 4.12, Transportation and Navigation. Unless the size and/or power of project-related aircraft were substantially different than that of existing aviation traffic, the per-event sound levels associated with aircraft takeoff, landing, and taxiing would not change, and therefore would not be expected to cause an adverse noise effect beyond about 11 additional flights per week. Given the current level of aviation traffic at the Kokhanok airport, the increase in noise at the airport would primarily be due to the increase in aviation traffic from the project. Using a sleep disturbance criterion of 45 dBA $L_{max}$, the perpendicular distances from which a sleeping recreationist (not within a building) might be awakened is 6.5 miles and 4.5 miles for takeoff and approach, respectively. However, most flights would occur in the daytime. Based on the information above, the geographic extent of aircraft noise adversely affecting the recreation setting and experiences in the Kokhanok airport area by decreasing naturalness and may lead to displacement of recreation from a limited area of around 4.5 to 6.5 miles from the airport for the duration of the project. Based on the slight increase in aviation traffic at the Iliamna airport, noise-related impacts to the recreation setting and experiences surrounding the airport would generally be of low magnitude, expected for the duration of the project. The aircraft used would not fly through Lake Clark Pass and would not be noticeable to Lake Clark visitors.

The ferry terminals would result in long term, direct loss of recreational area during project construction, operations, and closure. This impact would be certain to occur if the ferry terminals were permitted and built, and limited to the immediate areas around the ferry terminals. However, given the low use of these portions of the corridor for recreation and the availability of comparable areas for recreation, the loss of acreage for recreation would likely result in minimal displacement of recreational use to other lands in the general area with similar habitat, and magnitude of impacts would be low.

Project-related construction, operations, and closure activities would result in noise impacts, geographically limited to 0.4 mile from ferry terminals for operations and up to 2 miles for closure activities, which would affect both on and off-water recreation uses surrounding the terminals for the life of the project.

Construction of the pipeline and ferry terminals and operation of the ferry would likely displace boaters from the area immediately surrounding the equipment, ferries, and facilities. Boaters would likely be displaced to other areas of the lake during project construction, operations, and closure to avoid the noise and hazards presented by the equipment and activities. Project-related noise and equipment would particularly affect non-motorized boating, which is generally a quieter activity that requires more time and effort to circumnavigate in-water obstructions, and thus the ferry and infrastructure would be a hinderance. Magnitude of impacts would be medium to high for recreation at Iliamna Lake during construction, but would be low during project operations because there would be just one ferry trip per day, which would not be expected to contribute considerably to boat traffic on the lake. The likelihood of the impact would be high if the ferry terminal is permitted and built. Although recreational lake boat traffic may slow down and avoid the ferry, alternative open water would be available for boating use during ferry operations. The ferry terminals would be visible from portions of the lake (about 3 to 5 miles from the terminal) and would change the recreation setting in these limited areas of the lake to a more developed setting for the duration of the project. However, recreationists could relocate to nearby lake areas and shorelines for a less developed setting. Impacts to night sky from ferry terminal lighting would have a larger geographic extent, affecting visibility of stars up to 12 miles from the ferry terminals. Impacts to land-based recreation opportunities, experiences, and settings would be similar to those described above for recreation near the mine site.

During the winter after adequate ice has formed, there is heavy snowmachine use of Iliamna Lake. Most of this use is considered transportation use; however, there is some recreational snowmachine use of the lake. The operational winter ice-breaking ferry traffic may displace snowmachine use in and adjacent to the ferry route across the lake; however, the remainder of the lake would be available for snowmachine use. For those traversing the lake across the ferry route, there would be alternate routes available; however, there would be an increase in time and distance. Therefore, magnitude of impacts would be high where ice-breaking would occur because it would eliminate recreational snowmachine use or add to the distance traveled, but those impacts would occur over a limited geographic extent. Impacts would be long term, occurring every winter during the life of the project and would be certain to occur if the project is permitted and built. Recreationists may need to take longer routes to avoid open water from the ice-breaking ferry (see Section 4.12, Transportation and Navigation, for more information on snowmachine traffic impacts).

Iliamna Lake provides opportunities for wildlife viewing, although there are no known opportunities specific to the ferry terminal locations, ferry route, or pipeline route. Fishing is the primary recreational use of the lake, and extensive opportunities for fishing are available given the lake's size. The project would likely displace wildlife and fish from the locations of the ferry terminals and ferry route during all phases, thus reducing the likelihood of viewing any wildlife or catching fish in and immediately adjacent to the EIS analysis area. Impacts would be of medium to high magnitude since the recreational experience could be reduced. These effects would be certain and long term if the project is permitted and built. Project noise would also alter the recreation setting of the terminal sites from quiet and remote to developed and active. Although all project phases would adversely affect wildlife viewing and fishing experiences and opportunities on Iliamna Lake, other locations around the lake may be available for displaced wildlife viewing and fishing use.

As stated in Section 4.11, Aesthetics, the magnitude of the effect of mine traffic would be highest when viewed from higher elevations or superior viewer positions, where visual contrast is strongest. Therefore, the presence of the mine and port access roads, mine traffic, and night lighting may adversely affect the recreation setting from visible distances of the transportation corridor by decreasing the naturalness of the area and increasing visible human development of the area. This may adversely affect recreation experiences for people participating in wilderness or wilderness-type recreation opportunities. These impacts would be certain to occur if the mine is permitted and built, would begin during construction, and would be long term lasting though mine closure.

The mine access road would be visible from Roadhouse Mountain, where there is some known recreational use (see figures in Appendix K4.11). Therefore, the project would alter the setting for recreationists on Roadhouse Mountain by decreasing the naturalness of the area and increasing visible human development of the area. This may adversely affect recreation experiences for people participating in wilderness or wilderness-type recreation opportunities at Roadhouse Mountain. These impacts, though low magnitude, would occur throughout all phases of the project, and would last beyond project closure. Impacts would be certain to occur if Alternative 1a is permitted and implemented.

Similar to the mine site, project-related noise and activities along the Alternative 1a mine access road would not have substantial direct effects on recreational settings or activities in Lake Clark National Park and Preserve, which is 3 miles or farther from the corridor. Roadway traffic would generally result in noise-related impacts to the recreation setting, geographically limited to about 1 to 2 miles from the roadway, and project-related activities would generally result in noise impacts limited to 0.4 and 2 miles of the ferry terminals, for operations and closure activities, respectively. Given the distance of the Lake Clark park unit, noise impacts to recreation settings or activities would not be expected in the park unit.

The road and vehicles associated with the transportation corridor may be intermittently visible from the far northern edges of the preserve at high elevations; however, visibility from this distance would be limited. Similarly, the transportation corridor on the McNeil River State Game Refuge would be visible in some portions of the refuge, at higher elevations (see Appendix K4.11 for complete viewshed figures, and Section 4.11, Aesthetics, for more information on viewsheds and aesthetic impacts). These northern borders of the refuges are generally inaccessible; however, the construction, operations, and closure of the corridor could adversely affect the recreation experience for the few visitors using the northern border of both recreation areas from the change in recreation setting to a more developed and less remote, primitive area. Given the intermittent visibility, and the low level of recreational use of the northern borders of both refuges, the magnitude of impacts to recreation experiences from the transportation corridor would be low and the geographic extent of those impacts would be limited; however, they would be certain to occur and would last though mine operations and closure.

Activities in the transportation corridor would be visible to visitors flying over the corridor. The presence of roads, ferry terminals, and ferries in an otherwise generally primitive area would adversely affect the recreation experience post-closure until facilities are no longer needed and reclaimed. The recreational setting would change from remote and primitive to more developed and seemingly accessible for visitors flying over the corridor; however, because of the narrow road corridor and the small size of land displaced by the ferry terminals (27 acres), the geographic extent of impacts would be limited. The magnitude of impacts would be of medium magnitude, taking into account changes to recreation setting, number of recreationists affected, and the limited extent those impacts would be realized. The impact would be long term (lasting for some time post-closure) and would be certain if the transportation corridor is built.

The project may also have effects on incidental wildlife viewing along the transportation corridor; although the primary recreation use in most of the transportation corridor is likely from other activities, such as hunting and fishing. Movement and distribution of bears and other terrestrial mammals through the transportation corridor to the McNeil River State Game Refuge and Katmai National Park and Preserve may be disrupted; therefore, construction and operations activities may have indirect adverse impacts on wildlife viewing in those recreation areas. In addition, the behavior of bears may be altered due to human exposure at the project facilities or altering migration patterns to avoid the project, though the nature or extent of behavior changes are unknown. Existing bear viewing facilities are site specific at both recreation areas; therefore, changes to bear behavior that result in changes to their typical feeding and other behavioral patterns could affect the ability of visitors to see bears from existing bear viewing facilities, resulting in direct adverse impacts on wildlife viewing. Changes in bear behavior from human exposure or food conditioning at project facilities could lead to bears that are adversely affected by or habituated to human activity. The magnitude of those impacts to bear viewing areas, to hunting and fishing camps, or in conjunction with other recreational activities, are unknown. These impacts would occur throughout the life of the project (see Section 4.23, Wildlife Values, for more information on impacts to bear movement and distribution and behavior).

Limited access to the roadways and ferry terminals would be available to local residents and businesses only (see Section 4.3, Needs and Welfare of the People—Socioeconomics). Therefore, the transportation corridor facilities would induce a small amount of recreation and could potentially expose some previously inaccessible areas to public access and use from a few residents near the mine and port access roads (PLP 2018-RFI 027). Depending on access agreements, there may be the possibility for non-local recreationists to gain access to the transportation corridor. The magnitude would be unknown.

Alternative 1a would result in increased air transportation associated with project construction and operations. There would be 20 to 40 flights per month (average of five to 10 flights per week) to Amakdedori port before the Kokhanok airstrip could be accessed by road. Once the Kokhanok spur road is established, there would be approximately 11 flights per week with Twin Otter aircraft to Kokhanok. Temporary impacts to recreational activities due to elevated noise would be of high magnitude and intermittent and could affect recreation opportunities at the Lake Clark or Katmai park units, McNeil River State Game Refuge, Alaska Maritime National Wildlife Refuge, or commercial lodges. During operations, project flights would include those transporting employees on 2-week rotations as well as cargo flights. These operational increases in air traffic have the potential to be observed by visitors to Lake Clark National Park and Preserve, where small aircraft are the primary transportation for park visitors; however, the potential would be reduced because flights from Anchorage to Bristol Bay generally fly over Iliamna Lake or the project area (FAA 2018) rather than the preserve (see Section 3.12 and Appendix K3.12, Transportation and Navigation). In addition, the Pebble-related air traffic would not conflict with small planes, which fly at lower altitudes and use narrow passes such as Lake Clark Pass. Helicopter traffic would remain throughout operations to perform ongoing environmental monitoring (variable of frequency and season) and aerial inspections of the transportation corridor (weekly or monthly) (PLP 2018-RFI 027b). These effects would be long term, occurring throughout the life of the project, and would be definite if the project is permitted and constructed. Operational impacts would be of medium magnitude, intermittent, and could affect recreational opportunities at the Lake Clark or Katmai park units, McNeil River State Game Refuge, Alaska Maritime National Wildlife Refuge, or commercial lodges.

#### 4.5.3.3 Amakdedori Port

The construction and operation of Amakdedori port would directly impact 33 acres, including 2 acres of wetlands and other waters. These acres would be permanently removed from use for recreation opportunities. The impact would be certain to occur if the project and port are permitted and built.

Boat traffic to and from the port would be up to 27 concentrate vessels and 33 supply barges per year during operations. Concentrate vessels would be moored for four to five days at the lightering locations, which could displace recreational boaters. There would be a larger number of boats used during construction with fewer used during operations. These impacts would be long term and certain to occur if the port is built; however, Cook Inlet is large with expansive shorelines and waters available nearby for any boaters displaced from construction or operation of the port or lightering sites. Construction, operations, and closure activities at Amakdedori port (including lightering) would therefore result in low magnitude adverse impacts on recreational boat traffic, and on boating experiences and opportunities around the port site, lightering locations, and in Cook Inlet. The visual presence of the port would affect the recreational setting for boaters in view of the port for the duration of the project and may adversely affect the recreational experience for boaters preferring a more natural/less developed setting. The geographic extent of these impacts would be limited to a small portion of Cook Inlet.

Construction, operations, and closure of the project may affect wildlife viewing, hunting, and fishing opportunities at the port site to the extent that they occur. Noise and activities would displace wildlife and fish from the immediate area adversely affecting wildlife viewing, hunting, and fishing opportunities and experiences. Recreationists would be less likely to see wildlife or catch fish for the duration of the project. There is known bear hunting at the port site, which would be eliminated for the duration of the project due to port activities and noise. Hunters would be displaced from the area. Although hunting is allowed in other nearby bear hunting locations, such as State lands farther north, there may not be areas of equal habitat and access. These impacts would be of low to medium magnitude because opportunities for known recreational activities would be reduced, to a limited geographic extent. In addition, similar activities could be experienced in nearby locations. Impacts would be long term, lasting for the duration of the project, and would be certain to occur if the port is permitted and built.

In addition, project-related noise and activities during construction, operations, and closure at Amakdedori port would adversely affect the recreational experiences of visitors in view and earshot of the port site due to the change from a quiet, undeveloped area to a developed site with visible facilities, generators, and in-water facilities. The extent of the impact would be those areas in view and earshot of the port. For the duration of the project, the adverse effects would displace visitors preferring a quiet, undisturbed recreation setting, or visitors who participate in recreation opportunities such as wildlife viewing, hunting, and fishing, which typically require a quiet, undisturbed recreation setting. Displacement of these visitors would shift recreation use to other areas or result in decrease of opportunity if suitable alternatives are not available. Magnitude of impacts would be higher in summer months during the peak visitation period for McNeil River State Game Refuge and the Alaska Maritime National Wildlife Refuge.

The port site, including construction, operations, and closure activities, would be visible from the Cook Inlet shoreline area farther north of the port, but visibility would decrease with distance out to about 10 miles. The port would be visible from some portions of the McNeil River State Game Refuge and Alaska Maritime National Wildlife Refuge islands and may be visible from flights over the site to regional recreation destinations such as Katmai National Park and Preserve, or towns farther west such as King Salmon or Naknek. The port site would be visible from the Chenik Creek area of the McNeil River State Game Refuge and would affect views from this recreation area. The lighting at the port would be visible to Chenik Creek, although long daylight hours in the summer would limit impacts. The port would not be visible from McNeil River Camp (see Appendix K4.11, Aesthetics), which is the main recreation area in the McNeil River State Game Sanctuary; therefore, views from this recreation site would not be affected, though vessel traffic may be evident and may intermittently affect the recreation setting at the camp during project construction and operations. The port would not be visible from the shore of Augustine Island and would not be discernable from elevated portions of the island. Impacts to night sky affecting visibility of stars could affect a small portion (about 2 percent) of McNeil River State Game Refuge.

These impacts on views would be long term and certain to occur if the port is permitted and built. On-water sightseeing and/or wildlife viewing may occur in these locations, but recreational use of McNeil River State Game Refuge shoreline areas is limited by access. Construction, operations, and closure at Amakdedori port could adversely affect the recreational experience for visitors participating in sightseeing or wildlife viewing opportunities in these surrounding areas by causing a change in the recreational setting to a more developed and less remote, primitive area; however, impacts would be of low magnitude due to the low number of visitors to the port site.

The project would not result in changes in access to McNeil River State Game Refuge or Sanctuary. Visitors fly in to the sanctuary where the main recreational use areas are located. McNeil River Camp, the main access point to the sanctuary and refuge, is 12 miles south of the Amakdedori port site. The main recreational use and access point of the McNeil River State Game Refuge is at Chenik Creek and Chenik Bay. Although the project may be visible from that point, there would not be displacement from that area.

### 4.5.3.4 Natural Gas Pipeline Corridor

The construction and operation of the compressor station on the Kenai Peninsula and materials sites for the pipeline would directly impact an area 308 acres in size, including 1 acre of wetlands and other waters. Potential impacts on recreation are described above for the transportation corridor where it shares a footprint with the natural gas pipeline. The construction of the pipeline between where it would come ashore north of Newhalen and the junction with the mine access road would temporarily disrupt recreation along that area. The noise and activity would displace hunting and fishing opportunities along that corridor, particularly fishing on the Newhalen River. During operations, the right-of-way (ROW) would follow roughly parallel to an existing road and would not open new areas to recreation, although it is possible that the ROW would be used by snowmachines and ATVs to avoid road traffic. These impacts to recreation use and experiences would be long term and continue beyond project closure. They would occur if Alternative 1a is implemented and the gas pipeline is permitted and built. Impacts to visitors flying over the pipeline would be the same as those described under the transportation corridor for this alternative.

Existing recreational use along the pipeline alignment in Cook Inlet and on the Kenai Peninsula consists of boating in the inlet; beach combing, clamming, fishing, and hunting in and around the area where the compressor station is located; and recreational use at the state park sites on the Kenai Peninsula. Boating in Cook Inlet is both an activity in itself and a means of accessing other recreation opportunities such as fishing, wildlife viewing, birdwatching, and beach combing.

Visible and audible effects from equipment present in Cook Inlet during project construction and closure would occur over a limited geographic extent to recreational boaters (motorized and non-motorized) about 2 to 3 miles from the activities and would be short term, lasting only during construction and closure activities. These impacts would temporarily displace any boating and fishing use from the area immediately surrounding the equipment and construction activity; however, alternate open water would be available for use by displaced boaters or anglers. This temporary displacement would cease upon completion of construction and closure activities, and the types of vessels and construction activities used for the project would be typical of the types of activities already occurring in the Cook Inlet. Impacts would be medium magnitude, since it would completely displace some recreational activities, but the activities could occur in other locations nearby. The impacts would be certain to occur if the pipeline is permitted and constructed.

Noise and activities during project construction and closure may temporarily adversely affect recreation experiences for visitors to the Stariski State Recreation Site approximately 1.5 miles north of the compressor station. Visitors participating in camping and picnicking may be temporarily adversely affected by the change in recreation setting caused by noise from project activities, which would adversely affect their recreation experiences. Some visitors may be temporarily displaced from the site to other state parks or locally managed recreation sites along the Kenai. The campground at the state recreation site would be far enough away that temporary noise-related impacts to sleeping at the campground would not be expected. The compressor station would not be seen from Anchor Point State Recreation Area or Stariski Campground. Overall, the magnitude of impacts would be low and limited in their geographic extent. These temporary effects would be certain to occur during construction and closure if the pipeline and compressor station is permitted and built.

The recreation facilities including the boat launch and boat use at the Anchor River State Recreation Area are over 5 miles from the compressor station and pipeline; no visual impacts or noise impacts to Anchor River State Recreation Area are expected.

Recreation activities also occur in the general area surrounding the gas pipeline and compressor station outside of the two state park units, including beach combing, clamming, fishing, and hunting. Project construction and closure noise and activities would temporarily displace wildlife and fish from the area and could discourage hunting and fishing. Project construction may temporarily close a portion of the beach for recreation activities; but this impact would be short term, occurring only during the construction phase. Noise and activities from general project construction and closure would also temporarily adversely affect the recreation setting for beach recreation in view and earshot of the construction activities and thus may temporarily adversely affect recreational experiences for people in the area surrounding the compressor station and gas pipeline. Long-term impacts from the visual presence of the compressor station on the recreational setting and experiences would be low magnitude because it would introduce weak visual contrast against the existing landscape. The likelihood of these impacts would be certain if the pipeline and compressor station are permitted and built.

The pipeline would be south of Augustine Island in Cook Inlet. Some recreation occurs on the island itself; sightseeing of the island's volcano and wildlife occurs from the water. Therefore, equipment and noise associated with construction and closure would temporarily adversely affect sightseeing opportunities and experiences along the southwestern side of the island. These impacts would be low magnitude because of the low number of recreationists affected and because displaced boats would be able to view the island from other locations around the island that would not be affected by project equipment and noise. Noise impacts would be limited to approximately 2 to 3 miles from construction activity, with the exception of helicopter support, which would have further reaching effects.

The pipeline would not be visible above ground and would not remove any acreage from use for recreation opportunities. Recreation experiences for on-water or state park unit visitors during pipeline operations would be minimally impacted because of the presence of boat traffic during pipeline maintenance. These impacts would extend along the pipeline ROW. Their likelihood to affect recreation activities would depend on the timing of maintenance activity. Although there would be anchoring restrictions along the pipeline, recreation use could continue; the area around the pipeline in Cook Inlet, except for the width of the pipeline, would be available for anchoring.

### 4.5.4 Alternative 1

This alternative would result in the direct loss of 9,600 acres of area available for recreation activities, including 2,188 acres of wetlands and other waters. This includes the mine site, transportation corridor, port, and natural gas pipeline components. The impact would be long term, lasting through the life of the project and would be certain to occur if Alternative 1 is permitted and built.

Transportation facilities would directly impact 1,143 acres of land, including 60 acres of wetlands and other waters, and would remove those acres from use for recreation opportunities. The magnitude of impacts on recreation from the mine site would be the same as discussed under Alternative 1a. These impacts would be long term and would be certain to occur if Alternative 1 is permitted and built.

Noise and activities along the transportation corridor during project construction, operations, and closure would be the same as discussed for the port access road of Alternative 1a and would affect the recreation setting and experiences for sport hunting, fishing, and other activities in and surrounding the EIS analysis area by generating potential noise and visual impacts. These impacts would occur where the transportation corridor crosses the Gibraltar River. Along the mine access road, there are recreational use opportunities in the general road area, particularly along the Newhalen River and Upper Talarik Creek (UTC). Due to its current inaccessibility and location of nearby recreation opportunities, recreational use of the mine access road corridor and the Iliamna spur road is likely low and would have low magnitude impacts. The types of impacts would be the same as described under Alternative 1a.

Project-related noise and activities would not affect recreational settings or activities in Lake Clark National Park and Preserve, which is over 8 miles at its closest point from the transportation corridor (along the Iliamna spur road). The geographic extent of impacts from the transportation corridor would be limited because it would only be visible from high elevations in the southwestern corner of the park near Roadhouse Mountain (see Section 4.11, Aesthetics). Due to the distance of the park unit from the transportation corridor, roadway, ferry, and aviation noise during all project phases, it would not be expected to affect recreation settings or experiences for park users.

Impacts to boating and snowmachine use on Iliamna Lake would be the same as those discussed under Alternative 1a.

As discussed for Alternative 1a, movement and distribution of bears and other terrestrial mammals through the transportation corridor to the McNeil River State Game Refuge and Katmai National Park and Preserve may be disrupted and may have some indirect adverse impacts on incidental wildlife viewing in those areas. Bears' behavior may be altered due to human exposure at the project facilities or altering migration patterns to avoid the project, though the nature or extent of behavior changes are unknown. Impacts would be the same as discussed for Alternative 1a.

Impacts to recreation activities near Amakdedori port would be the same as Alternative 1a; some activities may be displaced in the immediate area, and the port would be visible from offshore. Barge traffic may be noticeable to recreationists in Cook Inlet.

Impacts on recreation from construction and operation of the natural gas pipeline would be the same as the transportation corridor where they are co-located. Impacts of the natural gas pipeline through Cook Inlet and on the Kenai Peninsula would be the same as discussed under Alternative 1a.

#### 4.5.4.1 Alternative 1—Kokhanok East Ferry Terminal Variant

The magnitude of impacts from the Kokhanok East Ferry Terminal Variant would be similar to those described above for Alternative 1. The geographic extent of impacts would be a direct loss of 9,599 acres including 3,504 acres of wetlands and other waters available for recreation activities. This includes all project components. The loss would be long term and certain to occur if this Alternative 1 ferry terminal variant is chosen, permitted, and built.

#### 4.5.4.2 Alternative 1—Summer-Only Ferry Operations Variant

The Summer-Only Ferry Operations Variant would avoid impacts to snowmachine use of the lake (see Section 4.12, Transportation and Navigation, for impacts to non-recreational lake traffic). The magnitude of impacts during summer months would be higher than Alternative 1 due to daily truck traffic between the mine site and the port that would double to 78 round-trips per day on either side of the ferry route, or approximately 5.5 trucks per hour crossing in each direction (PLP 2018-RFI 065). In addition, a summer-only ferry operation would double to require two daily ferry trips. The geographic extent of impacts would be the direct loss of area available for recreation activities would be 9,661 acres. This includes all project components. These impacts would be long term lasting for the life of the project and would be realized if the Summer-Only Ferry Operations Variant is chosen and implemented.

#### 4.5.4.3 Alternative 1—Pile-Supported Dock Variant

The impacts from the Pile-Supported Dock Variant would be similar to those described above, except the dock footprint would be smaller (i.e., 22 acres). There would be a direct loss of 9,589 acres available for recreation.

### 4.5.5 Alternative 2—North Road and Ferry with Downstream Dams

This alternative would result in the direct loss of 9,763 acres of area available for recreation activities, including 2,268 acres of wetlands and other waters. This includes the mine site, transportation corridor, port, and natural gas pipeline components. The impact would be long term, lasting through the life of the project and would be certain to occur if Alternative 2 is permitted and built.

#### 4.5.5.1 Mine Site

Project construction, operations, and closure at the mine site would result in the physical removal of 8,478 acres of land currently available for recreation. This would include the loss of 2,135 acres of wetlands and other waters. Magnitude of impacts on recreation from the mine site would be the same as discussed under Alternative 1a although the geographic extent would be slightly larger. These impacts would be long term and would be certain to occur if Alternative 2 is permitted and built.

#### 4.5.5.2 Transportation Corridor

The transportation corridor under this alternative would result in the direct loss of 887 acres of area available for recreation activities, including 60 acres of wetlands and other waters. Visitors would likely be displaced to other lands in the general area with similar habitat. These impacts would be long term and would occur if Alternative 2 is permitted and built. Impacts along the mine access road to Roadhouse Mountain would be the same as Alternative 1a.

There are opportunities for hunting bear and moose in and adjacent to the transportation corridor. Magnitude of impacts on sport hunting opportunities and experiences from project-related noise and activities would be similar to those described above for the mine site under Alternative 1a; geographic extent of impacts would be slightly less.

Impacts to visitors flying over the corridor would be the same as those described under the transportation corridor for Alternative 1a, with fly-in visitors to the lodges in the Pedro Bay area in particular being affected by the change in recreation setting with the additional road, ferry terminal, and gas pipeline development.

Northern Iliamna Lake and the surrounding area provide opportunities for wildlife viewing. There are no known opportunities specific to the ferry terminal locations, ferry route, or road corridor. However, the movement and distribution of bears and other marine and terrestrial mammals throughout the transportation corridor may be disrupted by project activities over the long-term. Thus, construction and operations activities may have some indirect adverse impacts on wildlife viewing, including viewing of the Iliamna Lake harbor seals, in the transportation corridor. These impacts would occur if Alternative 2 is chosen, permitted, and built (see Section 4.23, Wildlife Values, for more information on impacts to wildlife movement and distribution).

Impacts to recreational fishing under Alternative 2 would be the same as those described under Alternative 1a; however, there are more guided fishing operations that could be impacted by Alternative 2.

Impacts to boating and snowmachine use on Iliamna Lake would be the same as those discussed under Alternative 1a (see Section 4.12, Transportation and Navigation, for impacts to non-recreational lake traffic); however, the impacts to these activities would occur in the northeastern side of the lake. The opportunities for hunting and fishing in these areas are different from those under Alternative 1a, and therefore would disrupt different boat and snowmachine traffic for those uses.

Similar to the mine site, project-related noise and activities along the Alternative 2 transportation corridor would not have substantial direct effects on recreational settings or activities in Lake Clark National Park and Preserve, which is 3 miles or farther from the corridor. Project-related construction, operations, and closure activities under Alternative 2 would result in similar noise impacts to those described for the Alternative 1a transportation corridor. Roadway traffic would generally result in noise-related impacts to the recreation setting, geographically limited to about 1 to 2 miles from the roadway; project-related activities would generally result in noise impacts limited to 0.4 and 2 miles of the ferry terminals for operations and closure activities, respectively. Given the distance of the Lake Clark park unit, noise impacts to recreation settings or activities would not be expected in the park unit.

The magnitude of effect of the transportation corridor, including the roads and the ferry terminals, would be highest from higher elevation or superior viewer positions located in the west end of the Lake Clark park unit (see Section 4.11, Aesthetics). Visitors to these few locations in the park would be able to see the transportation corridor, which would adversely affect recreation experiences, particularly wilderness experiences, due to the increased sight of human-made development (see Appendix K4.11 for project viewshed models). These impacts would occur through all phases of the project and would last beyond project closure. They would be certain to occur if Alternative 2 is permitted and built.

Transportation corridor facilities would not expose previously inaccessible areas to public access and use for some area residents as roads would either be for private use only, used by some residents in coordination with PLP, or would be located near an existing roadway. The improved Williamsport-Pile Bay Road would be in the vicinity of the current Williamsport-Pile Bay Road and would not create access to a previously inaccessible area. The mine access road and new portions of the port access road would have controlled access with scheduled public or shipping use. This would enhance the economic and logistic appeal of shipping supplies to villages so that recreational equipment (such as an ATV or a kayak) may be more readily available and/or less expensive to obtain. Thus, the road may increase recreation use on or around Iliamna Lake. Use of the transportation corridor and Pile Bay ferry terminal site may impact the annual transport of boats from Homer to Bristol Bay (see Section 4.12, Transportation and Navigation).

Construction of the natural gas pipeline along the port access and mine access roads would result in similar impacts to those described below for the Alternative 3 transportation corridor.

Frequency and impacts of flights to and from Iliamna would be the same as Alternative 1a. Construction cargo and passenger flight frequencies to the airstrip in Pile Bay would be similar to flight frequencies to Kokhanok under Alternative 1a. Impacts to Pedro Bay would be similar to those discussed for Kokhanok under Alternative 1a, including the use of the airport at Pedro Bay during construction. PLP would not construct a new airstrip at Diamond Point but would improve the existing airstrip near Pile Bay for limited use during construction.

#### 4.5.5.3 Diamond Point Port

The construction of the Diamond Point port would result in the direct loss of 113 acres of area that is currently partially available for recreation, including 72 acres of wetlands and other waters. However, there are already some industrial activities occurring in the area; some authorized fill has already been placed for the Diamond Point Quarry project. Therefore, the magnitude and extent of recreational impacts in Cook Inlet would be less under Alternative 2 than Alternative 1a. The loss of recreational area would be permanent and would be certain to occur if the Diamond Point port is permitted and built.

Construction, operations, and closure noise and activities would displace wildlife and fish from the Diamond Point port area, thus adversely affecting wildlife viewing, hunting, and fishing opportunities and experiences by reducing the likelihood of seeing wildlife or catching fish. Project-related noise and activities during construction, operations, and closure at Diamond Point port would add to current adverse effects to recreational experiences of visitors in the port area due to existing activity at the quarry site and may lead to additional displacement of visitors from increased noise and visual disturbance in the area and reduced opportunities for wildlife viewing, hunting, and fishing. Geographic extent of effects would be limited to a relatively small portion of Cook Inlet. There are nearby alternate locations where such recreational activities could occur; therefore, impacts would be low magnitude but would be long term, lasting for the life of the project and would occur if the Diamond Point port is permitted and built.

Impacts to boating from the Diamond Point port would be similar to those described under Alternative 1a for the Amakdedori port, except during the period of time when commercial fishing boats are transported from Williamsport to Pile Bay. During this transport, boats can get backed up in Iliamna Bay. Project-related boat traffic, particularly during construction when more boats may be accessing the port site or during lightering activities, would be more noticeably affected during this time.

The Alaska Maritime National Wildlife Refuge is the only designated recreation area where the port site, including construction, operations, and closure activities, would be visible. The recreational setting in affected areas of the refuge would change from a natural, undeveloped setting with mostly fishing boat traffic, to a setting with visible developed facilities and larger vessel traffic. Therefore, project construction, operations, and closure may adversely affect recreation experiences for refuge visitors who desire a more natural (less human-made development) view for recreation activities such as wildlife viewing and nature photography. There would be no new access to the refuge created, but the US Fish and Wildlife Service has expressed concern over trespass in the refuge. However, because the Alaska Maritime National Wildlife Refuge would be approximately 13 miles from the port, magnitude of impacts would be low and geographic extent limited to portions of the refuge with views toward the port. These effects would be long term and would be realized if the Diamond Point port is permitted and built.

### 4.5.5.4 Natural Gas Pipeline

Impacts on recreation from construction of the natural gas pipeline through Cook Inlet (except near Ursus Cove) would be the same as discussed under Alternative 1a; however, the pipeline would pass north of Augustine Island.

Under Alternative 2, the natural gas pipeline would come into Ursus Cove and then cross land north to reach Cottonwood Bay and the Diamond Point port site. Ursus Cove is a known bear hunting location (H&H Alaskan Outfitters 2018); both Ursus Cove and Cottonwood Bay are known commercial fishing locations (ADNR 2001) and are used for recreational fishing as well. Both Ursus Cove and Cottonwood Bay may also be used for other hunting activities and wildlife viewing.

Project-related noise from construction of the natural gas pipeline would occur during construction and may result in temporary impacts to recreation settings and experiences. These impacts would be short term, lasting only through construction of the transportation corridor. The loudest anticipated noise would be from general activities and utility equipment with helicopter support. The noise level from this activity would exceed 30 dBA, which could cause sleep disturbance for recreationists up to 3.7 miles from the roadway. Therefore, recreation users in this area, including Lake Clark park unit users in the Roadhouse Mountain and Tazimina River areas, could be temporarily affected by noise from the construction of pipeline and roads. Temporary impacts to recreation from the increased noise level would include low magnitude adverse effects on the recreation setting and recreation experiences, particularly wilderness experiences due to increased human-made sounds. These impacts would be certain to occur if Alternative 2 is permitted and built.

The magnitude and extent of noise and activities related to construction of the natural gas pipeline would be sufficient to temporarily displace wildlife and fish from the vicinity of the construction area, thus reducing the likelihood of viewing or hunting any wildlife or catching fish in and immediately adjacent to the EIS analysis area. These temporary construction impacts would occur along the rivers and areas in the northern Iliamna Lake area crossed by the pipeline, as well as the Diamond Point port site, Cottonwood Bay, and Ursus Cove. The impacts would occur if Alternative 2 is built and permitted. Hunters, anglers, or guides who currently use these areas would likely stop using these areas and would be displaced to other areas during construction activities.

During operations, the pipeline ROW between the two ferry terminals may create a route for ATV or snowmachine traffic (see Section 4.12, Transportation and Navigation). The most likely users of this new route along the ROW would be the residents in the communities of Pedro Bay, Nondalton, Iliamna, and Newhalen. Therefore, low magnitude impacts would result from an increase in recreation use along the ROW, in particular to gain access to hunting and fishing areas along the ROW, which previously would have been more difficult to access. If recreation use were to increase along the ROW via motorized vehicles, this may adversely affect recreation experiences for current visitors to the pipeline ROW area desiring solitude and other wilderness-type experiences. These impacts to recreation use and recreation experiences would be long term and continue beyond project closure; they would occur if Alternative 2 is implemented and the gas pipeline is permitted and built. Impacts to visitors flying over the pipeline would be the same as those described under the transportation corridor for this alternative.

The magnitude of impacts would be highest from the cleared pipeline ROW between the junction with the mine access road and port access road, which would contrast with the existing natural landscape (see Section 4.11, Aesthetics). This would adversely affect recreation experiences for visitors that could see this contrast due to a decrease in naturalness, particularly from nearby higher elevations where a larger portion of the entire cleared ROW would be visible. These impacts to the recreation setting and recreation experiences would be long term, extending beyond project closure. They would be realized if Alternative 2 is permitted and built.

Impacts to boaters on Cook Inlet and Iliamna Lake would be similar to those described for Alternative 1a.

#### 4.5.5.5 Alternative 2—Summer-Only Ferry Operations Variant

The Summer-Only Ferry Operations Variant would avoid the winter impacts to snowmachine use of the lake (see Section 4.12, Transportation and Navigation, for impacts to non-recreational lake traffic). The magnitude of impacts of this variant would be higher in summer due to doubling the daily truck traffic between the mine site and the port to 78 round-trips per day on either side of the ferry route, or approximately 5.5 trucks per hour crossing in each direction (PLP 2018-RFI 065). In addition, a summer-only ferry operation would require two daily ferry trips instead of one. The extent of impacts to recreation would be the direct loss of 9,819 acres that would otherwise be available to recreationists. This includes all project components. These impacts would be long term, lasting through the life of the project and would be realized if the Alternative 2, Summer-Only Ferry Operations Variant was chosen, permitted and built.

#### 4.5.5.6 Alternative 2—Pile-Supported Dock Variant

The magnitude of impacts from the Pile-Supported Dock Variant would be similar to those described above but 102 acres at the port site would be impacted. There would be a total loss of 9,753 acres available for recreation.

#### 4.5.5.7 Alternative 2—Newhalen River North Crossing Variant

The magnitude of impacts from the Newhalen River North Crossing Variant would be similar to those described above but would occur at the location of the bridge and 907 acres of the transportation corridor would be impacted. There would be a total loss of 9,783 acres available for recreation.

### 4.5.6 Alternative 3—North Road Only

This alternative would result in the direct loss of 10,130 acres of area available for recreation activities, including 2,231 acres of wetlands and other waters. This includes the mine site, transportation corridor, port, and natural gas pipeline components. The impact would be long term, lasting through the life of the project and would be certain to occur if Alternative 3 is permitted and built.

Under Alternative 3, the extent and duration of impacts on recreation would be the same as discussed under Alternative 2 for the mine site, Diamond Point port, and portions of the north access road that overlap with the transportation corridor of Alternative 2. The magnitude of impact would be greater than Alternative 2 because the port site is currently undeveloped and does not have authorized fill as a quarry. Impacts from construction of the natural gas pipeline would be the same as Alternative 2; however, operational impacts from potential ATV or snowmachine use of the ROW would not occur as the pipeline would be in the ROW of the north access road, which would be a private use road. Therefore, public use of the road would be limited as would the magnitude of impacts. Impacts to the recreation setting and experiences from the road would be similar to those described for other alternatives.

Impacts from the north access road on recreation settings, opportunities, and experiences from project-related noise and activities would be similar to those described above for the mine site under Alternative 1a and under Alternative 2 for the natural gas pipeline. Impacted visitors would likely be displaced to other lands in the general area with similar habitat. Impacts to visitors flying over the corridor would be the same as those described under the transportation corridor for Alternative 2. Impacts to recreational settings, experiences, and activities in Lake Clark National Park and Preserve would be the same as those described for Alternative 2.

The project may also affect incidental wildlife viewing along the transportation corridor; although most recreational use in the corridor is from other activities, such as fishing. Movement and distribution of bears and other terrestrial mammals through the corridor may be disrupted; therefore, construction and operations activities may have some adverse impacts on wildlife viewing along the transportation corridor. These impacts would be long term and would occur if Alternative 3 is permitted and built (see Section 4.23, Wildlife Values, for more information on impacts to bear movement and distribution).

There are fishing opportunities on the rivers and streams that cross the Alternative 3 transportation corridor, particularly along the Newhalen and Iliamna rivers due to the quality of fishing on these rivers and the presence of lodges in the Pedro Bay area. Construction noise and activities would displace fish at river/stream crossings, which would particularly affect fishing at the road crossings on the Newhalen and Iliamna rivers. Project noise would also change the recreation setting of the north access road corridor from quiet and remote to developed and active. Therefore, all project phases would adversely affect fishing experiences and opportunities along the transportation corridor. These impacts would occur where the transportation corridor crosses the Newhalen River; impacts would be long term and would occur if Alternative 3 is permitted and built. Impacts would be of medium magnitude because other portions of the streams crossed by the transportation corridor would be available for anglers that prefer a remote experience away from the roadway (see Section 4.6, Commercial and Recreational Fisheries, for more information on the economic impacts to fishing, and Section 4.12, Transportation and Navigation, for information on how structures would impact boat traffic).

The transportation corridor facilities would not expose previously inaccessible areas to public access and use as roads would either be for private use only, used by some area residents in coordination with PLP, or would be located near an existing roadway. Impacts to recreation from the Williamsport-Pile Bay Road would be the same as described under Alternative 2.

Impacts to boat portaging on the Williamsport-Pile Bay Road would be similar to those described for Alternative 2 (see Section 4.12, Transportation and Navigation).

Frequency and associated magnitude of effects from flights to and from Iliamna would be the same as under Alternative 1a. Flight frequencies to Pedro Bay and associated magnitude of effects would be similar to Alternative 2, but the connecting of Pedro Bay by road to the Cook Inlet would affect frequency of flights after construction if the road leads to more traffic through Pedro Bay. Potential effects from flights on Pedro Bay would be limited to resident crew change flights.

#### 4.5.6.1 Alternative 3—Concentrate Pipeline Variant

The Concentrate Pipeline Variant would result in impacts of similar magnitude to those described above for Alternative 3. A total of 10,132 acres would be unavailable for recreation.

### 4.5.7 Cumulative Effects

Potential cumulative impacts to recreation include reduction of recreational opportunities and changes in recreational setting and experiences. The cumulative effects analysis area for recreation is the same as the EIS analysis area.

Past, present, and reasonably foreseeable future actions (RFFAs) in the cumulative impact analysis area have the potential to contribute to impacts on recreation. Section 4.1, Introduction to Environmental Consequences, details the past, present, and RFFAs considered for evaluation. Of the RFFAs detailed in this section, all types are considered to have the potential to cumulatively impact recreation in the analysis area because they would all introduce people and/or structures into the environment that could degrade or reduce the recreation setting and experience. Some listed RFFAs that were removed from further consideration include those outside the analysis area or those with temporary impacts, such as during construction.

### 4.5.7.1 Past and Present Actions

Past and present actions that have affected or are currently affecting recreation in the analysis area are minimal. Current development consists of a small number of towns, villages, and roads. Present activities include mining exploration and non-mining related projects, such as transportation, oil and gas development, or community development actions. These actions have resulted in displacement of recreation activities and adversely affected the recreation setting. While these actions have affected localized areas, they are also additive to other actions, increasing the total areas affected and compounding impacts to the recreation setting, opportunities, and experiences. Around the mine site, current and past exploration drilling at the Pebble deposit has disturbed some wildlife that attracts hunters and anglers, which has displaced some recreationists as well.

Recreation and subsistence activities are currently the most prevalent uses of the land in the region, including several lodges and opportunities for guided recreation activities. Participation in recreation and subsistence activities may be increasing slightly, which increases the number of people in the area and can detract from the recreation experiences of people looking for opportunities for solitude and wilderness.

### 4.5.7.2 Reasonably Foreseeable Future Actions

The RFFAs identified in Section 4.1, Introduction to Environmental Consequences, that could contribute cumulatively to recreation impacts and are carried forward in this analysis include mining claims; oil and gas development in Cook Inlet; road improvement projects; and continuance of recreation activities in the greater regional area.

The No Action Alternative would not contribute to cumulative effects on recreation.

Collectively, the project alternatives with RFFAs' contribution to cumulative effects on recreation are summarized in Table 4.5-2.

**Table 4.5-2 Contribution to Cumulative Effects on Recreation**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Pebble Mine Expanded Development Scenario | **Mine Site:** An expanded development scenario for this project would include additional years of mining and processing, and involve a larger mine site and transportation system footprint. In addition to removing the footprint acreage from potential recreation use, the expanded mine would also displace wildlife over a larger area than the project and thus opportunities for hunting, fishing, and wildlife viewing would be reduced. Recreation opportunities in the footprint and wildlife-related recreation opportunities surrounding the mine site area would be displaced to other lands in the region, although there are few recreationists in this area. Mineral exploration activities associated with expansion of the Pebble mine would increase the developed/ modified area of the region, which would affect the recreation setting and thus recreation experiences for visitors in view and earshot of the mine site by reducing the naturalness of the area. There would also be additive effects to recreation experiences for visitors flying over the region because the landscape as a whole is more visible from a higher elevation, and the mine site would be more noticeable as it expanded. Due to the increase in development at the mine site, there would also be decreased opportunities for solitude in the area and increased recreation experience degradation for visitors participating in wilderness or wilderness-type activities or experiences.<br><br>Mine expansion would place waste rock storage and water management into the headwaters of the UTC watershed; the expansion of the open pit and bulk tailings facility would increase the amount of disturbance in the North Fork Koktuli and South Fork Koktuli rivers. The potential effects of mine site expansion would affect fish habitat, distribution, and numbers; therefore, sport fishing in the immediate vicinity of the facilities would also be affected. Even under routine operations, there could be project-generated noise and perceived impacts | **Mine Site:** Similar to Alternative 1a.<br><br>**Other Facilities:** Similar to Alternative 1a, except that the portion of the access road from the Eagle Bay ferry terminal to the existing Iliamna area road system would not already be constructed. The north access road would be constructed from the mine site to Iniskin Bay. A concentrate pipeline and a diesel pipeline would be constructed along the Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay.<br><br>**Magnitude:** Overall expansion would affect 32,148 acres that would be unavailable for recreation (more than the other alternatives), given that portions of the north access road and gas pipeline would not already be constructed. Impacts to recreation from mine expansion would be more than those under Alternative 1a.<br><br>**Duration/Extent:** The duration/extent of cumulative impacts to recreation would be similar | **Mine Site:** Similar to Alternative 1a.<br><br>**Other Facilities:** Expanded mine site development and associated contributions to cumulative impacts would be the same as Alternative 1a, although there would not be concurrent operations activities and traffic associated with Amakdedori port and the southern transportation corridor. Under Alternative 2, there would be a road constructed between the ferry terminals, resulting in impacts to recreation opportunities, experiences, and the recreation setting described above. Impacts from the Diamond Point port would also continue. Development in Iniskin Bay would result in impacts to recreation described under Alternative 1a, but would cumulatively contribute to impacts to recreation, and there would be existing impacts at the port site and in Iniskin Bay. The addition of a service road to both Iniskin Bay and between the ferry terminals would increase adverse impacts to recreation opportunities, | **Mine Site:** Similar to Alternative 1a.<br><br>**Other Facilities:** Expanded mine site development and associated contributions to cumulative impacts would be the same as described under Alternative 1a. Under Alternative 3, additional project facilities would have the same impacts to recreation as discussed under Alternative 2, with the exception that there would be no ferry operations associated with Alternative 3 and that the north access road would already be constructed and in operation.<br><br>**Magnitude:** Overall expansion would affect 31,541 acres that would be unavailable for recreation (fewer acres than Alternative 1a, and Alternative 1, but more than Alternative 2), given that the north access road and gas pipeline would already be constructed. Impacts to recreation from mine expansion would be less than those under Alternative 1a.<br><br>**Duration/Extent:** The duration/extent of |

**Table 4.5-2 Contribution to Cumulative Effects on Recreation**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | on the quality of the sport fishing experience in the upper portions of those drainages.<br>**Other Facilities:** Because the Amakdedori port facility and the transportation corridor (including ferry) would continue to be used through the life of mine expansion, impacts to recreation in those areas would continue, although with levels of truck traffic reduced to 21 round trips per day after 20 years. The construction and operation of additional facilities in Iniskin Bay, along with concentrate and diesel pipelines and the north access to Diamond Point, would further reduce recreational opportunities, displace recreation opportunities to other areas and waters, and reduce the naturalness of the area, thus impacting the recreation setting and recreation experiences for those visitors desiring or requiring a natural setting. A new road from Pile Bay to Eagle Bay would result in impacts similar to those described for Alternative 3 and would cumulatively affect recreation opportunities and experiences in the region, as well as adversely affecting the overall recreation setting of the area by increasing development.<br>**Magnitude:** The Pebble mine expanded development scenario project footprint would impact approximately 31,892 acres that would be unavailable for recreation.<br>**Duration/Extent:** Potential cumulative effects on recreation associated with the expanded Pebble project would be longer in duration (78 total years of mining, with another 20 to 40 years of processing) than Alternative 1a. The extent would include the Amakdedori port and mine access road of Alternative 1a, and the port access road and Diamond Point/Iniskin Bay ports of Alternatives 2 and 3.<br>**Contribution:** Recreation opportunities in the footprint and wildlife-related recreation opportunities surrounding the project area likely would be displaced to other lands in the region. | to those under Alternative 1a, although affecting more acres.<br>**Contribution:** The contribution to cumulative effects would be slightly more than that under Alternative 1a and Alternative 2 and Alternative 3. | experiences, and the recreational setting, although it is likely that the ferry would cease operations once the access road was constructed. The use of the concentrate pipeline would reduce truck traffic associated with transporting copper/gold concentrate to Diamond Point.<br>**Magnitude:** Overall expansion would affect 31,528 acres that would be unavailable for recreation (fewer acres than the other alternatives), given that a portion of the north access road and all of the gas pipeline would already be constructed. Impacts to recreation from mine expansion would be less than those under Alternative 1a.<br>**Duration/Extent:** The duration/extent of cumulative impacts to recreation would be similar to those under Alternative 1a, although affecting fewer acres.<br>**Contribution:** The contribution to cumulative impacts would be similar to that under Alternative 1a, although affecting fewer acres. | cumulative impacts to recreation would be similar to those under Alternative 1a, although affecting fewer acres.<br>**Contribution:** The contribution to cumulative impacts would be similar to that under Alternative 1a, although affecting fewer acres. |

**Table 4.5-2 Contribution to Cumulative Effects on Recreation**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Other Mineral Exploration Projects | **Magnitude:** Mineral exploration is likely to continue in the analysis area for the mining projects listed above and involve summer drilling as well as helicopter and camp support. Mineral exploration activities could contribute cumulatively to degradation of recreation experiences, particularly wilderness experiences, through noise in the immediate vicinity of drilling, the presence of aircraft, and increases in landscape disturbance. Exploration activities would also reduce acreage available for recreation and displace wildlife, thereby reducing opportunities for hunting, fishing, and wildlife viewing in remote areas during the summer season. There would be additive effects to recreation experiences for visitors flying over the region because there would be more noticeable development in this remote area.<br>**Duration/Extent:** Exploration activities typically occur at a discrete location for one season, although a multi-year program could expand the geographic area affected in a specific mineral prospect. Section 4.1, Introduction to Environmental Consequences, identifies seven mineral prospects in the EIS analysis area where exploratory drilling is anticipated (four are relatively close to the Pebble Project).<br>**Contribution:** This contributes to cumulative effects of reduction or degradation of recreational experiences, although the areal extent of disturbance is a relatively small portion of the Kvichak and Nushagak watersheds. | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |
| Oil and Gas Exploration and Development | **Magnitude:** Onshore oil and gas exploration activities could involve seismic and other forms of geophysical exploration, and exploratory drilling in limited cases. Impacts to recreation would be similar to those discussed for mining exploration. Noise, aircraft traffic, and the sight of exploration equipment would all affect the recreation experience in the immediate vicinity of activities. | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |

**Table 4.5-2 Contribution to Cumulative Effects on Recreation**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | Offshore oil and gas exploration could detract from marine recreation experience in the immediate vicinity, although recreation activity in lower Cook Inlet is limited. Potential impacts from ship traffic associated with the ASAP and Alaska LNG projects would be similar.<br>**Duration/Extent:** Seismic exploration and exploratory drilling are typically single season temporary activities. Ship traffic associated with the Alaska LNG or ASAP projects would occur for the construction and operational life of those projects.<br>**Contribution:** Oil and gas projects in Cook Inlet could contribute cumulatively to temporary adverse impacts to boating, fishing, and boat traffic in the Cook Inlet if construction periods overlapped. Note that there would not be development of both the Alaska LNG and ASAP projects; only one of these two projects would be carried forward. Onshore exploration and development would affect the recreation experience in the immediate vicinity of activities. | | | |
| Road Improvement and Community Development Projects | **Magnitude:** Anticipated road improvement projects in the region, such as the Williamsport-Pile Bay Road upgrade, could create new access to recreation areas and/or improve current access, thereby increasing opportunities for recreation but reducing opportunities for solitude and adversely affecting wilderness experiences. The most likely road improvements are in the development footprint of existing communities and would not affect recreation. Development in the vicinity of Stariski Creek could reduce the effect of the natural gas compressor station on the recreation setting by increasing development, thus decreasing the noticeability of the station. However, this development would also reduce the naturalness of the area, cumulatively affecting the recreation setting.<br>The Diamond Point rock quarry could adversely contribute to cumulative impacts to recreational | Similar to Alternative 1a and Alternative 2; with greater impacts than Alternative 3 | Cumulative impacts would likely be less under Alternative 2 due to commonly shared project footprints with the quarry site. | Similar to Alternative 2; less than Alternative 1a and Alternative 1. |

**Table 4.5-2 Contribution to Cumulative Effects on Recreation**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | opportunities and experiences, boat traffic, and changes to the recreation setting in Iliamna Bay.<br>**Duration/Extent:** Disturbance from road construction would typically occur over a single construction season. The geographic extent would be limited to the vicinity of surrounding communities and Diamond Point.<br>**Contribution:** Road construction could create new access to recreation areas and/or improve current access, thereby increasing opportunities for recreation but reducing opportunities for solitude and adversely affecting wilderness experiences. | | | |
| Summary of Project contribution to Cumulative Effects | Overall, the contribution of Alternative 1a to cumulative effects to recreation, when taking other past, present, and reasonably foreseeable future actions into account, would be minor in terms of magnitude, duration, and extent, given the limited acreage and small number of recreationists that would be affected. | Similar to Alternative 1a, although slightly more acres would be affected by expansion of the Pebble Mine. | Similar to Alternative 1a, although slightly fewer acres would be affected by expansion of the Pebble Mine. | Similar to Alternative 1a, although fewer acres would be affected by expansion of the Pebble Mine. |

Notes:
ASAP = Alaska Stand Alone Pipeline
LNG = Liquefied Natural Gas
UTC = Upper Talarik Creek

## 4.6 COMMERCIAL AND RECREATIONAL FISHERIES

This section addresses the direct and indirect effects of the No Action Alternative and action alternatives on commercial and recreational fishing. The Alaska Department of Fish and Game (ADF&G) Commercial Salmon Fishery Area T and Area H; ADF&G Commercial Shellfish Area H; Cook Inlet Management Area (for groundfish); and ADF&G Statewide Harvest Survey (SWHS) areas S, T, N, and P comprise the Environmental Impact Statement (EIS) analysis area for this resource.

Potential impacts include:

- Short- or long-term direct and indirect changes in salmon populations, or harvestability of returning salmon, which reduce the number of returning adult spawners available for harvest by commercial permit holders, thus reduce:
  - Wholesale fisheries value, payments to permit holders and crew, and expenditures into local economies
  - Delivery of fish to processors, revenue generated by processed fish, and employment of and payments to processing labor
  - Generation of tax revenue to state and local governments through sales tax, real property tax, and raw fish tax
  - Directed commercial and sport recreational fishing effort
- Short- or long-term direct and indirect changes in groundfish or shellfish populations in Cook Inlet, thus reducing:
  - Wholesale fisheries value, payments to permit holders and crew, and expenditures into local economies
  - Delivery of fish to processors, revenue generated by processed fish, and employment of and payments to processing labor
  - Generation of tax revenue to state and local governments through sales tax, real property tax, and raw fish tax
  - Directed commercial and sport recreational fishing effort
- Reduction in consumer willingness to buy Bristol Bay salmon due to a perceived loss of quality, resulting in a lower price paid to commercial harvesters
- A reduction or displacement of recreational fishing effort associated with affected waterbodies, along with an associated reduction in guide/lodge company revenues and government revenue generated by the professional guide tax if the proposed project reduces fish populations or the real or perceived quality of fishing opportunities
- An increase in recreational fishing effort associated with long-term project-driven population changes and/or changes in the regional transportation network

The magnitude (i.e., size) of impact from the project is primarily determined by the number of fish that would be impacted; the duration and geographic extent of impacts depends on the location and season that the disturbance occurs (construction, operations, or closure); and the potential of impact is the likelihood that the project would impact fisheries. Duration would be considered long term if the effect lasted throughout the life of the project, or for years to decades.

Scoping comments specifically addressed concerns that Bristol Bay commercial and recreational fisheries would be impacted, and that the Bristol Bay wild salmon brand would be damaged by the presence of the project because the watershed would no longer be pristine. Other comments expressed concern that all commercial fishing jobs would be lost, that construction and operation of the Amakdedori port would conflict with commercial salmon fishing, and that increased marine traffic would impede other fishing operations.

**Commercial Fisheries**—The project has potential to affect the Bristol Bay commercial fisheries sector and related fiscal contributions through two primary mechanisms. One potential mechanism of effect would be a decline in the productivity of Bristol Bay river systems due to destruction of fish habitat from the placement of fill, and from changes in habitat quality such as increased sedimentation or altered stream flows and water quality. These effects of these mechanisms would be reflected through a decline in total fishery harvest. The other mechanism, though not expected to occur, would be a change in market reception of Bristol Bay fish. The total value of the fishery in economic terms starts with volume (i.e., productivity) and price (i.e., what the market will pay for the fish). Although permit holders and processors are the two most frequently discussed groups associated with the fishery, the economic connections of the fishery extend to crew members, shipping companies, local businesses, utilities, and governments. In Cook Inlet, impacts on fisheries would be in the form of potential disruption of traditional fishing practices and locations (e.g., groundfish fisheries, salmon fisheries in the Cottonwood and Chenik subdistricts); or by affecting productivity (e.g., the Kamishak Bay Weathervane scallop [*Patinopecten caurinus*] beds or the recovery of Pacific herring [*Clupea pallasi*] populations). Mitigation measures to reduce impacts to fish populations and thus reduce impacts on the economic value of the fish are discussed in Chapter 5, Mitigation.

In terms of magnitude, the loss of any harvestable fish from a project-induced decline in productivity would result in a lower total fishery value. Every harvested salmon has a quantifiable value to permit holders, processors, and state and local governments. This value varies from year to year with average ex-vessel price and average wholesale value, but it is demonstrable that every salmon lost to harvest has an economic value. Estimates of lost productivity as analyzed in Section 4.24, Fish Values, are used to estimate lost ex-vessel payments, lost wholesale value, and lost fishery-related government revenues.

It is easier to connect lost productivity in the fishery to lost ex-vessel and first wholesale values than it is to connect the effect of a change in consumers' willingness to pay for Bristol Bay salmon to these same measures. Bristol Bay prices reflect both the market for wild Alaska salmon products and the broader market for all salmon products, including farmed salmon (see Section 3.6, Commercial and Recreational Fisheries). Bristol Bay salmon has traditionally received a price discount compared to other sockeye salmon [*Oncorhynchus nerka*] fisheries in Alaska because of factors such as unbranded status, distance, product mix, high operating costs, and run timing (McDowell 2014). In 2016, the Bristol Bay Regional Seafood Development Association launched the fishery's first effort to develop a cohesive brand identity in an attempt to change the traditional price discount and potentially establish a premium price as the Copper River fishery has done. It is currently a challenge for many consumers to identify Bristol Bay salmon at their point of sale (McDowell 2014), but the Bristol Bay Regional Seafood Development Association is consistently working to make it easier for consumers to do so. These efforts have the potential to raise prices, but higher visibility also increases the potential for a reduction in consumer willingness to pay if consumers feel that brand is threatened or not representative of the product for sale.

In Cook Inlet, the project could affect commercial groundfish, shellfish, and salmon harvests. Because the fishery is smaller, the magnitude of these disruptions would be smaller than potential Bristol Bay effects, but broader in extent. Commercial groundfish harvesters may have to change where they place fixed gear, such as pots and longlines, because of the natural gas pipeline. They could experience changes in harvest rates or increased operational costs. Processors would only experience effects if the project caused a change in the timing and distribution of harvests, which is not expected for these fisheries. Commercial salmon harvesters could experience changes in fishing patterns in the Chenik and Cottonwood subdistricts of the Lower Cook Inlet salmon fishery. In addition, the harvest and long-term productivity of the Kamishak Bay weathervane scallop fishery could be affected by the route of the natural gas pipeline. These effects would be long term and expected to occur to some degree if the pipeline is permitted and constructed.

**Recreational Fisheries**—Specific potential effects of the project on recreational fisheries could be:

- Direct loss of angler days on portions of the North and South Fork of the Koktuli River, which are in the project area
- Changes in angler behavior and charter business behavior in Cook Inlet to avoid the route of the natural gas pipeline or to adapt to change in the geographic distribution of the Pacific halibut resource caused by the pipeline or port operations
- A reduction in angler days downstream of the project area if the project reduces fish populations of target species such as Rainbow trout (*O. mykiss*), Dolly Varden (*Salvelinus malma)*, and adult salmon in downstream waters
- Reduction in angler days caused by a change in the quality of the fishing experience (e.g., changes in catch rates and/or the aesthetic quality of the experience) on waterbodies affected by the selected transportation routes
- Reduction in and/or redistribution of income to commercial guides, lodges, and air transporters based on reduction in angler days or redistribution of angler response to changes in the quality of the fishing experience
- An increase in angler days caused by an increase in the number of opportunities through expansion of the local road network or an increase in regional population

The Bristol Bay watershed is renowned for the diversity of its recreational angling opportunities. Therefore, fishing effort (angler days) and the ability of anglers and guides to redirect operations to substitute sites are key in determining the magnitude and duration of recreational fishing impacts.

### 4.6.1 Summary of Key Issues

Under normal operations, the alternatives would not be expected to have a measurable effect on fish numbers or result in long-term changes to the health of the commercial fisheries in Bristol Bay (Table 4.6-1). In terms of magnitude and extent, Alternative 1a would be expected to have minimal effects on commercial fisheries in Cook Inlet, with the highest probability of impacts centered around the Amakdedori port site and the siting of the natural gas pipeline. The Chenik subdistrict salmon harvests and the Kamishak Bay weathervane scallop fishery are the fisheries most likely to experience direct effects from construction and operations activities. The Cook Inlet groundfish fishery could also experience direct effects because of pipeline construction and operations. The Pacific herring fishery in Kamishak Bay could experience direct or cumulative effects, but the magnitude of effects is unknown. In terms of geographic extent of impacts, Alternative 2 and Alternative 3 avoid the noted Cook Inlet salmon, scallop, and herring interactions of Alternative 1a and Alternative 1.

With regard to recreational fishing, the extent of project impacts would be displacement of recreational fishing effort by mining activities along a short length of the upper Koktuli River, and by road transportation activities along Upper Talarik Creek under Alternative 1. In terms of magnitude of effects, ADF&G SWHS data indicate that effort along these rivers is modest, with a 1996 through 2016 average of 424 angler days a year along the entire Koktuli River and 147 angler days per year on the entire Upper Talarik. The Koktuli does not appear in ADF&G Guide

Logbook data for 2011 through 2014, and the estimated average number of guided days on the Upper Talarik is fewer than 50 angler days per year. Alternative 1a and Alternative 1 would result in a new road alongside and across the Gibraltar River. This river receives roughly the same total annual recreational fishing effort and six times the guided angling effort of the Koktuli River and Upper Talarik Creek, combined. Alternative 1a, Alternative 2, and Alternative 3 would intersect with the Newhalen and Iliamna rivers. These rivers are already connected by road to local communities and together host approximately 2,900 angler days per year (Table 4.6-1). Alternative 3 would also intersect the Pile River, which has measurable recreational fishing effort. The road corridor intersections may result in the redistribution of some angler days along the river.

**Table 4.6-1: Summary of Key Issues for Commercial and Recreational Fisheries**

| Effect | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| **Mine Site** | | | | |
| Effects to commercial fisheries | Impacts from the mine site would be the same across all alternatives. The mine site would result in loss of fish habitat in the upper North and South Fork Koktuli rivers. This disturbance would not be expected to have measurable effects on the number of adult salmon returning to the Nushagak and Kvichak district (see Section 4.24, Fish Values). The mine site area is not connected to the Togiak, Ugashik, Naknek, and Egegik watersheds and is not expected to affect fish populations or harvests from these watersheds.<br>The mine site is not expected to affect Cook Inlet commercial fisheries. | | | |
| Effects to recreational fisheries | All alternatives would affect upper portions of the North and South Fork Koktuli rivers. The Koktuli River does not appear in some ADF&G SWHS publications because not enough survey respondents report fishing on the river. The river also does not appear in ADF&G Guide Logbook data for 2011 through 2014. The unpublished ADF&G SWHS estimates for the entire Koktuli River for 2007 through 2016 average 285 angler days per year. Some of these days would be displaced if they occurred in the project area.<br>The mine site is not expected to affect Cook Inlet recreational fisheries. | | | |
| **Transportation Corridor** | | | | |
| Effects to commercial fisheries | This corridor would intersect with Upper Talarik Creek, the Gibraltar River, Dunuletak Creek, Amakdedori Creek, and the Newhalen River, and would cross Iliamna Lake. This alternative would not be expected to have measurable effects on the number of adult salmon, and therefore would have no impact to commercial fisheries. | This corridor would intersect with Upper Talarik Creek, Pete Anderson Creek, the Gibraltar River, Dunuletak Creek, and Amakdedori Creek, and would cross Iliamna Lake. This alternative would not be expected to have measurable effects on the number of adult salmon, and therefore would have no impact to commercial fisheries.<br>The Kokhanok East Ferry Terminal Variant would avoid impacts to Gibraltar River. | This corridor would intersect with Upper Talarik Creek, the Newhalen River, and the Iliamna River while crossing Iliamna Lake. This alternative would not be expected to have measurable effects on the number of adult salmon, and therefore would have no impact to commercial fisheries. | This corridor would intersect with Upper Talarik Creek, the Newhalen River, Chekok Creek, Canyon Creek, Knutson Creek, the Pile River, and the Iliamna River. This alternative would not be expected to have measurable effects on the number of adult salmon, and therefore would have no impact to commercial fisheries. |

**Table 4.6-1: Summary of Key Issues for Commercial and Recreational Fisheries**

| Effect | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Effects to recreational fisheries | The Gibraltar River (approximately 650 angler days per year) and the Newhalen River (approximately 1,900 angler days per year) are the most frequently fished waterbodies along this route. The Gibraltar River is currently roadless, and the project would change the character of the river in the immediate vicinity of the intersection with the access road. Angling pressure on the river may redistribute to other locations along the waterbody or to other waterbodies.<br>Along the Newhalen River, transport activity may disrupt fishing effort where the corridor intersects the river, but this effort would be redistributed.<br>These impacts could impact the revenue of guides, lodges, and air transporters who support recreational fishing in this area, with related impacts to local and state revenue. Overall impacts should be limited in magnitude, with the potential for large-magnitude localized impacts for anglers and businesses who focus on the Gibraltar River in particular.<br>The corridor would cross Iliamna Lake, which (including its tributaries) hosts 1,900 to 2,200 angler days per year. Transport across the lake should not affect these fisheries. | Only the Gibraltar River hosts a measurable amount of angling pressure (approximately 650 angler days per year). The Gibraltar River is currently roadless, and the project would change the character of the river in the immediate vicinity of the access road intersection. Angling pressure on the river may be redistributed to other locations along the waterbody or to other waterbodies. This could impact the revenue of guides, lodges, and air transporters who support recreational fishing in this area, with related impacts to local and state revenue.<br>The corridor would cross Iliamna Lake, which (including its tributaries) hosts 1,900 to 2,200 angler days per year. Transport across the lake would not be expected to affect these fisheries.<br>The Kokhanok East Ferry Terminal Variant would avoid impacts to Gibraltar River.<br>The Summer-Only Ferry Operations Variant would result in more impacts than Alternative 1 to recreational fishing setting at the Gibraltar River. | The Newhalen River drainage (approximately 1,900 angler days per year) and the Iliamna River (approximately 1,000 angler days per year) are the most frequently fished waterbodies along this route. Transportation activity may disrupt fishing effort where the corridor intersects with these creeks, but this effort should redistribute along the waterbodies as long as fish populations are unaffected. Overall effects should be low in magnitude, but higher-magnitude localized effects are possible.<br>Iliamna Lake (including its tributaries) hosts 1,900 to 2,200 angler days per year. Transport across the lake should not affect these days.<br>Only the pipeline ROW would intersect with the smaller creeks noted in Alternative 3, impacting recreation experience primarily during construction.<br>The Summer-Only Ferry Operations Variant would result in more impacts to recreational fishing at the Newhalen River, based on increased truck traffic. | The Newhalen River drainage (approximately 1,900 angler days per year) and the Iliamna River (approximately 1,000 angler days per year) are the most frequently fished waterbodies along this route. Transportation activity may disrupt fishing effort where the corridor intersects with these creeks and other waterbodies, but this effort would redistribute along the waterbodies. Overall effects should be low in magnitude, but higher-magnitude localized effects where transportation corridors cross the river are possible. |

**Table 4.6-1: Summary of Key Issues for Commercial and Recreational Fisheries**

| Effect | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| **Port Site** | | | | |
| Effects to commercial fisheries | The Amakdedori port site intersects with the Chenik subdistrict of the Kamishak Bay District and is the location of an annual salmon fishery. In addition, the port site is in an area that hosted a historical Pacific herring fishery. This fishery is now closed because of low biomass, but could reopen in the future. | | The Diamond Point port site is near a chum salmon (*O. keta)* fishery, which does not experience harvest every year. Permit holders and ADF&G have expressed concern that the presence of the port would interfere with tidal seine operations during years when there is harvest and that operations could impact juvenile rearing areas. | |
| Effects to recreational fisheries | The Amakdedori port site is near Amakdedori Creek, which does not appear in SWHS or guide logbook data. The closest waterbody with measurable fishing effort Is the Kamishak River, which is approximately 20 air miles south. | | There are no recreational fishing resources of note near the Diamond Point port site. The closest waterbody with measurable fishing effort is the Iliamna River. | |
| **Pipeline Route** | | | | |
| Effects to commercial fisheries | On the western side of Cook Inlet and in the Bristol Bay watershed, the natural gas pipeline would not directly interact with the Bristol Bay salmon fishery after construction. The pipeline would cross waters fished by the Cook Inlet salmon fishery and Cook Inlet groundfish fisheries. The pipeline would not directly interact with the drift net salmon fishery, given that the salmon fishery occurs in the top 30 feet of the water column. Seine gear in the Chenik subdistrict could be impacted by the pipeline.<br>Alternative 1a and the Alternative 1 pipeline route could disturb the northern Kamishak Bay weathervane scallop bed, negatively affecting biomass and delaying or impeding the reopening of that fishery. Alternative 2 and Alternative 3 avoid this potential effect.<br>The ROW of Alternative 2 and the transportation corridor of Alternative 3 would intersect with Brown's Peak Creek, which has a sustainable escapement goal for pink salmon (*O. gorbuscha)*. Comments from ADF&G indicate that this creek is periodically targeted by commercial fisheries. | | | |
| Effects to freshwater recreational fisheries | The pipeline would follow the transportation corridor and would not be expected to affect recreational fishing resources beyond those aforementioned under the transportation corridor. Cook Inlet and Anchor River fishing opportunities would be unaffected. | The pipeline would follow the transportation corridor and would not be expected to affect recreational fishing resources beyond those aforementioned under the transportation corridor. Cook Inlet and Anchor River fishing opportunities would be unaffected. | The pipeline would cross the same streams as the north access road under Alternative 3. Access along the ROW may increase for recreational fishing, but the increase would be low intensity. Cook Inlet and Anchor River fishing opportunities would be unaffected. | The pipeline would follow the transportation corridor and would not be expected to affect recreational fishing resources beyond those aforementioned under the transportation corridor. Cook Inlet and Anchor River fishing opportunities would be unaffected. |
| Effects to Cook Inlet saltwater recreational fisheries | The pipeline would cross waters used by Cook Inlet salmon and groundfish anglers. Salmon in saltwater are traditionally caught by trolling in the upper reaches of the water column. Because the pipeline would lie on the seabed, salmon anglers are unlikely to be affected by it. Groundfish anglers traditionally target Pacific halibut by placing baited and weighted hooks on or just above the seabed. They may need to avoid the pipeline route, or may be affected by the disruption of traditional halibut "holes" and the potential for changes in local halibut abundance. | | | |

Notes:
ADF&G = Alaska Department of Fish and Game
ROW = right-of-way
SWHS = Statewide Harvest Survey

## 4.6.2 No Action Alternative

Under the No Action Alternative, federal agencies with decision-making authorities on the project would not issue permits under their respective authorities. The Applicant's Preferred Alternative would not be undertaken, and no construction, operations, or closure activities specific to the Applicant’s Preferred Alternative would occur. Although no resource development would occur under the Applicant's Preferred Alternative, Pebble Limited Partnership (PLP) would retain the ability to apply for continued mineral exploration activities under the State's authorization process (ADNR 2018-RFI 073) or for any activity not requiring federal authorization. In addition, there are many valid mining claims in the area, and these lands would remain open to mineral entry and exploration by other individuals or companies.

It would be expected that current State-authorized activities associated with mineral exploration and reclamation, as well as scientific studies, would continue at levels similar to recent post-exploration activity. The State requires that sites be reclaimed at the conclusion of their State-authorized exploration program. If reclamation approval is not granted immediately after the cessation of activities, the State may require continued authorization for ongoing monitoring and reclamation work as it deems necessary.

Therefore, no future direct or indirect effects on commercial or recreational fisheries would be expected, and current trends in commercial and recreational fisheries would continue.

### 4.6.2.1 Commercial Fishing

The total value of the Bristol Bay salmon fishery depends on two primary factors: the volume of salmon harvested and the value per pound of that salmon. Direct and indirect effects to commercial fishing from the project require a connection between any alternative and either or both of those factors.

#### Permit Holders and Crew Members

Under the No Action Alternative, there would be no project-associated change that could affect price in the number of returning fish available for harvest, the long-term productivity from the Nushagak and Kvichak river systems, or the reputational value of the fishery. The ex-vessel value of the fishery earned by permit holders and wages paid to crew members would continue to be affected by the broader drivers of the value of the Bristol Bay salmon fishery, including world protein markets, world salmon markets, the overall productivity of the fisheries, and the decisions of processors about what products to produce.

#### The Processing Sector

Without an effect on the value or volume of salmon produced by the ecosystem, the No Action Alternative would not have any effect on the processing sector.

#### Fiscal Contributions

The No Action Alternative would not negatively affect fiscal contributions to state and local governments. It is possible that the future attractiveness of the fishery could increase if permit holders and processors have been withholding investment in recent years with the expectation that the proposed project would be built and would materially affect the fishery. However, there is no evidence that permit holders or processors have been withholding investment in the fishery. In 2014, Silver Bay Seafoods opened the fishery’s first new major plant in several years. The company expanded the plant in 2015 and has the capability to expand more if the flexibility is needed (SBS 2018). Over the last decade, permit holders have installed refrigerated seawater systems to properly chill their salmon immediately after harvest and obtain the chilling bonuses offered by processors. The amount of slush ice in Bristol Bay, usually provided by processors, has not increased in recent years. Without growth in slush ice availability, new chilling capacity is coming from refrigerated seawater installations (NEI 2018).

### 4.6.2.2 Recreational and Tourism-Based Fishing

Recreational fishing is driven by two populations: resident anglers and non-watershed resident anglers, including other Alaskans. The Bristol Bay region is renowned for its productive rainbow trout, king salmon, and sockeye salmon fisheries, as well as its ability to provide an uncrowded fishing experience in a remote and pristine environment. Fishery effort varies with fishing conditions, the availability of tour providers/guides, and the state and world economy. Recreational fishing in areas N, S, and T declined from 2000 to 2002 and from 2007 to 2009 as the US economy experienced economic recessions (see Section 3.6, Commercial and Recreational Fisheries). Recreational fishing in Area T also declined from 2014 to 2016. Effort in individual fisheries varies with the quality of the runs, and weak Chinook salmon (*O. tshawwytscha*) returns can affect participation in Chinook fisheries. For example, weak runs over the last decade have reduced the number of guided angler days on the Kenai River between Cook Inlet and the Soldotna Bridge from 34,000 in 2008 to just under 22,000 in 2016. In 2010, the Nushagak River closed to the retention of Chinook salmon. Angler days between the ADF&G sonar site and the mouth of the Mulchatna River declined from 8,100 in 2009 to 3,600 in 2010. The data imply that retention closures reduced angler days by more than 4,000, or 50 percent of prior year effort (ADF&G 2018d). In Cook Inlet, total saltwater effort currently stands at approximately 185,000 days per year. Effort in Cook Inlet is slowly growing but is economically sensitive; total effort dropped from 175,000 days in 2008 to 166,000 days in 2009. Effort recovered to 196,000 days in 2014 as the local and national economies recovered, but then dropped to 181,000 days in 2016 as Alaska entered the largest recession since the 1980s. Under the No Action Alternative, recreational fishing would continue under current conditions and trends, affected by temporally limited events such as recessions and temporary restrictions on fishing effort or harvest.

#### Commercial Fishing Guides, Lodges, and Air Transporters

The high-value fishing experience that can be found in the Bristol Bay Region and portions of Cook Inlet supports a number of commercial fishing guides and charter operations, commercial fishing lodges, and air transporters. Under the No Action Alternative, the availability of sport fish that support these operations and the quality of the fishing experience would remain the same in the EIS analysis area.

#### Fiscal Contributions

Under the No Action Alternative, recreational fishing fiscal contributions, including guide and air taxi revenues, government sales, and use tax revenues, would continue under current conditions and trends.

## 4.6.3 Alternative 1a

Project construction and operations could have an impact on both the commercial fishing community (e.g., crew members or processing), on the recreational sector via recreational fishing, and on revenue generated to state and local government. Potential impacts are influenced by project-related effects on fish population, habitat, and runs (see Section 4.24, Fish Values), as well as real and perceived effects on the quality of the fish, environment, and fishing experience.

### 4.6.3.1 Commercial Fishing

The ADF&G manages for the maximum sustain yield of the fishery by ensuring that a minimum, but preferably optimal, number of spawners reach their home rivers (see Section 3.6, Commercial and Recreations Fisheries). The ADF&G has no control over external factors such as ocean conditions, so it largely manages the number of returning spawners by adjusting commercial and recreational fishing harvest via effort. The ADF&G restricts effort when the strength of the returning run requires less harvest to meet the escapement goals, and liberalizes harvest opportunity when run strength threatens to exceed optimal escapement maximums goals. ADF&G reviews escapement goals every 3 years and adjusts them when data indicate that system productivity, and the optimal number of spawners, has changed. Beyond the scheduling of fishing openings and closures, the ADF&G also has the ability to define the geographic extent of fishery openings. For example, the points at which the Naknek and Kvichak rivers empty into Bristol Bay are just miles apart. In years when the Kvichak sockeye run has been weak, the ADF&G has restricted the fishing fleet to the mouth of the Naknek River to limit the harvest of Kvichak-bound fish. Under more normal conditions, this district is managed with less specificity.

ADF&G manages the fishery to try to obtain a river's maximum sustainable yield. This goal means ensuring that the optimal number of spawners, based on carrying capacity, return to natal streams. If system productivity is reduced, resulting in a measurable reduction in returning fish (after ADF&G management adjustments), then permit holders, crew, and processors will harvest and process fewer fish and very likely earn a reduced income. Crew members, permit holders, processors, and local municipalities are all dependent on the total value of the Bristol Bay fishery, which is a function of market price and harvested volume. When permit holders harvest fewer fish, the net result is that permit holders receive a lower net income, crew members are paid less, processors have less product to sell, and municipalities have less economic activity to tax.

Alternative 1a would not have measurable effects on the number of adult salmon returning to the Kvichak and Nushagak river systems as a result of project construction and operations, due the limited lineal footage of upper Koktuli River fish habitat affected by placement of fill (see Section 4.24, Fish Values). Section 4.27, Spill Risk, discusses the potential for salmon loss resulting from spills.

As noted above, the commercial fishing sector has expressed concerns that the existence of the project could lower the perceived quality of Bristol Bay salmon and thus lower price. Prices paid in Bristol Bay are nearly always lower than those paid in other Alaska salmon fisheries producing similar products, which reflects the higher transportation expense associated with Bristol Bay's geographic location and the lack of a strong brand identity that could boost average prices. Other salmon fisheries in Alaska exist in conjunction with non-renewable resources. For example, the Cook Inlet salmon fisheries exist in an active oil and gas basin, and there are headwaters near developed areas of Anchorage and the Matanuska-Susitna Borough. The Copper River salmon fishery occurs in a watershed with the remains of the historic Kennecott Copper Mine, and the Trans-Alaska Pipeline System crosses the headwaters of portions of the fishery. Both of these fisheries have average higher prices per pound than the Bristol Bay Salmon Fishery (see Section 3.6, Commercial and Recreational Fisheries). This information noted, no other wild salmon fishery in the world exists in conjunction with an active mine of this size, so existing examples are limited in their usefulness as working comparisons. Section 4.27, Spill Risk, discusses the impacts of the *Exxon Valdez* oil spill and the Fukushima nuclear accident on fish prices.

The Amakdedori port would be situated in the Chenik subdistrict of the Kamishak Bay District of the Lower Cook Inlet Management Area. Commercial salmon harvest in this area averages approximately 57,596 sockeye salmon in the years when fishing occurs, but harvests vary significantly from year to year (see Section 3.6, Commercial and Recreational Fisheries). In terms of the magnitude of impacts, construction and operation of the project would not be expected to have measurable effects on the number of adult salmon returning to the area. In terms of the geographic extent of impacts, commercial harvesters may have to change fishing patterns based on the proximity of fishing to port operations, or could experience losses if port operations affected salmon returns. This area also historically hosted a commercial Pacific herring sac roe fishery, which has been closed since 2000 because of low abundance. The ADF&G, has expressed concern that there is the potential that the Pacific herring biomass might recover enough during the life of the project to support a reopening of the fishery. The department also expressed concern that project activities at the port site could delay the recovery of the biomass, and if the fishery were reopened "purse seine gear interacts with the bottom in waters shallower than approximately 95 feet and may create a conflict with the natural gas pipeline and port activities" (ADF&G 2018q). The department did not provide projections for biomass recovery, but simply noted the potential for recovery of the historic resource.

Alternative 1a would route the natural gas pipeline through the Kamishak Bay scallop beds identified in Section 3.6, Commercial and Recreational Fisheries. If the Kamishak Bay scallop fishery reopens, then it would be expected that fishing gear and the pipeline would interact unless fishing effort avoided the area around the pipeline. Scallops are harvested by lowering a scallop dredge to the ocean floor. It is not usual for scallop harvesters to lose dredges when they encounter rock formations, other lost fishing gear, sunken vessels, communication cables, etc. These interactions can reduce harvest efficiency and damage gear, increasing permit holder operating costs and lowering profits. Fishers work to avoid areas with known seabed hazards. In addition to gear interaction costs, routing through the pipeline corridor could adversely affect long-term bed productivity (over the life of the project). The fishery is currently closed because of low biomass but could reopen before the mine closes. The ADF&G expressed concern that the pipeline under this alternative could affect the timing of the reopening of the fishery or affect biomass enough to result in the closure of a reopened fishery. The magnitude and extent of impacts would depend on the placement of the pipeline relative to the location of the resource, and both elements are highly uncertain at this time.

On the western side of Cook Inlet and in the Bristol Bay Watershed, the natural gas pipeline would not directly interact with the Bristol Bay salmon fishery after construction. Construction activities would be timed to minimize effects on anadromous salmon streams and would not be anticipated to affect these streams in a material manner. On the eastern side of Cook Inlet, numerous existing anadromous resources on the Kenai Peninsula are crossed by subservice pipelines without causing an effect to commercial and recreational fisheries. Although the pipeline would cross waters of the Cook Inlet salmon fishery, it would not directly interact with the salmon fishery (outside of the Chenik subdistrict noted above), given that the salmon fishery occurs in the top 30 feet of the water column. After construction, groundfish commercial harvesters (in the halibut and Pacific cod fisheries) may need to adjust the placement of their bottom gear, such as pots or longlines, to avoid the natural gas pipeline. As described above, permit holders frequently avoid areas with known seabed obstructions. A change in location could result in decreased harvest efficiency and increased costs and risks. The magnitude and extent of these effects is expected to be limited, given the size of the fishing area relative to the size of the pipeline corridor. Typically, the duration of impacts on commercial fisheries from the gas pipeline would be long term occurring throughout the life of the project. Displacement is likely to be most intense during construction.

## Permit Holders and Crew Members

Based on estimations of the effect to fish populations (see Section 4.24, Fish Values), this alternative would not result in changes in permit holder revenues, crew member payments, or permits in Bristol Bay due to a change in the return of adult spawners.

Commercial fishers in Cook Inlet face potentially higher costs associated with gear/infrastructure interactions and the potential for reduced earning associated with the Chenik subdistrict salmon fishery. The impacts are expected to be negligible relative to areawide fishing opportunities and revenues. There is the potential for reduced earnings associated with delayed recoveries in Pacific herring and weathervane scallop stocks, but the magnitude of the recovery delay for both stocks is unknown; at this time, no timelines for recovery for either stock are known.

## The Processing Sector

Reductions in harvest by permit holders is generally transmitted to the processing sector as fewer fish to be processed and sold into the world sockeye market. The exception to this case is when processors are operating at maximum capacity and additional fish cannot be processed; this phenomenon is known as “being plugged.” When plants are not “plugged,” the lost harvest results in lower total wholesale value for processors. The magnitude of the financial loss depends on the size of the harvest reduction and individual choices by processor regarding adjustments to their product mix. Processors make these decisions based on run size, their individual capabilities, and the needs of the world market, which means that any long-term loss in harvest would express itself differently each year based on the aforementioned factors. As noted above, under this alternative, no measurable effects on the number of returning salmon and the historical relationship between ex-vessel values and wholesale values would not be expected. Therefore, the alternative would not be expected to result in changes to wholesale values or processor operations (see Section 4.24, Fish Values).

## Fiscal Contributions

As noted above, the fiscal contributions of the Bristol Bay salmon fishery to state and local government depend on the long-term health of the fishery. In terms of magnitude of impacts, lost harvest value would be directly expressed through reduced Fisheries Business Tax and Raw Fish Landings Taxes. Significant reductions in long-term value of the fishery would affect property taxes, sales taxes, and use taxes (see Section 4.3, Needs and Welfare of the People—Socioeconomics, for a discussion of potential effects of reductions in state and local revenue). However, no long-term measurable changes in the fishery would be expected; therefore, there would be no long-term changes expected in fishery fiscal contribution attributable to this alternative (see Section 4.24, Fish Values).

Changes in fiscal contributions from Cook Inlet saltwater fisheries are expected to be negligible or nonexistent, particularly given the uncertainty surrounding the potential for and magnitude of impacts on resources such as the Pacific herring and the weathervane scallop.

### 4.6.3.2 Recreational and Tourism-Based Fishing

Recreational fishing effort in areas S, T, N, and P is based on several different types of fisheries with different goals, attributes, and experiences. For example, a Chinook salmon angler on the Nushagak River is likely to be fishing from a boat and focused on the harvest of Chinook salmon for consumption. An angler fishing the Gibraltar River is fishing a much smaller waterbody with more shore fishing and is more likely to be targeting rainbow trout for a non-consumptive purpose. The effects of Alternative 1a on the overall recreation fishery would depend on the factors noted above and the availability of alternative opportunities. There are few worldwide alternatives to the

Nushagak River, which has one of the largest recreational Chinook fisheries in Alaska. In 2016, anglers harvested more than 7,500 Chinook from the Nushagak, nearly as many as the 8,500 Chinook harvested from the Kenai River, and more than the 4,700 harvested in the entire Susitna River drainage (ADF&G 2018d).

In terms of extent of impacts, the three most important recreational fisheries that would interact with Alternative 1a are Iliamna Lake and the Gibraltar and Newhalen rivers. Iliamna Lake and its unnamed tributaries host roughly 1,900 to 2,200 angler days per year. This effort is dispersed across the lake and numerous unidentified tributaries without enough SWHS survey responses to allow for individual effort estimates. Under normal operations, the ferry across the lake would not be expected to limit or affect the quality of these fishing days.

The Gibraltar River (approximately 650 angler days per year) primarily hosts fly-in wade and float anglers. The river is currently not accessible via road, and the transportation corridor would create a new road and crossing along the river. There would be no anticipated measurable changes in the number of fish along the river, but the presence of the road and bridge crossing would change the fishing experience on the river, particularly for float anglers who would have to pass the bridge to float the length of the river (see Section 4.24, Fish Values). Construction activities would be disruptive, and the road and bridge would be in place through project operations and post-closure until they are no longer needed. Therefore, potential adverse impacts to the recreational fishing experience would be long term.

The Gibraltar River offers a remote fishing experience for rainbow trout but is one of several streams offering this type of experience in the Bristol Bay region. Rainbow trout are common, and angling opportunities in remote conditions are widespread throughout the region. The loss of fishing opportunities in these areas would be more likely to be experienced by select guide and lodge operators than by a substantial portion of all anglers in the Bristol Bay region. For example, between 2011 and 2014, ADF&G Freshwater Guide Logbook data recorded nine businesses providing 289 fishing days a year on average for the Gibraltar River system. Across all of Area S, the Kvichak River drainage, guided anglers generated an average of 10,400 fishing days per year. Therefore, the Gibraltar River system represents less than 3 percent of all angling effort in Area S. Affected operators could substitute fishing on different streams, albeit at potentially higher costs to themselves and their consumers, or anglers could redirect their fishing to other sites in the Bristol Bay region or in Alaska. Anglers themselves would likely be able to find similar opportunities on other streams in the region if the extent of effects of Alternative 1a are limited to a subset of regional fishing opportunities. Impacts would be long term, lasting through construction and operations, but opportunities would be available at other locations.

The Newhalen River drainage (approximately 1,900 angler days per year) is the most frequently fished waterbody along the mine access road. Most of this effort is by unguided anglers. ADF&G Freshwater Guide Logbook data indicate a cumulative average of fewer than 200 guided days per year on Newhalen River, determined by an average of nine and seven businesses, respectively. In terms of magnitude and extent of impacts, trucking activity may displace the fishing effort of anglers who prefer solitude, particularly where the road corridor intersects or run along these waterbodies. Conversely, for anglers who are less sensitive to transportation activity, roads frequently provide new access points for anglers. Aggregate fishing effort should not be adversely affected as long as fish populations are unaffected but may redistribute along the waterbodies.

Mine facilities under Alternative 1a would directly impact portions of the tributaries of the North and South Fork Koktuli River watersheds, and support and transportation infrastructure would affect the Gibraltar River and Iliamna Lake (see figures in Chapter 2, Alternatives). In terms of potential magnitude of effects, these watersheds account for a small portion of overall recreational fishing effort in SWHS areas S, T, and N (see Section 3.6, Commercial and Recreational Fisheries). The ADF&G SWHS estimates and Guide Logbook Program data indicate that total fishing effort on the entire Koktuli River is fewer than 50 angler days per year, and total effort in SWHS areas S and T is estimated at more than 40,000 days per year.

The waterbodies affected by Alternative 1a have fewer total recreational angler days than the waterbodies affected by Alternative 2 or Alternative 3. The main angling waterbodies affected by Alternative 2 and Alternative 3 (the Newhalen, Pile, and Iliamna rivers) already have some road access from local communities. In contrast, Alternative 1a differs from Alternative 2 and Alternative 3 because it includes new road affecting the Gibraltar River, a waterbody without current road access and more than 500 recreational fishing days per year; the rivers affected by Alternative 2 and Alternative 3 already have some road access and do not share the Gibraltar River's roadless state. Impacts would be expected to occur under Alternative 1a and would be long term, lasting through closure until the road is no longer used.

The Amakdedori port site is closer to the Kamishak River, which hosts several hundred guided angler days per year, more than the Diamond Point port site in Alternative 2 and Alternative 3. This resource is approximately 20 air miles south of the port site; the magnitude, extent, and duration of the effects of project operations on recreational fishing at that location is unclear.

In terms of magnitude and geographic extent of impacts, Cook Inlet saltwater recreational fishing could be affected by the natural gas pipeline, which could disrupt traditional groundfish fishing locations. The pipeline is not expected to have measurable effects on the numbers of groundfish, salmon, or rockfish, but could result in changes in the localized distribution of groundfish resources, which could then affect angler success rates or costs. These impacts would be long term and would be expected to occur.

Shore-based anglers and boat anglers in Kachemak Bay would not be expected to notice the project or need to change their behavior because of it. In terms of extent of impacts, some anglers fishing from just north of Anchor Point to the boundary between Cook Inlet and the Northern Gulf of Alaska could interact with the natural gas pipeline if they were targeting groundfish such as Pacific halibut and Pacific cod. Pacific halibut are the primary target of recreational anglers in Cook Inlet, with the species accounting for approximately 60 percent of the recreational harvest, based on SWHS data. The next most commonly harvested species are "rockfish"[1] (approximately 12 percent of harvest), Chinook salmon (approximately 6 to 7 percent of harvest), and silver salmon (approximately 6 to 7 percent of harvest). These species account for more than 80 percent of area's recreational harvest. The salmon species are primarily caught through trolling or by shore anglers at the Homer Spit; the natural gas pipeline would not be expected to impact these angler days. Anglers fishing for Pacific halibut can catch the species while trolling for salmon, but the dominant method is to place weighted and baited hooks on the seafloor where halibut live. In terms of magnitude and extent of impacts, these anglers would risk losing gear if fishing over the pipeline, and the pipeline itself could disturb traditional halibut concentrations referred to as "holes." The impacts would be long term and would be expected to occur under Alternative 1a.

## Commercial Fishing Guides, Lodges, and Air Transportation

There would be no measurable impacts on sport fish populations that could affect commercial fishing guides, lodges, or air transporters (see Section 4.24, Fish Values). The extent of the effect of construction and operations of the project would be to affect the quality of fishing experience in the immediate vicinity of the project where project facilities are visible or project activities are

[1] The SWHS does not collect data on harvest by species in the rockfish complex (*Sebastes spp.*). All species are grouped under the term "rockfish."

audible, as described above. In addition, some anglers may be sensitive to the idea of an operational mine in the area regardless of whether they would experience any activity or disturbance associated with it. Although English et al. (2018) centers on the effect of the Deepwater Horizon oil spill and not the on existence of an industrial facility, authors note that beaches unaffected by the spill saw reduced angler days. Perception mattered to a certain number of anglers, particularly when it came to a spill. In terms of magnitude, there could be associated reductions in and/or redistribution of income to commercial guides, lodges, and air transporters based on reductions in angler days. Redistribution of angler response to changes in the quality of the fishing experience would depend on the availability and appeal of substitute fishing destinations. Fishing packages in Bristol Bay cost between $600 and $1,000 per night. Client concerns about the quality of the experience could result in cancellations and associated economic impacts to the guide companies, lodges, air transporters, and the communities that support them. In terms of duration, such effects would be more pronounced during construction, but would continue during operations, be long term in duration, and would be expected to occur.

**Fiscal Contributions**

Under Alternative 1a, the magnitude of impacts on fiscal contributions from recreational fishing would be a potential reduction in guide and air taxi revenues, as well as government sales and use tax revenues if anglers reduced fishing effort in the region. In terms of the extent of impacts, if anglers shift effort in the region but do not change overall effort, then revenues would shift between municipalities and companies. The municipality most likely to be affected by any shift in effort is the Lake and Peninsula Borough, which has both a guided fishing tax and a bed tax, and encompasses much of the project area. At the same time, positive or negative shifts in revenue could also affect the Bristol Bay Borough (bed tax) and the city of Dillingham (sales taxes), depending on whether anglers shift effort towards or away from recreational fishing business in these communities.

Changes in fiscal contributions from Cook Inlet saltwater recreational fisheries are expected to be negligible or nonexistent, particularly given the uncertainty surrounding the potential for and magnitude of impacts on resources such as the Pacific herring and the weathervane scallop.

### 4.6.4 Alternative 1

#### 4.6.4.1 Commercial Fishing

Alternative 1 and any of its variants would not be expected to measurably affect the health or value of Bristol Bay salmon fishery, including permit holder earnings, permit holder value, crew earnings, fishery first wholesale values, processor earnings, or state and local fiscal contributions. The extent, duration, and likelihood of effects on Cook Inlet fisheries would be identical to Alternative 1a, as discussed above.

#### 4.6.4.2 Recreational and Tourism-Based Fishing

Mine and transportation facilities under Alternative 1 would directly impact portions of the same tributaries discussed under Alternative 1a, and would also affect the Upper Talarik Creek watershed. In terms of potential magnitude of effects, this watershed accounts for a small portion of overall recreational fishing effort in SWHS areas S, T, and N (see Section 3.6, Commercial and Recreational Fisheries). The ADF&G SWHS estimates and Guide Logbook Program data indicate that total fishing effort on Upper Talarik Creek averages fewer than 150 angler days per year, but total effort in SWHS areas S and T is estimated at more than 40,000 days per year.

The Newhalen River at the Newhalen spur road and the Gibraltar River at the port access road are the most frequently fished waterbodies along the Alternative 1 transportation corridor from the Amakdedori port to the mine site. For these resources, interactions and impacts would be the same as described for Alternative 1a.

This alternative does not differ from Alternative 1a with respect to Cook Inlet recreational fisheries. Interactions and impacts would be the same as described for Alternative 1a.

**Commercial Fishing Guides, Lodges, and Air Transporters**

The magnitude, duration, and likelihood of potential economic impacts to commercial fishing guides, lodges, and air transporters would be similar to those described under Alternative 1a. The extent would differ because some different recreational fishing areas would be affected along the mine access road, potentially affecting different service providers. [2]

**Fiscal Contributions**

As under Alternative 1a, under Alternative 1, recreational fishing fiscal contributions, including guide and air taxi revenues as well as government sales and use tax revenues, could be affected if anglers reduced fishing effort in the region. In terms of magnitude and extent, if anglers shift effort in the region but do not change overall effort, then revenues would shift between municipalities and companies. The municipality most likely to be affected by any shift in effort is the Lake and Peninsula Borough, which has both a guided fishing tax and a bed tax and encompasses much of the project area. At the same time, positive and negative shifts in revenue could also affect the Bristol Bay Borough (bed tax) and the city of Dillingham (sales taxes). The duration of these impacts would be long term, lasting throughout the life of the project.

Changes in fiscal contributions from Cook Inlet saltwater recreational fisheries are expected to be negligible or nonexistent, particularly given the uncertainty surrounding the potential for and magnitude of impacts on resources such as the Pacific herring and the weathervane scallop.

### 4.6.4.3 Alternative 1—Kokhanok East Ferry Terminal Variant

Under this variant, the impacts to recreational and commercial fishing on the Gibraltar River from the transportation corridor would not occur because this variant would not cross the river.

### 4.6.4.4 Alternative 1—Summer-Only Ferry Operations Variant

In terms of magnitude and extent, truck traffic under this variant would double during the summer, which would increase impacts to the setting of recreational fishing where the transportation corridor crosses the Gibraltar River. This impact would be long term, lasting though operation of the mine, and would be certain to occur under this variant.

### 4.6.4.5 Alternative 1—Pile-Supported Dock Variant

The Pile-Supported Dock Variant would result in impacts with magnitudes, extents, durations, and likelihoods similar to those described above for commercial and recreational fisheries.

[2] In the comment period for the Draft EIS, commenters mentioned possible effects to Lower Talarik Creek. The viewshed analyses indicate that mine operations could not be seen or heard from the Lower Talarik Creek watershed. However, anglers might be able to see the mine during flight operations traveling to/from Lower Talarik Creek.

### 4.6.5 Alternative 2—North Road and Ferry with Downstream Dams

Under Alternative 2, the magnitude, extent, duration, and likelihood of project effects on commercial fishing would be expected to be the same as Alternative 1a; mine operations would be the same, and the different transportation corridors would not be expected to cause any long-term effects to fish populations. The magnitude, extent, duration, and likelihood of impacts to the commercial and recreational fisheries in Cook Inlet from the pipeline would also be similar to Alternative 1a; however, in terms of extent, the port access road under the Alternative 2 transportation corridor would affect different recreational fishery resources. This alternative would avoid the currently roadless Gibraltar River area and the Amakdedori area, and would be much farther away from the Kamishak River. However, the mine access road and/or the pipeline right-of-way (ROW) would cross a number of waterbodies with fishing pressure, including the Newhalen River and the Iliamna River.

#### 4.6.5.1 Commercial Fishing

As with Alternative 1a, in terms of magnitude and extent, Alternative 2 would not be expected to affect the health or value of the Bristol Bay salmon fishery, including permit holder earnings, permit holder value, crew earnings, fishery first wholesale values, processor earnings, or local fiscal contributions. With respect to the magnitude and extent of impacts in Cook Inlet, Alternative 2 would avoid the potential effects on the Chenik subdistrict salmon fishery, the Kamishak Bay Pacific herring fishery, and the Kamishak Bay Weathervane scallop fishery. However, the Diamond Point port has the potential to interfere with an intermittent chum salmon fishery near Cottonwood Creek. The average harvest numbers for Iliamna and Iniskin bays in years when harvest was recorded was slightly more than 27,000 chum salmon and approximately 3,600 pink salmon (ADF&G 2018q). Commercial permit holders expressed concern that port operations at this site would interfere with tidally dependent seine opportunities. The magnitude and duration of disruption to these fisheries would be due to additional boat traffic. More boat traffic would be expected during construction than operations.

The pipeline ROW of Alternative 2 and the transportation corridor of Alternative 3 would intersect with Brown's Peak Creek, which has a sustainable escapement goal for pink salmon. Comments from ADF&G indicate that this creek is periodically targeted by commercial fisheries. There would be no measurable impact to returning fish in this creek, and no impact would be expected to commercial fisheries.

#### 4.6.5.2 Recreational and Tourism-Based Fishing

The Newhalen River drainage (approximately 1,900 angler days per year) and the Iliamna River (approximately 1,000 angler days per year) are the most frequently fished waterbodies along the Alternative 2 transportation corridor route. Impacts to the Newhalen River would be the same as those discussed under Alternative 1a.

Along the Iliamna River, most of this effort is by unguided anglers. ADF&G Freshwater Guide Logbook data indicate an average of slightly more than 400 guided days per year on the Iliamna River, determined by an average of nine and seven businesses, respectively. The impacts would be similar to those at the Newhalen River, discussed under Alternative 1a.

In terms of magnitude and extent of impacts on recreational and tourism-based fishing:

- Alternative 2 would affect freshwater waterbodies with higher fishing effort than Alternative 1a and Alternative 1, but it would not establish new roads near waterbodies such as the Gibraltar River, which are known for the remote characteristics and have measurable fishing effort.

- Alternative 2 crosses fewer waterbodies along the Iliamna Lake's northern boundary than Alternative 3 by virtue of the ferry from Eagle Bay to Pile Bay and the road corridor to Diamond Point port.
- Alternative 2 and Alternative 3 would use a port at Diamond Point. As noted above, this port site is farther from Kamishak River, which hosts several hundred guided angler days per year, more than the Amakdedori port site in Alternative 1a and Alternative 1.
- The pipeline ROW under Alternative 2 would cross the same streams as discussed below for Alternative 3. In terms of the magnitude and extent of effects, access along the ROW could increase slightly for recreational fishing. To the extent that fishing efforts are redistributed, there could be adverse economic impacts to fishing guides and lodges. The impacts would be long term, lasting through the duration of operations.

**Commercial Fishing Guides, Lodges, and Air Transporters**

The magnitude, duration, and likelihood of potential economic impacts to commercial fishing guides, lodges, and air transporters would be similar to those discussed under Alternative 1a. The extent would differ because different recreational fishing areas would be affected as described above, consequently affecting different service providers.

**Fiscal Contributions**

As with Alternative 1a, under Alternative 2, recreational fishing fiscal contributions, including guide and air taxi revenues as well as government sales and use tax revenues, could be affected if anglers reduced fishing effort in the region. In terms of magnitude and extent, if anglers shift effort in the region but do not change overall effort, then revenues would shift between municipalities and companies. The municipality most likely to be affected by any shift in effort is the Lake and Peninsula Borough, which has both a guided fishing tax and a bed tax and encompasses much of the project area. At the same time, positive and negative shifts in revenue could also impact the Bristol Bay Borough (bed tax) and the city of Dillingham (sales taxes). The duration of these impacts would be long term, lasting throughout the life of the project.

Changes in fiscal contributions from Cook Inlet saltwater recreational fisheries are expected to be negligible or nonexistent, particularly given the uncertainty surrounding the potential for and magnitude of impacts on resources such as the Pacific herring and the weathervane scallop.

### 4.6.5.3 Alternative 2—Summer-Only Ferry Operations Variant

In terms of magnitude and extent of impacts, truck traffic under this variant would double during the summer; this would increase impacts in relation to Alternative 2, to the setting of recreational fishing where the transportation corridor crosses the Newhalen and Iliamna rivers. These impacts would be long term and would be expected to occur under this variant.

### 4.6.5.4 Alternative 2—Pile-Supported Dock Variant

The Pile-Supported Dock Variant would result in impacts with magnitudes, extents, durations, and likelihoods similar to those described above for Alternative 2 for commercial and recreational fisheries.

### 4.6.5.5 Alternative 2—Newhalen River North Crossing Variant

The Newhalen River North Crossing Variant would result in impacts with magnitudes, extents, durations, and likelihoods similar to those described above for Alternative 2 for commercial and recreational fisheries.

### 4.6.6 Alternative 3—North Road Only

Under Alternative 3, the magnitude, duration, and likelihood of effects of the project on commercial and recreational fishing would not be expected to be different than under Alternative 1a because mine operations would be the same, and the transportation corridor would not be expected to affect fish populations over the long term. However, though overall effects would remain the same, the extent of impacts due to Alternative 3 would differ because different recreational fishery resources and less-used recreational fishery resources would be affected compared to Alternative 1a. Alternative 3 would avoid the currently roadless Gibraltar River, but would cross a number of waterbodies with measurable recreational fishing pressure, including the Pile River and the Iliamna River.

#### 4.6.6.1 Commercial Fishing

As with Alternative 1a, Alternative 3 would not be expected to measurably affect the health or value of Bristol Bay salmon fishery, including permit holder earnings, permit holder value, crew earnings, fishery first wholesale values, processor earnings, or local fiscal contributions. The extent, duration, and likelihood of effects on Cook Inlet fisheries are identical to Alternative 2, with fewer expected effects than Alternative 1a and Alternative 1, as discussed above.

#### 4.6.6.2 Recreational and Tourism-Based Fishing

The Alternative 3 transportation corridor would extend from Diamond Point on land across Chekok, Canyon, and Knutson creeks; on to Pile Bay; across the Pile River; and then cross the Iliamna River, leading to the mine site.

As noted for Alternative 2, the Newhalen River drainage and the Iliamna River are the most frequently fished waterbodies along this route. The magnitude and extent of impacts from Alternative 3 are that transport activity may displace fishing effort where the corridor intersects with these waterbodies, but the corridor overlap would be short in length. Construction activities would be disruptive and truck traffic would adversely affect the recreation experience that occurs in the vicinity of the road for those anglers that prefer a more remote experience. Fishing effort should not be adversely affected overall, but in terms of extent may be redistributed along the waterbodies as long as fish populations are unaffected by changes in distribution of fishing effort.

With respect to additional waterbodies cross by Alternative 3 compared to Alternative 2:

- ADF&G data indicate that Chekok Creek has limited fishing activity (fewer than 50 days per year).
- Other waterbodies along the Alternative 3 transportation corridor, including the Pile River, do not appear in published ADF&G data. A consistent absence from the SWHS and the Freshwater Guide Logbook Program generally indicates a lack of fishing pressure in that area.
- It is very likely that Alternative 3 would increase fishing pressure on freshwater waterbodies because of the presence of a continuous road providing access to these waterbodies along the north side of Iliamna Lake between the mine site and Pile Bay. These impacts would last for the life of the road.

Additionally, with respect to impacts from Alternative 3:

- Alternative 2 and Alternative 3 would use a port at Diamond Point. As noted above, this port site is farther from Kamishak River, which hosts several hundred guided angler days per year, more than the Amakdedori port site in Alternative 1a and Alternative 1.

- The transportation corridor under Alternative 3 (shared with the Alternative 2 pipeline ROW) would cross a number of streams. In terms of the magnitude and extent of effects, access along the ROW could increase slightly for recreational fishing. To the extent that fishing efforts are redistributed, there could be adverse economic impacts to fishing guides and lodges. The impacts would be long term, lasting through the duration of operations.

**Commercial Fishing Guides, Lodges, and Air Transporters**

The magnitude, duration, and likelihood of potential economic impacts to on commercial fishing guides, lodges, and air transporters would be similar to those discussed under Alternative 1a. The extent would differ because different recreational fishing areas would be affected as described above, consequently affecting different service providers.

**Fiscal Contributions**

Under Alternative 3, recreational fishing fiscal contributions, including guide and air taxi revenues as well as government sales and use tax revenues, could be affected if anglers reduced fishing effort in the region. In terms of magnitude and extent, if anglers shift effort in the region but do not change overall effort, then revenues would shift between municipalities and companies. The municipality most likely to be affected by any shift in effort is the Lake and Peninsula Borough, which has both a guided fishing tax and a bed tax and encompasses much of the project area. At the same time, positive and negative shifts in revenue could also impact the Bristol Bay Borough (bed tax) and the city of Dillingham (sales taxes). The duration of these impacts would be long term, lasting throughout the life of the project. Alternative 3 would affect more waterbodies than Alternative 1a, but would not establish new roads near currently roadless waterbodies with existing fishing effort.

Changes in fiscal contributions from Cook Inlet saltwater recreational fisheries are expected to be negligible or nonexistent, particularly given the uncertainty surrounding the potential for and magnitude of impacts on resources such as the Pacific herring and the weathervane scallop.

#### 4.6.6.3 Alternative 3—Concentrate Pipeline Variant

The concentrate pipeline variant would add two additional pipelines (concentrate and water return) in the road/natural gas pipeline corridor, increasing the width of visual disturbance that could affect the quality of the fishing recreational experience. It would result in impacts with magnitudes, extents, durations, and likelihoods similar to those described above for Alternative 3 for commercial and recreational fisheries. However, it would reduce truck traffic associated with shipment of concentrate and potentially have less impact on the nature of the recreational fishing experience.

### 4.6.7 Cumulative Effects

Impacts to commercial and recreational fisheries would include short- or long-term changes in fish populations or harvestability, reduction in consumer willingness to buy Bristol Bay salmon due to perceived loss of quality, reduction or displacement of recreational fisheries, or an increase in recreational fishing caused by population changes. Potential cumulative impacts to commercial fisheries could be affected by productivity losses, including incremental loss of spawning and rearing habitat, fragmentation of habitat, changes in wetland types, and loss or degradation of ecosystem functions. Potential cumulative impacts to recreational fisheries could be affected by any reduced fish populations (both salmon and non-salmon) associated with productivity losses, as well as loss of scenic and recreational value of fishing sites.

The EIS analysis area includes commercial and recreational fisheries, the ADF&G Commercial Salmon Fishery Area T and Area H, the Cook Inlet Management Area (including associated federal waters), and the ADF&G SWHS areas S, T, N, and P.

Past, present, and reasonably foreseeable future actions (RFFAs) in the cumulative effects analysis area have the potential to contribute cumulatively to impacts on commercial and recreational fisheries. Section 4.1, Introduction to Environmental Consequences, details the past actions, present actions, and RFFAs considered for evaluation. Several of the RFFAs detailed are considered to have no potential for cumulatively impacting commercial and recreational fisheries in the analysis area. These would include non-industrialized point-source activities that are unlikely to result in any appreciable impact on wetlands beyond a temporary basis (such as tourism, recreation, fishing, and hunting). Other RFFAs removed from further consideration include those outside the analysis area.

Section 4.24, Fish Values, does not estimate fish population changes associated with cumulative effects of the RFFAs. It is clear that changes in the number of returning salmon spawners have a direct effect on the value of the Bristol Bay salmon fishery. The ADF&G is obligated to manage for the long-term health of the resource, prioritizing that health over the economic condition of the fishery. This prioritization means ensuring that enough spawners return to their natal streams. If the returning number of adult fish drops, ADF&G will prioritize making sure enough of the fish enter the river system to spawn, and commercial and recreational harvest opportunities may drop as result.

Cumulative effects on recreational fisheries are harder to quantify than those on commercial fisheries. In addition to salmon, recreational anglers in the region primarily target rainbow trout and Dolly Varden, which depend on salmon eggs and salmon flesh for a good portion of their annual caloric intake. Mineral development could contribute cumulatively to the reduction of the undeveloped nature of the region, and thereby reduce opportunities available for recreation activities fishing in remote areas. However, recreational anglers are more mobile and have the option to select similar substitute experiences. The most likely effect is a redistribution of days to different locations rather than a large reduction in total days. Lodges are not mobile, and providers who frequent rivers that may no longer provide the same experience they once did may choose to change the services that they offer, access different locations via air, and/or lose a portion of their clientele. Changes in angler demand for trips in the region would depend on the magnitude of changes in the angling experience, angler preferences, and the type of responses by trip providers.

#### 4.6.7.1 Past and Present Actions

Past and present actions that have or are currently affecting commercial and recreational fisheries in the analysis area are minimal. Current development consists of six communities on or near Iliamna Lake and nearby roads. Present activities include mining exploration and non-mining related projects, such as transportation, oil and gas development, or community development actions. These actions have resulted in a loss of some fish habitat, and aircraft activity associated with mining exploration can degrade the quality of a remote recreational fishing experience. As noted in Section 4.22, Wetlands and Other Waters/Special Aquatic Sites; and Section 4.24, Fish Values, given the relatively small amount of past and present effects in individual watersheds and the project area in general, as well as the limited footprint of drilling, past/present cumulative impacts on fisheries are minimal in extent and magnitude for all alternatives.

### 4.6.7.2 Reasonably Foreseeable Future Actions

The list of RFFAs includes a number of potential mineral projects that are likely to be subjected to continued exploration and study (e.g., Big Chunk South, Big Chunk North, Fog Lake, Groundhog, Shotgun, and the Johnson Tract), as well as expansion of the Pebble Project, which is reasonably foreseeable as a future development in the RFFA timeframe. In addition, the RFFAs include community, transportation, and utility improvements spurred by economic activity in the area. Each project has the potential to impact localized fish population numbers, contributing to the cumulative effects on commercial and recreational fisheries in the region.

The No Action Alternative would not contribute to cumulative effects on commercial and recreational fishing.

Collectively, the project alternatives with RFFAs' contribution to cumulative effects on commercial and recreational fisheries are summarized in Table 4.6-2.

**Table 4.6-2 Contribution to Cumulative Effects on Commercial and Recreational Fisheries**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Pebble Project Expansion Scenario | **Mine Site:** The mine site footprint would have a larger open pit and new facilities to manage water and store tailings and waste rock, which would contribute to cumulative effects on surface waters and fish habitat through removal of overburden, waste rock, and ore.<br>**Other Facilities:** A north access road, concentrate and water return pipelines, and diesel pipeline would be constructed along the Alternative 3 road alignment to Eagle Bay, and extended to a new deepwater port site at Iniskin Bay. Pipeline construction would have potentially limited impacts on surface waters and fish habitat from trenching activities.<br>**Magnitude:** The primary potential future impacts to fish from the Pebble Project expansion would be direct loss of habitat, fish displacement and injury, habitat degradation, and changes in the natural flow regime. These impacts would be similar to those described for the project in Section 4.24, Fish Values, but with additional amounts of acreage and length of stream affected. With the mine expansion, the duration of these impacts would be extended by 78 years. The construction of the south waste rock facility collection pond would affect the South Fork Koktuli and Upper Talarik Creek watersheds, affecting sockeye, coho (*O. kitsuch*), chum, and Chinook salmon. Expanded development would increase the magnitude and duration of disturbance impacts. Any impacts that result in a reduction in the number of returning adult spawners would affect commercial fisheries. Commercial fishing impacts related to expansion of the mine site are limited to the Bristol Bay commercial fishery. The construction and operation of a deepwater port in Iniskin Bay would affect the commercial chum and pink salmon | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** The north access road and concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment to a new deepwater port site at Iniskin Bay.<br>**Magnitude:** The magnitude of cumulative impacts to commercial and recreational fisheries would be similar to that under Alternative 1a.<br>**Duration/Extent:** The duration/extent of cumulative impacts to commercial and recreational fisheries would be similar to those under Alternative 1a.<br>**Contribution:** The contribution to cumulative effects would be slightly more than that under Alternative 1a, and more than those under Alternative 2 and Alternative 3. | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** The north access road and concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment to a new deepwater port site at Iniskin Bay. Truck traffic along the north access road transportation corridor would decrease with construction of the concentrate pipeline, potentially decreasing the effects on quality of the recreational fishing experience in adjacent areas.<br>**Magnitude:** As noted in Section 4.24, Fish Values, the magnitude of cumulative fish effects, and therefore of commercial and recreational fishery effects, would be lower than Alternative 1a because it would not affect the Gibraltar River. However, the magnitude of effects would be higher than that under Alternative 3 because it would stagger road | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** Overall expansion would use the existing north access road. Concentrate and diesel pipelines would be constructed along the existing road alignment and extended to a new deepwater port site at Iniskin Bay.<br>**Magnitude:** Although Alternative 3 would have the same cumulative mine site effects as the other alternatives, cumulative effects related to transportation and infrastructure would be less, as the alternative would avoid the Gibraltar River and the need for a ferry, and because the natural gas pipeline and most of the road would already exist under Alternative 3.<br>**Duration/Extent:** The duration/extent of cumulative impacts to commercial and recreational would be similar in duration to those under the other alternatives, but less in |

**Table 4.6-2 Contribution to Cumulative Effects on Commercial and Recreational Fisheries**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | fishery in that area and could affect the recovery of the Pacific herring fishery. These effects would be similar to the potential direct effects described for Alternative 2 and Alternative 3. Cumulative effects on recreational fishing would mirror those for commercial fishing because recreational target species include salmon or species that are dependent on salmon. The desirability and viability of the South Fork Koktuli River and Upper Talarik Creek as recreational fishing locations would follow changes in salmon and salmonid populations and recreation experience. The construction of a deepwater port at Iniskin Bay with associated pipelines (concentrate and diesel) and access roads would result in recreational fishery effects similar in magnitude to potential combined direct effects described for Alternative 1a and Alternative 3 over a 78-year period.<br>**Duration/Extent:** The Pebble Project expansion scenario would result in an additional 78 years of mining/milling and include a larger open pit mine, with expanded and new storage facilities for tailings and waste rock.<br>**Contribution:** Expanded development and associated contributions to cumulative impacts would be the same for all alternatives for commercial and recreational fisheries, although there would be greater impacts to the affected portion of the Koktuli and Talarik creek watersheds. | | construction and ferry operations over a longer period of time.<br>**Duration/Extent:** The duration/extent of cumulative impacts to commercial and recreational fisheries would be similar in duration and extent to those under Alternative 1a, except that a smaller geographic area would be affected with the operation of only one access road.<br>**Contribution:** The contribution to cumulative impacts would be similar to that under Alternative 1a, although affecting fewer acres. | extent, particularly compared to Alternative 1a.<br>**Contribution:** The contribution to cumulative impacts would be similar to those under the other alternatives, although affecting a smaller number of acres. |
| Other Mineral Exploration Projects | **Magnitude:** Mining exploration activities would include additional borehole drilling, road and pad construction, and development of temporary camp facilities. Exploration activities, including additional borehole drilling and temporary camp facilities, would not affect commercial fishing but might affect the quality of experience of recreational fishing, | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |

**Table 4.6-2 Contribution to Cumulative Effects on Commercial and Recreational Fisheries**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | depending on the location and the level of associated aircraft noise.<br>**Duration/Extent:** Exploration activities typically occur at a discrete location for one season, although a multi-year program could expand the geographic area affected within a specific mineral prospect (see Section 4.1, Introduction to Environmental Consequences, which identifies seven mineral prospects in the EIS analysis area where exploratory drilling is anticipated [four relatively close to the Pebble Project]). Impacts to commercial and recreational fisheries are expected to be limited in extent and low in magnitude.<br>**Contribution:** This contributes to cumulative effects on commercial and recreational fisheries, although the areal extent of disturbance is a relatively small portion of the Kvichak and Nushagak watersheds. | | | |
| Oil and Gas Exploration and Development | **Magnitude:** Onshore oil and gas exploration activities could involve seismic and other forms of geophysical exploration, and exploratory drilling in limited cases. Seismic exploration would involve temporary overland activities, with permit conditions that avoid or minimize surface water disturbance. Should it occur, exploratory drilling would involve the construction of temporary pads and support facilities, with permit conditions to minimize anadromous fish water disturbance and restore drill sites after exploration activities have ceased. Offshore oil and gas exploration and development in Cook Inlet would be unlikely to have any population level effects on fish used for commercial and recreational fisheries. However, construction activities and location of offshore facilities could displace fishing effort on a short- and long-term basis, and affect the quality of marine recreational fishing experience. Barge traffic from the Pebble | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |

**Table 4.6-2 Contribution to Cumulative Effects on Commercial and Recreational Fisheries**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | Project and either the Alaska LNG or Alaska Stand Alone Pipeline project would add to the cumulative impacts to commercial fishing on Cook Inlet.<br>**Duration/Extent:** Seismic exploration and exploratory drilling are typically single-season temporary activities.<br>**Contribution:** Onshore oil and gas exploration activities would be required to minimize surface disturbance; they would occur in the analysis area but be distant from the project. The project would have minimal contribution to cumulative effects on commercial and recreational fisheries. | | | |
| Road Improvement and Community Development Projects | **Magnitude:** Road improvements projects would take place in the vicinity of communities and potentially have impacts on fish important to commercial and recreational fisheries through grading, filling, drainage disruptions, and potential increased erosion. Communities in the immediate vicinity of project facilities (e.g., Iliamna, Newhalen, Kokhanok, and Pedro Bay) would have the greatest contribution to cumulative effects, and would be affected by any road and port upgrades associated with the Williamsport-Pile Bay Road. Some limited road upgrades could also occur in the vicinity of the natural gas pipeline starting point near Stariski Creek, or in support of mineral exploration previously discussed. The construction of linear features and sedimentation could reduce functional productivity and result in changes to salmon and non-salmon fish populations, thus affecting the value of the commercial fishery and recreational fishing opportunities. Some of these improvements could result in additional access to recreational fisheries.<br>Two potential small-scale hydroelectric projects, at Knutson Creek and Igiugig, could have some limited | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |

**Table 4.6-2 Contribution to Cumulative Effects on Commercial and Recreational Fisheries**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | effects on fish. Although the Knutson Creek facility would be situated in that drainage, have limited effects, and be subject to mitigation required by ADF&G, the Igiugig facility would be in the Kvichak River, which provides migration for large numbers of adult spawning salmon and out-migrating smolt. Effects on fish populations are expected to be minimal but would be subject to a fish monitoring program.<br>**Duration/Extent:** Disturbance from road construction would typically occur over a single construction season. The geographic extent would be limited to the vicinity of communities and Diamond Point.<br>**Contribution:** Road construction would be required to minimize surface disturbance and would occur in the analysis area, but removed from the project. The project would have minimal contribution to cumulative effects. | | | |
| Summary of Project contribution to Cumulative Effects | Overall, the contribution of Alternative 1a to cumulative effects on commercial and recreational fisheries when taking other past actions, present actions, and RFFAs into account, would be minor to moderate in terms of magnitude, duration, and extent, given the limited acreage affected and permit requirements | Similar to Alternative 1a, although slightly more acres would be affected by expansion of the Pebble Mine. | Similar to Alternative 1a, although slightly fewer acres would be affected by expansion of the Pebble Mine. | Similar to Alternative 1a, although fewer acres would be affected than by other alternatives. |

Notes:
ADF&G = Alaska Department of Fish and Game
EIS = Environmental Impact Statement
LNG = Liquefied Natural Gas
RFFA = reasonably foreseeable future action

# 4.7 CULTURAL RESOURCES

This section discusses the environmental consequences that construction, operations, and closure of the project would have on cultural resources. For the purposes of this section, the broad definition of cultural resource types is maintained as described for the affected environment (Section 3.7, Cultural Resources). Cultural resource types may range from precontact archaeology sites, to traditional cultural properties and areas of cultural use, place names, traditional and contemporary resource collecting areas (see Section 3.9, Subsistence), sacred or religious sites, and historic-era sites such as cabins or shipwrecks.

Cultural resources, as defined in Section 3.7, Cultural Resources, also include "historic properties," as defined under the National Historic Preservation Act (NHPA) (54 United States Code [USC] 300308), "Protection of Historic Properties" (36 Code of Federal Regulations [CFR] 800.16[l]), and in 33 CFR Part 325 Appendix C. Section 106 of the NHPA requires federal agencies to take into account the effects of the undertaking on historic properties in the Area of Potential Effects (APE).Historic properties are defined as districts, sites, buildings, structures, or objects eligible for or listed on the National Register of Historic Places (National Register). Eligibility determinations under Section 106 of the NHPA have not yet been made for most sites discussed below. Two sites in the Environmental Impact Statement (EIS) analysis area have been determined as not eligible for listing in the National Register, and one historic property has been identified in the EIS analysis area.

The EIS analysis area provides the geographic extent for identifying cultural resources and includes the areas where project-related effects, both direct and indirect, may result. The analysis area for cultural resources is the project footprint for direct effects; and lands within 3 miles of the mine site (including material sites) and within 1 mile of the other project components (e.g., port sites, transportation corridors, and ferry terminals) for indirect impacts (e.g., atmospheric [dust, olfactory], visual [including the night sky], auditory). Offshore, the analysis area is the construction footprint of the pipeline for direct effects, and the width of the anchor spread area for indirect effects. The APE is defined in Section 3.7, Cultural Resources and is the same as the EIS analysis area.

The magnitude of impacts considers the types of impacts (direct or indirect), and quantifies, to the extent possible, the number and types of cultural resources in each alternative subject to these impacts. The duration of impact is determined by whether the resource would be permanently removed, have its use affected, mitigated, or have indirect impacts that would cease at the end of construction, operations, and closure activities. For example, removal of a site would be permanent; and long-term impacts would last throughout the life of the project, and potentially extend from multiple years to decades. Short-term impacts would be temporary, lasting only through the construction phase (i.e., months to years). The likelihood of impacts would be the certainty that the impact would occur.

## 4.7.1 Analytical Limitations

Systematic pedestrian survey has not been completed for all alternative project components; at present, only the current configuration of the mine site and location of specific facilities (i.e., Amakdedori port site, Newhalen and Gibraltar river crossings, and the south and Eagle Bay ferry terminals) have been subjected to more systematic cultural resource research and field investigations. Consequently, resource identification has largely been completed through archival and background analysis and ethnographic research.

Previous Pebble Limited Partnership (PLP) investigations completed background literature and file reviews for a broader regional area and conducted interviews in seven project area communities to identify cultural resources, place names, and use areas in and near the project footprint. These data are supplemented by ethnographic research, traditional knowledge, and subsistence investigations that cover all or portions of the analysis area (see Section 3.7, Cultural Resources, and Section 3.9, Subsistence). The information contained in these studies is integrated into this analysis. Cultural resources identified during subsequent field studies, including archaeological and historic districts, properties of religious and cultural significance, traditional cultural landscapes, or traditional cultural properties, will require additional consultation between the US Army Corps of Engineers (USACE), tribes, the Alaska State Historic Preservation Officer, and other consulting parties before these potential historic properties' eligibility for the National Register can be determined.

Where site-specific surveys have not been completed or where additional research needs have been identified, site-specific impacts are undeterminable at this time, as is the ability to quantify the number of resources potentially affected by the project and alternatives. To compensate for those limitations for the National Environmental Policy Act (NEPA) analysis, the USACE has assessed the potential for impacts to cultural resources across all of the alternatives based on known AHRS locations, interview-identified cultural resources, and place name data. Whether through additional background and site file research, archaeological investigations, consultation with tribes, and/or ethnographic analysis, the PA will ensure that cultural resource identification efforts in the analysis area are completed, consistent with the requirements of 36 CFR Part 800 and 33 CFR Part 325 Appendix C. These investigations would only be completed by the Applicant for the authorized alternative, if a permit is issued. Likewise, when project-related adverse effects to historic properties are identified, the PA and the Cultural Resource Management Plan will lay out the process for consultation, assessment of effects, and measures to avoid, minimize, and/or mitigate adverse effects.

### 4.7.2 Summary of Key Issues

**Table 4.7-1: Summary of Key Issues for Cultural Resources**

| Resource | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| **Mine Site** | | | | |
| Known AHRS locations (identified to date) | 2 known sites in the footprint would be destroyed as a result of facilities construction.<br>12 known sites would be subject to indirect impacts. | | | |
| Place names | 1 known place name would be subject to direct and indirect impacts.<br>4 known place names would be subject to indirect impacts. These include visual, night sky, auditory, olfactory, and atmospheric changes that may alter the character, setting, and use of these resources. | | | |
| Interview-identified cultural resources | 19 interview–identified cultural resources are in the mine site analysis area and would be subject to indirect impacts. 6 sites would be subject to direct and indirect impacts. Direct impacts could occur due to disruption to resource gathering cycles, access, routes, and trails. Indirect impacts could occur from new visual, night sky, auditory, olfactory, and atmospheric changes that may affect character, setting, and use of these cultural resources. In particular, traditional and contemporary cultural use of Frying Pan Lake and Groundhog Mountain could experience indirect impacts. Mining activities would create concern regarding culturally important elements of the environment such as salmon, and the waters and aquatic habitat that support them. | | | |
| Known Historic Properties | No known historic properties in the mine site analysis area. | | | |

**Table 4.7-1: Summary of Key Issues for Cultural Resources**

| Resource | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| **Transportation Corridor** | | | | |
| Known AHRS locations (identified to date) | 1 known site would be subject to direct and indirect impacts.<br>17 known sites would be subject to indirect impacts. | 0 known sites would be subject to direct and indirect impacts.<br>10 known sites would be subject to indirect impacts.<br>Kokhanok east ferry terminal variant: 4 known sites subject to indirect impacts. | 1 known site would be subject to direct and indirect impacts.<br>23 known sites would be subject to indirect impacts.<br>Newhalen River North Crossing Variant: 1 known site subject to direct impacts. | 3 known sites would be subject to direct and indirect impacts.<br>32 known sites would be subject to indirect impacts. |
| Place names | 6 place names in the footprint would be subject to direct and indirect impacts.<br>6 place names would be subject to indirect impacts. | 4 place names in the footprint would be subject to direct and indirect impacts.<br>7 place names would be subject to indirect impacts. | 16 place names in the footprint would be subject to direct and indirect impacts.<br>41 place names would be subject to indirect impacts. | 15 place names would be subject to direct and indirect impacts.<br>43 place names would be subject to indirect impacts. |
| Interview-identified cultural resources | 101 features would be subject to indirect impacts, including 38 features that would be subject to direct impacts. | 95 features would be subject to indirect impacts, including 30 features that would be subject to direct impacts. | 54 features would be subject to indirect impacts, including 26 features that would be subject to direct impacts. | 90 features would be subject to indirect impacts, including 37 features that would be subject to direct impacts. |
| Known Historic Properties | No known historic properties in the analysis area. | No known historic properties in the analysis area. | 1 known historic property would be subject to direct and indirect impacts. | |
| | **Amakdedori Port** | | **Diamond Point Port** | |
| Known AHRS locations (identified to date) | 0 known sites would be subject to direct impacts.<br>3 known sites would be subject to indirect impacts. | 0 known sites would be subject to direct impacts.<br>3 known sites would be subject to indirect impacts. | 0 known sites would be subject to direct impacts.<br>0 known sites would be subject to indirect impacts. | 0 known sites would be subject to direct and indirect impacts.<br>3 known sites would be subject to indirect impacts. |
| Place names | 1 known place name in the footprint would be subject to direct and indirect impacts. | | 7 place names in the footprint would be subject to direct and indirect impacts.<br>3 place names would be subject to indirect impacts. | 10 place names in the footprint would be subject to direct and indirect impacts.<br>1 place name would be subject to indirect impacts. |
| Interview-identified cultural resources | 9 features would be subject to indirect impacts, including 1 feature that would be subject to direct impacts. | 9 features would be subject to indirect impacts, including 1 feature that would be subject to direct impacts. | 1 feature would be subject to indirect impacts. | 5 sites would be subject to indirect impacts. |
| Known Historic Properties | No known historic properties identified to date. | | | |

**Table 4.7-1: Summary of Key Issues for Cultural Resources**

| Resource | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| **Natural Gas Pipeline** | | | | |
| Known AHRS locations (identified to date) | Same as transportation corridor, plus:<br>0 known sites would be subject to direct impacts.<br>12 known sites would be subject to indirect impacts. | Same as transportation corridor. | Same as transportation corridor, plus:<br>0 known sites would be subject to direct impacts.<br>3 known sites would be subject to indirect impacts. | |
| Place names | Same as the transportation corridor. | Same as transportation corridor. | Same as transportation corridor, plus:<br>3 place names in the footprint would be subject to direct and indirect impacts.<br>8 place names would be subject to indirect impacts. | 17 place names would be subject to direct and indirect impacts.<br>45 place names would be subject to indirect impacts. |
| Interview-identified cultural resources | Same as the transportation corridor, plus:<br>29 features would be subject to indirect impacts, including 3 features that would be subject to direct impacts. | Same as the transportation corridor. | 62 features would be subject to indirect impacts, including 21 features that would be subject to direct impacts. | 91 features would be subject to indirect impacts, including 38 features that would be subject to direct impacts. |
| Known Historic Properties | Same as the transportation corridor.<br>It is noted that there are no known AHRS locations or other cultural resources in the anchor spread of pipeline construction. There were no cultural resources identified in the analysis area offshore. | Same as the transportation corridor. | Same as the transportation corridor. | Same as the transportation corridor. |

Note:
AHRS = Alaska Heritage Resources Survey

## 4.7.3 Impacts to Cultural Resources

Scoping comments expressed concerns regarding impacts to cultural resources and historic properties such as historical and pre-contact sites; traditional use areas and practices; salmon, clean water, and the confidentiality of information shared on culturally and religiously significant properties. Some additional places of cultural importance were provided during the comment period on the Draft EIS (DEIS), and through Section 106 consultation completed after publication of the DEIS. This information has been incorporated into Section 3.7, Cultural Resources, and the following analysis.

All alternatives have the potential for direct impacts to cultural resources from the construction, operations, reclamation, and closure of the project. Necessary ground-disturbing actions involved with constructing and operating the mine and its facilities (i.e., transportation corridor, natural gas pipeline, and port facilities) can destroy, remove, or otherwise damage cultural resources. Direct impacts can include the physical destruction of a cultural resource, removal of a cultural resource from its original location, or result from project activities that increase a site's susceptibility to erosion. These types of direct effects are irreversible and permanent. For example, an archaeological site or spiritual object cannot be reconstructed once gone; its significance (both cultural and scientific) is lost.

Indirect impacts are those that occur later in time or that are farther from the initial and primary action. For example, the presence of new visual elements, night-sky pollution, noise, olfactory (odors), and air pollution can impact aspects of a cultural resource from which they derive their significance. These changes result in alterations to the character and setting of a cultural resource. There is potential for permanent visual effects that alter the viewshed to or from a cultural resource with the introduction of mine components (e.g., open pit, tailings, and waste rock storage, and water management ponds), buildings, and roads where none currently exist. These impacts are particularly acute where setting and feeling are crucial aspects of a cultural resource's importance. The night sky could be impacted by introducing artificial skyglow around the project components. In the EIS analysis area, the impact would be such that the baseline rating of the night sky would be degraded. Beyond the EIS analysis area, artificial skyglow may be detected, but would not affect the Bortle rating (see Section 4.11, Aesthetics). Access restrictions, noise, pollution, lack of privacy, and visual and olfactory intrusions can all negatively impact cultural landscapes, traditional cultural properties, and sites of religious or ceremonial significance, including burial grounds. Access to these areas and the associated cultural practices could be limited or eliminated. Conversely, increased access to the region via construction of access roads could lead to inadvertent or purposeful negative effects on cultural resources, such as looting, vandalism, or trespass in culturally sensitive areas. Collectively, these indirect changes can result in a loss of cultural identity at a landscape level as lifeway patterns and practices are disrupted. Temporary disruptions can still result in permanent impacts on lifeway practices and values.

Construction and operations of the project and related infrastructure could impact the availability, setting, and access to subsistence areas and other cultural resources, including traditional cultural landscapes (TCLs), which would alter the manner that people interact with their natural surroundings. Effects could include the loss of access to particular travel corridors, displacement from the project area, and impacts to the setting of landscapes and areas of cultural significance. The highest intensity of impacts would occur nearest to the project and would diminish in intensity with distance. These impacts would last through the project operations and would diminish if cultural practices and access are re-established after closure. Although there is a timeframe for the mine and subsequent closure and reclamation, and attempts would be made to restore the visual and natural conditions following operations, cultural resources may not always be able to be restored to pre-project conditions if damage occurs.

Local residents participate in subsistence activities to a high degree. The level of participation may be affected by changes in resource abundance and quality, season and bag limits, changes in physical access, changes in cultural perceptions of resources, and/or the physical presence of project facilities in an area that was previously undeveloped. Changes in harvest participation are a leading indicator of cultural changes; continued participation is important to the transfer of knowledge and skills across generations, for the formation of social relationships in and between communities, and to cultural continuity. Salmon provide a large proportion of their nutritional food resources and represent an essential part of the language, spirituality, and social relations for the Yup'ik and Dena'ina cultures in the analysis area. Subsistence and customary practices are the foundation of culture, helping maintain the connection of people to their land and environment, and supporting healthy diet and nutrition (Boraas and Knott 2013; Deur et al. 2018). In an area where the manner in which people interact with the natural environment is at the core of cultural beliefs, impacts of the project would be heightened, typically adverse, and may be permanent. Impacts on lifeway patterns, cultural and spiritual interactions with the environment, physical or indirect changes to archaeological sites, and other cultural resource types represent disruptions to the relationship between the people, and natural and cultural resources, which could impact the current and continuing health and vitality of their cultures.

The analysis below identifies the number of known AHRS sites, place names, and interview-identified cultural resources for each project component to aid the comparison of alternatives. However, the potential impacts to cultural resources described above; in particular, the indirect impacts, must be considered more holistically. All resources described below are interconnected; and together, have more cultural value than their individual quantities.

Potential impacts on elements of the environment that are of cultural importance such as subsistence harvest, fish, wildlife, and water are addressed in Section 4.9, Subsistence; Section 4.24, Fish Values; Section 4.23, Wildlife Values; and Section 4.18, Water Quality, respectively.

### 4.7.4 Impacts to Historic Properties

Under Section 106 of the NHPA, an adverse effect occurs when an undertaking alters, directly or indirectly, any of the characteristics of a historic property that qualify the property for inclusion on the National Register in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association (36 CFR Part 800.5[a][1]). All of the alternatives have potential to cause adverse effects resulting from the construction, operations, and closure of the project. The discussion of types of effects and environmental consequences provided for direct and indirect impacts on cultural resources would apply to the consideration of adverse effects on historic properties.

Additional identification and evaluation of each project component would take place through the Section 106 consultation process to quantify the number and types of historic properties present prior to assessing types of effects that may occur. This process can be concurrent with the NEPA process and is currently underway. The USACE is addressing potential effects to historic properties through the Section 106 process, including development of a PA. If a federal permit is issued, actions to identify and assess historic properties, as well as to avoid, minimize, or mitigate adverse effects to historic property, as specified by the PA, would be a requirement of the permit. The USACE is conferring with consulting parties through the Section 106 process to develop the PA. The PA would record the actions agreed on to resolve potential adverse effects, and to include consideration of mitigation measures and ongoing strategies to identify and evaluate historic properties pre- and post-permitting. The PA would be part of the Record of Decision (ROD), and the USACE and Bureau of Safety and Environmental Enforcement would be responsible for enforcing the PA if federal authorizations are issued. Compliance with the procedures established by the executed PA would satisfy the federal agency NHPA Section 106 responsibilities for the project (see Appendix L for the draft PA).

### 4.7.5 Avoidance, Minimization, and Mitigation

In general, NEPA involves strategies such as modifying the project to avoid or minimize impacts to cultural resources. PLP has modified the transportation corridor and the natural gas pipeline alignment to avoid impacts to potential historic properties. The NEPA public process resulted in gathering information and perspectives on potential mitigation measures, which were incorporated into the FEIS. Project-related mitigation measures are incorporated into this analysis, and are discussed in Chapter 5, Mitigation.

Specific measures are being developed through the NHPA Section 106 and PA process to resolve (i.e., avoid, minimize, or mitigate) adverse effects on historic properties, to the extent practicable. The following are typical measures used to resolve adverse effects:

- Avoidance, which could be accomplished by shifting the footprint away from the resource, limiting activities in the vicinity of the resource, monitoring construction activities near the resource to inform whether additional actions are warranted, or through any combination of these techniques.
- Minimization, which would reduce the effects on the resource through avoidance measures as described above but would not completely eliminate the effects.
- Mitigation, which may involve data recovery, protections of similar resources in nearby areas, contributions to local heritage programs in affected communities, interpretive exhibits, education curricula, or a host of other measures that would be decided on through consultation with the agencies and involved consulting parties.

### 4.7.6 No Action Alternative

Under the No Action Alternative, federal agencies with decision-making authorities on the project would not issue permits under their respective authorities. The Applicant's Preferred Alternative would not be undertaken, and no construction, operations, or closure activities specific to the Applicant’s Preferred Alternative would occur. Although no resource development would occur under the Applicant's Preferred Alternative, PLP would retain the ability to apply for continued mineral exploration activities under the State's authorization process (ADNR 2018-RFI 073) or for any activity not requiring federal authorization. In addition, there are many valid mining claims in the area, and these lands would remain open to mineral entry and exploration by other individuals or companies.

It would be expected that current State-authorized activities associated with mineral exploration and reclamation, as well as scientific studies, would continue at levels similar to recent post-exploration activity. The State requires that sites be reclaimed at the conclusion of their State-authorized exploration program. If reclamation approval is not granted immediately after the cessation of activities, the State may require continued authorization for ongoing monitoring and reclamation work as it deems necessary.

There would be no new impacts to known AHRS sites or historic properties in the region, and existing activities that impact place names or other types of cultural resources would continue at the current intensity.

### 4.7.7 Alternative 1a

#### 4.7.7.1 Mine Site

As noted in Section 3.7, Cultural Resources, there are a number of cultural resources in or near the mine site area that include AHRS-listed resources, interview-identified cultural resources (e.g., routes/trails, resource gathering areas, battle sites, reindeer stations, and camps), and place names; however, a complete survey of the project component footprints has not yet been completed by PLP. Consequently, additional resources may be identified through public input, further research, and field survey.

Cultural resources in or near the mine site may be directly or indirectly impacted by construction and operations activities. Construction and operations of the mine involve activities such as grading/excavation and blasting. Ground disturbance is necessary not only for open pit operation, but also for activities such as construction of all the ancillary facilities, including camps, shops, power and crushing plants, waste rock and tailings storage areas, quarry development, and road construction and maintenance. Ground disturbance would occur for both permanent and temporary activities. Each of these actions can directly impact cultural resources. Indirect impacts include auditory impacts from construction and operations (e.g., running equipment, blasting), dust and air pollution, olfactory pollution, introduction of new visual elements, and night-sky pollution. The indirect effects can alter the character, setting, and experience of adjacent cultural resources and TCLs, and/or change the use pattern and access to these resources.

Twelve known AHRS locations would be in the EIS analysis area for the mine site, and two of them would be in the mine site footprint for Alternative 1a. ILI-00251 is a small lithic scatter composed of two flakes and would be in the seepage collection system. The magnitude and extent of adverse effects from construction of the seepage system would be the destruction of this site. ILI-00218, a single microblade core, would be in the footprint of the mine access road along the eastern side of the water management pond. Construction of the mine access road and pond would also permanently destroy this site and cover it with water. These impacts are irreversible and would not be diminished through reclamation activities. The impacts on these two sites would be certain to occur.

No historic properties have been currently identified as part of NHPA Section 106 efforts in the analysis area for the mine site; therefore, there would be no direct or indirect impacts to identified historic properties in or near the mine site.

There are 19 interview-identified sites present in the mine site analysis area; six of these features are in the project footprint. These consist primarily of trails/routes and traplines that cross through the area, and traditional use areas (e.g., camps, harvest locations) for fishing, trapping, caribou and moose hunting near Sharp Mountain, the headwaters of the Koktuli River, Frying Pan Lake, and Groundhog Mountain. There is one place name in the project footprint (for Frying Pan Lake); four place names in the analysis area; and one that is categorized as a spiritually important place in the interview-identified cultural resources information (Groundhog Mountain *Qiyhi Qelahi, Qiyhi Dghil'u*). Portions of Groundhog Mountain and the Nushagak River are also identified as TCLs in the mine site area.

The magnitude and extent of adverse impacts on the use of these cultural resources from construction and operation of mine facilities and the presence of obstacles would be an interruption to the continuity and use of some of these linear features and traditional use areas. Resources accessed by these routes may also be displaced, which alters use patterns and changes the relationship of users to those resources. To the extent these areas are used for hunting and trapping, mine construction and operations would disrupt the subsistence use patterns of the area (see Section 4.9, Subsistence). For example, traditional use of Frying Pan Lake has already decreased due to past exploration activities; mine construction and operations would further impact its use due to restrictions on access, physical displacement of use areas, and degradation of user experience. Physical disruption would occur at Frying Pan Lake; and the potential for indirect effects remains for all cultural resources. Impacts on traditional use areas would be long-term, lasting for the duration of mine construction and operations, and are potentially permanent because these patterns of resource access and use would be altered.

There would also be permanent impacts remaining after closure, such as the pit lake and new landform resulting from closure and burial of the bulk tailings storage facility.

Indirect impacts may include visual, night sky, atmospheric, olfactory, and audible intrusions as a result of construction and operations activities, or disruptions to the subsistence lifestyle and increased presence of people in culturally sensitive areas. Traditional use areas for fishing and hunting are in the geographic extent of the mine site analysis area; there are camps, cabins, and trails/routes surrounding the mine site.

Cultural resources identified in the analysis area, but outside of the mine footprint, include hunting camps composed of modern and historic rock features (e.g., tent rings), refuse (e.g., shell casings, plastic, and food wrappers), and caribou antlers or bones, all demonstrating continued use for traditional subsistence and resource procurement activities. AHRS locations in the analysis area include isolated artifacts, lithic scatters, and cobble formations (e.g., rings and piles). Indirect effects related to visual (including the night sky), audible, or atmospheric changes (air pollution, olfactory) on archaeological sites are not expected. Indirect effects on archaeological sites and other cultural resources from increased population and use of the area would be site looting or trampling of cultural features; either purposefully or inadvertently. The magnitude and extent of impacts due to the introduction of noise, new visual elements in the landscape, helicopter traffic, and dust from construction and operations of the mine would be in the potential reduction of the use of traditional harvest areas identified near the mine. This impact would decrease with distance from the mine site, but would be long-term, lasting through the life of the mine and into closure. Impacts on the use of traditional harvest areas would be certain to occur. Camps, cabins, and sites would not be subject to other types of indirect impacts as much as use displacement. For example, Groundhog Mountain as a Traditional Cultural Landscape has been put forward as a potential historic property and has been identified as having historic and contemporary cultural use (PLP 2019-RFI 117a). Continued use of that area could be subject to visual and auditory effects during project construction and operations, depending on the specific area of use.

Finally, elements of the environment that are culturally valued, such as salmon and the water and aquatic habitat that support them, would be directly and indirectly affected in the immediate vicinity of the mine site. There would be loss of fish habitat due to the construction of mine facilities. There would also be discharge of treated water into streams. The habitat that would be lost is relatively unproductive, the number of fish affected would be low, and water quality would be required to meet state criteria. However, the loss of individual fish would be a cultural loss, and a perception of contamination could alter harvest patterns. Local residents would likely still have concern over impacts to cultural practices and use of the area in the vicinity of the mine site.

### 4.7.7.2 Transportation Corridor

The Alternative 1a transportation corridor, and particularly the port access road between Amakdedori and Kokhanok, is the component of the project with the least amount of information from previous research and field surveys. The transportation corridor (including the overland pipeline route and ferry terminals) would potentially subject cultural resources to the direct and indirect effects characterized above in the mine site discussion. Direct impacts from road, pipeline, and ferry terminal construction are one aspect of the potential consequences for cultural resources. The magnitude and extent of adverse impacts from construction activity would be the potential destruction of any cultural resources in the footprint of the port and access roads, spur roads, ferry terminals, and pipeline. The impacts could be permanent and would occur if the mine and transportation corridor are permitted and constructed.

There are 17 known AHRS locations in the transportation corridor analysis area; 6 along the port access road and 11 along the mine access road. One of these would be in the project footprint (ILI-00299) at the Gibraltar River crossing and would be subject to direct impacts. These AHRS locations include lithic debitage, cobble features, one shipwreck, and two village remains (Gibraltar and Amakdedori). The magnitude and extent of indirect impacts on the AHRS locations from increased access and potential visitation to these resources would be the potential destruction or looting of the site. These impacts would be permanent and are possible if the transportation corridor is built. For these archaeological sites, indirect effects related to air, noise, or visual impacts (including night sky) are unlikely because the integrity would not be impacted.

To date, no historic properties have been identified in the analysis area as part of the identification and evaluation efforts for the transportation corridor; therefore, no direct or indirect impacts to historic properties in the transportation corridor analysis area have been identified. Additional consultation and investigations performed before and during implementation of the PA may identify historic properties, assess project effects to these properties, and implement measures to avoid, minimize, or mitigate potential adverse effects. There are 101 interview-identified cultural features in the transportation corridor for Alternative 1a (with 38 occurring in the footprint), primarily those identified by interviews in Kokhanok. These include a range of cultural resource types as discussed in Section 3.7, Cultural Resources. There is one spiritually important place identified (a fish camp and old church site near Kokhanok), and one interview-identified place name (for the Gibraltar River). The place name database does not cover the section from Kokhanok to Amakdedori, but 11 place names are identified north of Iliamna Lake; 5 are intersected by the footprint. One place name for Amakdedori would also be in the project footprint. One place name for Iliamna Lake would be intersected by the ferry route and the natural gas pipeline.

The ice-breaking ferry has the potential to disrupt traditional winter travel and subsistence activities on Iliamna Lake, with associated cultural impacts. Coordination on alternative winter travel routes across Iliamna Lake have been discussed as part of mitigation. The ferry route associated with Alternative 1a would have less impact on winter travel using traditional routes compared to Alternative 1. The magnitude of adverse direct and indirect effects on these cultural resources from noise and visual intrusions may adversely affect qualities of these resources that contribute to their cultural significance and use. For example, burial sites and other spiritual sites may be impacted by traffic and helicopter noise and visual intrusions of a new mine or port access road in the vicinity, which could cause a disruption to users visiting these sites. Routes and trails that intersect the mine and port access roads and spur roads would be impacted, and use patterns would be perceptibly altered as a result. The discussion of impacts from disruption of traditional use areas in the mine site also applies here. For example, traditional hunting and resource-gathering grounds may be disrupted by traffic noise adjacent to the corridor, and access to these areas may be restricted or changed. Agreements for local resident use of project access roads could also improve access to cultural resources and for cultural practices. The magnitude of these impacts would be most noticeable in the immediate vicinity of project component footprints, but would diminish with distance from the roads and spurs. Noise and dust from construction and operations may also affect the setting and experience of these places. These impacts would be long-term, and would last through construction and operation of the transportation corridor; however, the displacement of resources and alteration of land use patterns could permanently impact cultural resources in the transportation corridor. Impacts to the spiritual significance and use of cultural resources would occur under Alternative 1a.

### 4.7.7.3 Amakdedori Port

Construction and operation of the port facility area would also subject cultural resources to direct and indirect effects, as characterized above. In addition to the three known AHRS locations (one village, one lithic scatter, one historic shipwreck), interview-identified data and public input suggest more cultural resources exist in this area; including, but not limited to: burials, cabins, and trails/routes. Nine interview-identified sites were recorded in the port analysis area, and one would be in the project footprint. No historic properties have been identified as part of NHPA Section 106 efforts in the port analysis area. Additional consultation and investigations performed before and during implementation of the PA may identify historic properties, assess project effects to these properties, and implement measures to avoid, minimize, or mitigate potential adverse effects.

Two archaeological sites are subject to indirect impacts. Although not in the project footprint, the revised location of Amakdedori Village (ILI-00044) places it southwest of the main port facility. The lithic scatter (ILI-00295) is along the port access road north of the main port facility. The magnitude and extent of indirect effects to these sites would be the potential for site destruction due to increased access to the area. This area is also used for culture camps and field trips; the presence of a port facility would be an intrusion on that experience. Access for cultural practices would be restricted in the immediate vicinity of the port site; however, agreements for local resident use of project access roads could also improve access to cultural resources and for cultural practices. Noise and dust would also have an adverse impact on the use of these sites. There is one place name for Amakdedori that would be in the footprint of the port. The place name (*Amaktatuli*) means "the place to carry things over," showing the significance of the area for past use. Storage and transfer of both fuel and metal concentrates in the vicinity of the port site could create concerns regarding environmental impacts and related effects on traditional and contemporary cultural practices, including subsistence activities. The setting and experience of contemporary site users would be adversely altered over the long-term (i.e., years to decades) by construction and operation of the port. Indirect impacts to these sites would be possible if the port is permitted and constructed.

### 4.7.7.4 Natural Gas Pipeline Corridor

Analysis for environmental consequences of other project components provided above also applies to the natural gas pipeline, particularly the direct and indirect impacts associated with the transportation corridor, because the pipeline is co-located with the transportation corridor for much of the route from Amakdedori port to the mine site. Underwater archaeology or historic maritime investigations have occurred for the subsea portion of the Cook Inlet crossing of the pipeline. Side-scan sonar data have been gathered and subjected to archaeological analysis (PLP 2019-RFI 025b). There are no known AHRS locations, historic properties, or other cultural resources in the anchor spread of pipeline construction. One shipwreck (ILI-00291, AGRAM) has been identified, but it is not in the footprint of the offshore components near Amakdedori port; therefore, adverse effects to this shipwreck are not expected. Any archaeological sites or shipwrecks in the alignment could be directly affected by construction; these cultural resources would likely be avoided, and therefore would not be impacted. The magnitude of indirect effects to cultural resources adjacent to the pipeline route in Cook Inlet would be in changes to the sites from subsurface wave action and sediment disturbance. These impacts would last only during the construction phase but would be expected to occur. The type of dredging technology selected to install the buried segments of the pipeline would not be expected to change the magnitude of effects.

For the section of the pipeline that would not follow the transportation corridor (from the north shore of Iliamna Lake to the mine access road), there are nine AHRS locations in the analysis area and 29 interview-identified cultural resources. Other than the shipwreck previously mentioned, no historic properties have been identified in the natural gas pipeline analysis area. The types of direct and indirect impacts would be similar to those discussed above. Additional consultation and investigations performed before and during implementation of the PA may identify historic properties, assess project effects to these properties, and implement measures to avoid, minimize, or mitigate potential adverse effects.

On the coast of the Kenai Peninsula, there are cultural resources in the analysis area near the compressor station. These include SEL-00164 (Clabo Midden Site), SEL-00369 (Whiskey Gulch Site 1), and SEL-00379 (Sterling Highway). No sites would be in the project footprint. Indirect effects on the other two sites are unlikely due to their distance from the potentially disturbed area.

### 4.7.8 Alternative 1

Alternative 1 would have the same impacts to AHRS locations, place names, interview-identified cultural resources, and historic properties as described for the mine site, south ferry terminal, port access road, and Amakdedori port under Alternative 1a.

No historic properties have been identified in the analysis area for the mine site, transportation corridor, Amakdedori port, or natural gas pipeline corridor. Therefore, no direct or indirect impacts to historic properties under this alternative have been identified at this time. Additional consultation and investigations performed before and during implementation of the PA may identify historic properties, assess project effects to these properties, and implement measures to avoid, minimize, or mitigate potential adverse effects.

Along the mine access road, there would be four known AHRS sites; none in the project footprint. There would be 37 interview-identified cultural resources, with 14 in the project footprint. The impacts to the AHRS locations and the interview-identified cultural resources would be similar to the impacts for these types of resources discussed for Alternative 1a.

The natural gas pipeline would be co-located with the transportation corridor from Amakdedori port to the mine site, and therefore would have the same impacts to cultural resources. Alternative 1 would also share the cultural resources discussed for the compressor station on the Kenai Peninsula that were discussed for Alternative 1a.

The magnitude of adverse direct and indirect effects on these cultural resources from noise and visual intrusions may adversely affect qualities of these resources that contribute to their cultural significance and use, as discussed above. The discussion of impacts from disruption of traditional use areas in the mine site also applies here. The magnitude of these impacts would be most noticeable in the immediate vicinity of project component footprints, but would diminish with distance from the roads and spurs. Noise and dust from construction and operations may also affect the setting and experience of these places. These impacts would be long-term, lasting through construction and operation of the transportation corridor. However, the displacement of resources and alteration of land use patterns could permanently impact cultural resources in the transportation corridor. Impacts to the spiritual significance and use of cultural resources would occur under Alternative 1.

#### 4.7.8.1 Alternative 1—Kokhanok East Ferry Terminal Variant

The area of the Alternative 1 Kokhanok East Ferry Terminal Variant includes known AHRS locations at Kokhanok, a contemporary village that contains historic-era buildings identified in the AHRS (e.g., ILI-00025 Saints Peter and Paul Chapel and ILI-00262 Kokhanok Bureau of Indian Affairs School). Direct impacts to these buildings or Old Kokhanok (ILI-0008) are not likely to occur from the construction of the Kokhanok east spur road to the village. This variant would also impact 56 interview-identified cultural resources along the port access road, 10 of which would be in the project footprint. The magnitude and extent of indirect impacts would include changes in the setting caused from increases in project-generated noise and dust due to traffic. As described above, these impacts would be long-term, and would be certain to occur under this variant.

No historic properties have been identified as part of NHPA Section 106 cultural resource identification and evaluation efforts in the analysis area for the Kokhanok East Ferry Terminal Variant. Therefore, no direct or indirect impacts to historic properties under this alternative have been identified at this time. Additional consultation and investigations performed before and during implementation of the PA may identify historic properties, assess project effects to these properties, and implement measures to avoid, minimize, or mitigate potential adverse effects.

#### 4.7.8.2 Alternative 1—Summer-Only Ferry Operations Variant

This variant for Alternative 1 avoids the types of direct or indirect impacts from winter ferry operations on cultural practices and activities associated with winter over-ice travel on Iliamna Lake. An increase in truck traffic on transportation corridor roads during the ice-free season would potentially increase the impacts on access to and experience of cultural activities in the vicinity of the transportation corridor.

#### 4.7.8.3 Alternative 1—Pile-Supported Dock Variant

This variant for Alternative 1 does not change the types of direct or indirect impacts anticipated, or the quantity of resource impacted.

### 4.7.9 Alternative 2—North Road and Ferry with Downstream Dams

Alternative 2 would have the same potential for direct and indirect impacts on cultural resources at the mine site as discussed above for Alternative 1a.

The transportation corridor, Diamond Point port, and the natural gas pipeline would have the same types of potential effects as Alternative 1a, but in different locations. These include 23 known AHRS sites in the transportation corridor, one is in the footprint of the port access road: the Williamsport-Pile Bay Road (ILI-00132). There is one interview-identified feature recorded in the EIS analysis area, and no known AHRS sites at the Diamond Point port site.

The Williamsport-Pile Bay Road (ILI-00132) is the only identified historic property under this alternative, described in Section 3.7, Cultural Resources. The alternative includes the construction of an access road from Diamond Point to Pile Bay; this road intersects—and in some cases is co-located with—the historic property. The magnitude and extent of the impact would be the partial destruction of the historic property and introduction of a new visual element in the current road corridor that affects the setting and feeling of the historic property; indirect impacts (i.e., change in historic setting) would decrease in intensity with distance. The duration of the direct impact (i.e., partial destruction) would be permanent. The likelihood would be certain under these alternatives.

In terms of potential modification to the setting, the transportation corridor under this alternative would cross through areas where there are 41 known locations with indigenous place names (16 are in the footprint). The natural gas pipeline and the Diamond Point port would intersect seven place names, three of which would intersect the project footprint.

Under this alternative, 54 interview-identified cultural features are present across the landscape, with 26 of in the project footprint. The ferry would have a different route than discussed under Alternative 1a, and winter operations would be less disruptive to traditional winter over-ice transportation associated with cultural practices, such as inter-community visits. The primary difference is that only travel between Pedro Bay and other communities would be affected by this alternative. The nature, magnitude, duration, and extent of direct and indirect impacts to these cultural features would be similar to those described above for sites potentially impacted by Alternative 1a.

#### 4.7.9.1 Alternative 2—Summer-Only Ferry Operations Variant

The potential impact of this variant would be similar to that discussed under the Alternative 1 Summer-Only Ferry Variant, except that the impacts of increased truck traffic during the open water season would occur on the north access road, and affect cultural resources and activities associated with Pedro Bay and Nondalton.

#### 4.7.9.2 Alternative 2—Pile-Supported Dock Variant

This variant would not change the types of direct or indirect impacts anticipated or the quantity of resource impacted.

#### 4.7.9.3 Alternative 2—Newhalen River North Crossing Variant

The mine access road under the Newhalen River North Crossing Variant would affect the same AHRS locations as in the mine access road of the Alternative 2 analysis area, plus one site in the footprint: ILI-00302, a multi-component subsurface and surface site discovered during 2019 surveys. Place names, historic properties, and interview-identified cultural resources would be the same as those for Alternative 2. Impacts to these cultural resources would also be the same as those under Alternative 2.

### 4.7.10 Alternative 3—North Road Only

Alternative 3 would have the same potential for direct and indirect impacts on cultural resources at the mine site as discussed above for Alternative 1a. The transportation corridor, Diamond Point port, and natural gas pipeline would have the same types of potential effects as Alternative 1a, but in different locations, some of which are discussed under Alternative 2. These include 32 known AHRS sites in the transportation corridor, and an additional four in the natural gas pipeline corridor. The transportation corridor would overlap with the one historic property, the existing Williamsport-Pile Bay Road (ILI-00132), which would have both direct and indirect impacts, as discussed under Alternative 2. There are three known AHRS sites in the EIS analysis area for the Diamond Point port site.

In terms of potential modification and setting, the transportation corridor would cross through areas where there are 43 known locations with indigenous place names (15 are in the footprint), and 90 interview-identified cultural features are present across the landscape, including 37 that would be in the project footprint. The magnitude, duration, and extent of direct and indirect impacts to these cultural features would be similar to those described above for sites potentially impacted by Alternative 1a.

#### 4.7.10.1 Alternative 3—Concentrate Pipeline Variant

The variant for Alternative 3 would be in the immediate vicinity of the natural gas pipeline; it would not change the types of direct or indirect impacts anticipated or the quantity of resources impacted, as discussed for the north road transportation corridor. No additional cultural resources would be impacted.

## 4.7.11 Cumulative Effects

Categories of impacts to cultural resources under cumulative effects are the same as those described for direct and indirect effects. The cumulative effects analysis area for cultural resources encompasses the analysis area, which has been defined as the project footprint and lands within 3 miles of the mine site (including material sites) and within 1 mile of the other project components (e.g., port sites, transportation corridors, and ferry terminals) for indirect impacts (e.g., dust, visual, auditory, and olfactory).

Past, present, and reasonably foreseeable future actions (RFFAs) have the potential to contribute cumulatively to effects on cultural resources, detailed in Section 4.1, Introduction to Environmental Consequences. All of the RFFAs listed have been considered in the analysis of cumulative effects on cultural resources.

Additional consultation and investigations performed before and during implementation of the PA may identify historic properties, assess project effects to these properties (including an assessment of potential cumulative effects), and implement measures to avoid, minimize, or mitigate potential adverse effects.

### 4.7.11.1 Past and Present Actions

Past and present actions that have, or are currently, affecting cultural resources, including historic properties, in the analysis area are minimal; there is no operational industry and limited infrastructure in the area. Such activities that have likely resulted in a loss of or adverse effects to some cultural resources and activities include development projects involving transportation infrastructure and community development actions, mining exploration and non-mining-related projects, commercial and subsistence fishing and hunting, and commercial recreation and tourism. Although past and present activities and development have removed or altered the character of some cultural resources in these areas, they are additive to other actions, increasing the total number of cultural resources affected.

Past exploration drilling at the Pebble deposit and other mineral deposits has occurred, including hundreds of boreholes for the project, which were surveyed for archaeological sites at the time so that they could be potentially avoided. The direct impact of these past and present actions on cultural resources from mining exploration activities are minimal due to limited ground disturbance. However, cultural resource interviews suggested that local residents reduced their use of Frying Pan Lake for subsistence and cultural activities, which constitute indirect effects on use and cultural context. It is likely that the presence of helicopters affected the context and experience of other cultural activities in the vicinity of exploration activities.

Past development projects such as transportation infrastructure and housing development have also occurred. Construction of roads affects cultural resources through direct removal and destruction of an archaeological site. Indirect effects may be associated with the visual changes of introducing a new road, and the potential for increased access and traffic noise that would result from constructing a new road. However, these development projects have a relatively small construction footprint, and consequently have likely resulted in limited past and present cumulative effects on a regional basis. They may also improve access to the location of cultural sites and activities. Those past and present projects that are considered federal undertakings, consistent with 36 CFR Part 800.16 and since the passing of the NHPA in 1966, would have required the applicable federal agencies to avoid, minimize, or otherwise resolve adverse effects to properties eligible for, or listed in, the National Register.

Additional consultation and investigations performed before and during implementation of the PA may identify historic properties, assess project effects to these properties (including an assessment of past and present actions), and implement measures to avoid, minimize, or mitigate potential adverse effects.

### 4.7.11.2 Reasonably Foreseeable Future Actions

RFFAs have the potential to contribute cumulatively to effects on cultural resources, and are detailed in Section 4.1, Introduction to Environmental Consequences. These potential future actions are similar to the EIS alternatives in that each may result in direct and indirect effects on cultural resources, as discussed above. These actions could generate incremental changes to cultural resources, including resources of cultural importance, and exposing additional cultural resource sites, or causing disturbance to the sites or their setting.

Each of the above RFFAs discussed in Table 4.7-2 would contribute to the increased potential for impacts on a wide range of cultural resources, including historic properties, because each action involves some aspect of ground-disturbing activity that can lead to the irreversible destruction of cultural resources, or affect the character or setting of the cultural resources.

The No Action Alternative would not contribute to cumulative effects on cultural resources.

Collectively, the project alternatives with RFFA contribution to cumulative effects on cultural resources are summarized in Table 4.7-2.

Additional consultation and investigations performed before and during implementation of the PA may identify historic properties, assess project effects to these properties (including RFFAs), and implement measures to avoid, minimize, or mitigate potential adverse effects.

**Table 4.7-2: Contribution to Cumulative Effects on Cultural Resources**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Pebble Project Expansion Scenario | **Mine Site:** The Pebble Project expansion scenario would increase the geographic area affected and duration of effects of the project by combining project elements of Alternative 1 and Alternative 3 and expanding the mine site footprint. Expansion would impact a greater aerial extent of specific resources discussed under direct and direct impacts. Once a cultural resource feature, archaeological site, or historic site is destroyed, its value is gone and cannot be restored. Areas of cultural use may be irretrievably altered, such as incorporating Frying Pan Lake into the South Waste Rock Facility Collection Pond. Future use of the lake would be dependent on the scope and success of restoration activities. Actions that expand mineral development at the Pebble deposit contribute to landscape-level effects, where there is continuous introduction of intrusive visual elements, increased noise and atmospheric pollution, and an increased volume of people. Pebble Project expansion would increase the likelihood of adverse visual and auditory effects on cultural activities associated with Groundhog Mountain over a longer period of time. Traditional access routes could be curtailed through areas of Pebble Project expansion, requiring finding alternative access. Such effects would occur over an extended period of operations. These could lead to inadvertent and purposeful destruction of cultural resource features, invasion of privacy and solace at spiritual and ceremonial sites, adverse impacts on natural resources that are central to cultural belief systems, and subsequent degradation of these cultural belief systems that have far-reaching social and physical health impacts.<br>**Other Facilities**: The south access road and ferry system would continue to operate, and a north access road and concentrate and diesel pipelines would be constructed along the Alternative 3 road | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** Similar to Alternative 1a, except that the north access road would be constructed from the mine site to Iniskin Bay.<br>**Magnitude:** Similar to Alternative 1a, except that the south access road would be larger and affect more cultural resources.<br>**Duration/Extent:** The duration and extent of cumulative impacts to cultural resources would be similar to duration and extent of Alternative 1a, although affecting a larger amount of acreage and geographic area.<br>**Contribution:** Cumulative impacts to cultural resources would be of greater magnitude and geographic extent than Alternative 1a. Alternative 1, in combination with the Pebble Project expansion scenario, may result in impacts to cultural resources over a larger geographic area and more acres than under Alternative 1a. | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** Similar to Alternative 1a, except that there would be no south access road constructed or used, and the Amakdedori port would not be built.<br>**Magnitude:** Similar to Alternative 1a, except that no additional transportation corridor and port facility would be used.<br>**Duration/Extent:** The duration and extent of cumulative impacts to cultural resources would be similar to duration and extent of Alternative 1a, although affecting a larger number of acres at the mine site and fewer acres in a single transportation corridor.<br>**Contribution**: The contribution to cumulative effects would be slightly less than Alternative 1a. | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** Overall Pebble Project expansion would use the existing north access road; concentrate and diesel pipelines would be constructed along the existing road alignment and extended to a new deepwater port site at Iniskin Bay.<br>**Magnitude:** Overall, Pebble Project expansion would affect fewer acres than Alternative 1a, given that the north access road and gas pipeline would already be constructed, and there would not be two operating transportation corridors.<br>**Duration/Extent:** The duration and extent of cumulative impacts to cultural resources would be similar to duration and extent of Alternative 1a, although affecting fewer acres and a smaller geographic area in a single transportation corridor.<br>**Contribution:** Because the Pebble Project expansion scenario would use the north access road that would already be built under Alternative 3, and not |

**Table 4.7-2: Contribution to Cumulative Effects on Cultural Resources**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | alignment, and extended to a new deepwater port site at Iniskin Bay, adding an additional geographic area of project activity that could impact cultural activities. There would be improvements to portions of the existing Williamsport-Pile Bay Road. As an indirect benefit, the condition of the road would be improved for current and future non-project users, although some access and traffic controls could be implemented to ensure the safety of mixed mine and non-mine traffic. The road would be maintained for year-round traffic, and the level of traffic would increase over current volumes. This would have some effect on the character and setting of the Williamsport-Pile Bay Road, but would be typical of other Alaska roads that have been identified as eligible for the National Register. Pipeline construction would have potentially limited impacts on cultural resources from trenching activities, but could lead to inadvertent and purposeful destruction of cultural resource features, invasion of privacy and solace at spiritual and ceremonial sites, adverse impacts on natural resources that are central to cultural belief systems, and subsequent degradation of these cultural belief systems that have far-reaching social and physical health impacts, similar to activities at the mine site. Effects such as habitat fragmentation, noise, and increased access for recreational hunting and fishing also disrupt subsistence activity and may result in reductions to resource-gathering areas and other cultural features.<br>**Magnitude:** The Pebble Project expansion scenario footprint would impact cultural resources from an additional transportation corridor, port, and an expanded mine footprint.<br>**Duration/Extent:** The duration and extent of cumulative impacts to cultural resources would occur over an extended 78-year period of | | | include any ferry operation, cumulative effects from Alternative 3, combined with the Pebble Project expansion scenario to cultural resources, would be less than the other alternatives. |

**Table 4.7-2: Contribution to Cumulative Effects on Cultural Resources**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | operations and closure activities, and to a larger geographic area.<br>**Contribution:** As noted above, ground disturbance activities associated with mining could lead to inadvertent and purposeful destruction of cultural resource features, invasion of privacy and solace at spiritual and ceremonial sites, adverse impacts on natural resources that are central to cultural belief systems, and subsequent degradation of these cultural belief systems that have far-reaching social and physical health impacts. This would occur in an area where development and ground disturbance is minimal outside communities and their road systems. | | | |
| Other Mineral Exploration Projects | **Magnitude:** Mining exploration activities, including additional borehole drilling, road and pad construction, and development of temporary camp facilities, would contribute a small amount of ground disturbance at discrete locations, depending on landowner permitting and restoration requirements. Although many of the mining exploration activities would have minimal ground disturbance, they would include helicopter overflights that can disturb cultural activities, and the context of a cultural resource of importance and a specific cultural resource site. Exploration activities, including additional borehole drilling and construction of temporary camp facilities, may result in disturbance to cultural resources.<br>**Duration/Extent:** Exploration activities typically occur at a discrete location for one season, although a multi-year program could expand the geographic area affected in a specific mineral prospect. | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |

**Table 4.7-2: Contribution to Cumulative Effects on Cultural Resources**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | **Contribution:** Impacts to cultural resources are expected to be limited in geographic and seasonal extent and low in magnitude. | | | |
| Oil and Gas Exploration and Development | **Magnitude:** Onshore oil and gas exploration activities could involve seismic and other forms of geophysical exploration; and in limited cases, exploratory drilling. Seismic exploration would involve temporary overland activities, with permit conditions that avoid or minimize soil disturbance. Should it occur, exploratory drilling would involve the construction of temporary pads and support facilities, with permit conditions to minimize soil disturbance and restore drill sites after exploration activities have ceased.<br>Offshore oil and gas exploration and development activities, and increased shipping in Cook Inlet associated with either Alaska LNG or ASAP, would likely be noticeable to people pursuing cultural resource activities on the western coast of Cook Inlet. Although it would not directly interfere with pursuit of cultural activities, it could adversely affect the quality of the experience.<br>**Duration/Extent**: Seismic exploration and exploratory drilling are typically single-season temporary activities. The 2013 Bristol Bay Area Plan amended plan shows 13 oil and gas wells drilled on the western Alaska Peninsula, and a cluster of three wells near Iniskin Bay. It is possible that additional seismic testing and exploratory drilling could occur in the analysis area; but based on historic activity, this is not expected to be intensive. Offshore oil- and gas-related activity would be long-term, for a period likely similar to the extended mine development.<br>**Contribution:** Onshore oil and gas exploration activities would be required to minimize surface disturbance; therefore, disturbance to cultural | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |

**Table 4.7-2: Contribution to Cumulative Effects on Cultural Resources**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | resources would occur in the analysis area, but distant from the project. The project would have minimal contribution to cumulative effects.<br>Activities associated with offshore oil and gas activities would contribute additional marine industrial activity noticeable to anyone pursing cultural resource activities on the western coast of Cook Inlet. | | | |
| Road Improvement and Community Development Projects | **Magnitude:** Road improvements projects would take place in the vicinity of communities and have impacts through grading, filling, and potential increased erosion. Communities in the immediate vicinity of project facilities, such as Iliamna, Newhalen, and Kokhanok, would have the greatest contribution to cumulative effects. Some limited road upgrades could also occur in the vicinity of the natural gas pipeline starting point near Stariski Creek, or in support of mineral exploration previously discussed.<br>Construction of community roads affects cultural resources through direct removal and destruction of a cultural resource site. Indirect effects may be associated with the visual changes of introducing a new road, and the potential for increased access and traffic noise that would result from constructing a new road. In particular, archaeological sites in the vicinity of the road could be subject to increased visitation and damage from use, vandalism, and trampling. Improvements to the Williamsport-Pile Bay Road would affect the nature of this cultural resource.<br>Additional community development RFFAs that have the potential to affect cultural resources in the region include energy and utility projects, the Diamond Point rock quarry, and various village infrastructure development projects. | Similar to Alternative 1a and Alternative 2; greater than Alternative 3. | The footprint of the Diamond Point Rock Quarry in Alternative 1a coincides with the Diamond Point port footprint in Alternative 2 and Alternative 3. Cumulative impacts would likely be less under Alternative 2 due to commonly shared project footprints with the quarry site. | Similar to Alternative 2; less than Alternative 1a and Alternative 1. |

**Table 4.7-2: Contribution to Cumulative Effects on Cultural Resources**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | **Duration/Extent:** These road improvement and community development projects would have effects similar to the Pebble Project but would be of lesser magnitude and geographic extent.<br>**Contribution:** Road construction would be required to minimize surface disturbance, and would occur in the analysis area, but removed from the project. However, when considered in combination with the Pebble Project, any cumulative impacts to cultural resources would increase if cultural resources are encountered during construction. | | | |
| Summary of Project Contribution to Cumulative Effects | The Pebble Project expansion scenario in a relatively undeveloped area would increase the geographic area affected and duration of effects of the project by combining project elements of Alternative 1a and Alternative 3. Other RFFAs would have geographical and contextual impacts to cultural resources. Once a cultural resource feature, archaeological site, or historic site is destroyed, its value is gone and cannot be restored. | Similar to Alternative 1a, although slightly more acreage would be affected by expansion of the Pebble Mine. | Cumulative impacts to cultural resources from Alternative 2, combined with the Pebble Project expansion scenario, would be of lesser magnitude and geographic extent than Alternative 1a. | Cumulative effects from Alternative 3, combined with the RFFAs, would be less than Alternative 1a. |

Notes:
ASAP = Alaska Stand Alone Pipeline
LNG = Liquefied Natural Gas
RFFA = reasonably foreseeable future action

## 4.8 HISTORIC PROPERTIES

The substance of Section 4.8, Historic Properties, has been moved to Section 4.7, Cultural Resources, and the information has been combined. This was done in response to comments that historic properties are a type of cultural resource and should not be discussed in a separate section.

Similarly, the substance of Section 3.8, Historic Properties, has been moved to and combined with Section 3.7, Cultural Resources.

## 4.9 SUBSISTENCE

This section describes potential impacts of the project on subsistence in communities near Iliamna Lake, in the Kvichak and Nushagak river drainages, and on the southwest coast of Kenai Peninsula. The magnitude, geographic extent, and duration of impacts are assessed for each project phase. The magnitude of impact from the project depends on the past and current level of subsistence use that would be impacted, the extent to which opportunities to harvest and experiences are altered, as well as the ability of subsistence users to use alternative areas with similar harvest opportunities and experiences. The duration and geographic extent of impacts depends on the location and season that the disturbance occurs during construction, operations, or closure, as well as the changes to subsistence use areas. Duration would be considered long term if the effect lasted throughout the life of the project (i.e., years to decades) while a short-term effect would be expected to last no longer than the construction phase (i.e., months to years). The potential of impacts is related to how likely the project would be to alter subsistence opportunities, experiences, and use level.

Potential impacts include:

- Changes in resource availability (including changes to resource quality): Construction and operation of project facilities may impact fish and wildlife habitat, and decrease or displace fish, wildlife, and vegetative resources used for subsistence.
- Changes in access to resources: Project facilities and transportation corridors may open or remove areas from subsistence activities, or facilitate or restrict access to subsistence resources. In addition to physical access, project activity may change the character of the subsistence activities.
- Changes in competition for resources: Changes to local population from direct and indirect employment and construction of project transportation access corridors may result in increased competition for subsistence resources.
- Changes in sociocultural conditions: Direct/indirect employment opportunities for local residents and the presence of new large-scale industrial facilities may have adverse and beneficial sociocultural effects and may have an adverse impact on subsistence users' experience.

The Environmental Impact Statement (EIS) analysis area for subsistence includes the resources that could be affected by the mine site (including material sites), port, transportation corridor, and natural gas pipeline corridor for each alternative. This includes habitat and migration routes for subsistence resources, community subsistence search and harvest areas, and areas used by harvesters to access resources.

Scoping comments not only requested that all subsistence hunting practices be considered in the analysis of effects, but requested consideration of the heavy reliance on fish for all users in the area. Specific impacts due to disturbance from mine transportation needs and potential effects of contaminants from the project on subsistence resources were also addressed by commenters.

### 4.9.1 Summary of Key Issues

**Table 4.9-1: Summary of Key Issues**

| Impact | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Impacts to availability of subsistence resources | Reduced availability of subsistence resources through habitat loss, disturbance and displacement of resources, fugitive dust deposits on resources, and increased costs and time for traveling to harvest areas. | Similar impacts to Alternative 1a. The magnitude of impact to the availability of freshwater seals would be less compared to Alternative 1a.<br>The Summer-Only Ferry Operations Variant would disturb freshwater seals less in winter. Other variants would not affect the availability of resources. | Similar impacts to Alternative 1a.<br>The Summer-Only Ferry Operations Variant would disturb freshwater seals less in the winter. Other variants would not affect the availability of resources. | Similar impacts to Alternative 1a, except that the transportation corridor would not impact the availability of freshwater seals.<br>The Concentrate Pipeline Variant would not affect impacts to the availability of resources. |
| Impacts to access to subsistence resources | Road and pipeline construction could interrupt or impede overland travel by subsistence users. Snowmachine access could be disrupted in the winter by the ice-breaking ferry and could also create a safety hazard. PLP would put measures in place to minimize impacts, such trail marking and crossings. | Impacts would be the same as for Alternative 1a, except that impacts would occur farther away from the communities of Iliamna, Newhalen, and Nondalton, and the magnitude of impacts to subsistence users' access to freshwater seal harvest locations would be less.<br>The Kokhanok East Ferry Terminal Variant would allow for access to Sid Larson Bay without crossing the ferry route.<br>The Summer-Only Ferry Operations Variant would disrupt snowmachine travel less than Alternative 1.<br>The Pile-Supported Dock Variant would have the same impacts to access as Alternative 1. | Impacts would be the same as Alternative 1a, except that the routes affected would be trails from Pedro Bay and the north and east end of the lake instead of the mid-lake region.<br>The Summer-Only Ferry Operations Variant would disrupt snowmachine travel less than Alternative 2.<br>The Pile-Supported Dock Variant and the Newhalen River North Crossing Variant would have the same impacts to access as Alternative 2. | Impacts would be similar to Alternative 2, except the magnitude of impacts from Pile Bay to Eagle Bay would be higher. Disruptions to wintertime access caused by the icebreaking ferry under the other action alternatives would not occur under Alternative 3. Subsistence users' access to freshwater seal harvest locations would not be impacted.<br>The Concentrate Pipeline Variant would have the same impacts to access as Alternative 3. |
| Impacts in competition for resources | There would be some availability to access other areas for harvest of resources, which could increase competition in some areas by providing additional access for local residents. | Similar to Alternative 1a.<br>Variants would be the same as Alternative 1. | Similar to Alternative 1a, but the longer overland pipeline ROW may increase competition for resources in that area by providing additional access for local residents.<br>Variants would be the same as Alternative 2. | Similar to Alternative 2, but the road paralleling the overland pipeline ROW would further facilitate access for local residents and could further increase competition for resources.<br>The Concentrate Pipeline Variant would not affect impacts to competition. |

**Table 4.9-1: Summary of Key Issues**

| Impact | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Impacts to sociocultural dimensions of subsistence | Beneficial effects from new income to invest in subsistence activities. Challenges in balancing time required for employment and time for subsistence activities. Adverse effects from out-migration, particularly if high-harvesting households leave. | Same as Alternative 1a. Variants would be the same as Alternative 1. | Same as Alternative 1a. Variants would be the same as Alternative 2. | Same as Alternative 1a. The Concentrate Pipeline Variant would not affect impacts to sociocultural dimensions of subsistence. |

Notes:
PLP = Pebble Limited Partnership
ROW = right-of-way

## 4.9.2 No Action Alternative

Under the No Action Alternative, federal agencies with decision-making authorities on the project would not issue permits under their respective authorities. The Applicant's Preferred Alternative would not be undertaken, and no construction, operations, or closure activities specific to the Applicant's Preferred Alternative would occur. Although no resource development would occur under the Applicant's Preferred Alternative, Pebble Limited Partnership (PLP) would retain the ability to apply for continued mineral exploration activities under the State's authorization process (ADNR 2018-RFI 073) or for any activity not requiring federal authorization. In addition, there are many valid mining claims in the area, and these lands would remain open to mineral entry and exploration by other individuals or companies.

It would be expected that current State-authorized activities associated with mineral exploration and reclamation, as well as scientific studies, would continue at levels similar to recent post-exploration activity. The State requires that sites be reclaimed at the conclusion of their State-authorized exploration program. If reclamation approval is not granted immediately after the cessation of activities, the State may require continued authorization for ongoing monitoring and reclamation work as it deems necessary.

No additional future direct or indirect effects to subsistence resources or access to subsistence resources would be expected, and existing habitat and resource trends discussed in Section 3.9, Subsistence, would continue. It should be noted that exploration activities associated with the project provided some local employment and income; the latter could contribute to pursuit of subsistence activities. Any displacement of current subsistence activities from exploration activities may continue.

PLP would be required by the State of Alaska to reclaim any remaining sites at the conclusion of their exploration program. The state determines reclamation approval after the cessation of reclamation activities and can require continued authorization for ongoing monitoring and reclamation work as deemed necessary.

## 4.9.3 Alternative 1a

### 4.9.3.1 Changes in Resource Availability

During the 4-year construction phase, project activities would, in varying degrees, affect the availability, abundance, and quality of traditional and subsistence resources through habitat loss; individual mortality, behavioral disturbance and displacement resulting from increased noise, vehicle/aircraft/ferry traffic, and human activity; fugitive dust deposits on vegetation; concerns about contamination of resources; avoidance of subsistence harvest areas; and increased costs and times for traveling to more distant areas (see Section 4.23, Wildlife Values; Section 4.24, Fish Values; Section 4.25, Threatened and Endangered Species; and Section 4.26, Vegetation, for discussions of project impacts on fish, wildlife, and vegetation). In addition, available areas for subsistence may not be the same habitat or quality as the areas residents could be displaced from, leading to more activity in higher-quality habitat areas. Adaptations would add a burden of increased expense and time needed to harvest subsistence resources. Adaptations could also result in inter-community conflicts if subsistence users from one community begin harvesting in areas typically used by another community.

During the operations phase, the effects of project activities would be similar. However, the effects would last for 20 years, and occur with less intensity along the transportation corridor than during construction because operations activities along the transportation corridor would generally be less disruptive than construction activities. Regular vehicle and ferry traffic and the physical presence of transportation corridor elements would continue to affect availability of subsistence resources over the long term, lasting through the life of the project and closure. Around the mine site, effects could occur with more intensity, associated with mining activity, noise, and expansion of the open pit and waste rock and tailings storage.

Resources and species of concern that have been identified through the scoping process and environmental baseline documents include salmon, caribou, moose, freshwater seal, berries, small mammals, and firewood. With regard to the mine site, displacement and individual mortality of fish would occur in the upper portions of the North and South Fork Koktuli rivers (including Tributary 1.190) directly affected by mine facilities; however, given the limited number of fish observed in that area and the quality of fish habitat, impacts would not be noticeable downstream from the affected channels (see Section 4.24, Fish Values). Similarly, there would be displacement of moose, caribou, brown bears (and black bears, to a lesser extent), gray wolves, small land mammals, and upland birds (grouse and ptarmigan) that use the mine site, but this would represent a small percentage of overall available habitat. Terrestrial wildlife would be anticipated to avoid the mine site due to behavioral disturbance, with avoidance distance varying between species and individuals. Some species may shift feeding, denning, and other critical life stages away from the mine site into adjacent habitat with less human disturbance. Alternatively, some species such as red fox, may be attracted to the mine site due to the presence of human food. Overall, impacts to fish and wildlife would not be expected to impact harvest levels because no population-level decrease in resources would be anticipated.

Subsistence users also may avoid harvesting waterfowl because of concerns about birds becoming contaminated from landing on and using open water at mine site facilities. Additionally, subsistence users may avoid the mine site area and other project features because of the association with industrial activity. In research conducted by the Alaska Department of Fish and Game (ADF&G), Nondalton residents said they are now avoiding the Frying Pan Lake basin west of Groundhog Mountain, a traditional winter and spring caribou hunting area for the Dena'ina people and a calving area for the Mulchatna caribou herd, because of the extensive exploration activity in this area associated with the project (Van Lanen et al. 2018).

With regard to transportation facilities such as the mine and port access roads and Iliamna Lake ferry operations, the magnitude of impacts would be in the amount of habitat lost from the facility footprint, potential displacement of individual fish and wildlife from human activities and noise, and potential injury and mortality from ferry traffic (salmon and seals) and strikes with truck traffic (large and small land mammals and birds) (see Section 4.23, Wildlife Values; and Section 4.24, Fish Values). However, the facility footprint would be small in comparison to the total habitat available and culverts on the access roads would allow fish passage. There would not be population-level effects from injury and mortality resulting from the entrainment of salmon and seal strikes from ferries or vehicle collisions with large and small land mammals and birds. There would be some site-specific habitat fragmentation from project facilities, causing behavioral disturbance to terrestrial wildlife and birds and localized changes in distribution. These impacts would occur if the project is permitted and built.

The magnitude, duration, and extent of direct impacts would be a long-term loss of resource availability for berries and firewood in the project footprint and the immediate area of mine and transportation facilities; but these resources are commonly available in the analysis area, and alternative gathering areas are available, which are traditionally used.

The extent of impacts from fugitive dust would occur in a narrow corridor on either side of the roadways as described in Section 4.26, Vegetation. The heaviest dust deposition would be anticipated to occur within 35 feet of the road; vegetation collection and berry picking activity may avoid dusted areas. Some localized impacts of dust settlement in stream channels where fishing occurs may be noticeable, but implementation of dust suppression and enforcement of slow speed limits at all stream crossings would minimize dust-related impacts to aquatic ecosystems (see Chapter 5, Mitigation). Impacts would be expected to extend through the life of the project and would be localized to the area of disturbance. Fugitive dust from construction, roadways, and mining activities deposited in streams and on berries, other traditionally used plants, plants that animals eat, and water, would discourage subsistence users from harvesting these resources near the areas affected by the mine site and the transportation corridor. Impacts associated with fugitive dust may be realized if the project were permitted, constructed, and built.

The communities closest to project infrastructure and transportation activities, including the mine site, transportation corridor, the ferry and terminals, port, and airports, would be the most affected by changes in resource availability. These communities include Nondalton, Iliamna, Newhalen, Pedro Bay, Igiugig, and Kokhanok. In contrast, communities in the Nushagak River drainage and in the Kvichak River drainage below Igiugig would experience little to no impact on resource availability as the potential impact on fish and wildlife would be small (see Section 4.23, Wildlife Values). Residents in Port Alsworth use an area in the vicinity of the mine site and along the mine access road to harvest caribou, moose, other land mammals, waterfowl, upland birds, and berries though the areas closer to and surrounding this community see higher concentrations of use. Little to no impact on resource availability in the concentrated use areas closer to the community of Port Alsworth during operations would be expected to occur. Additionally, specific individuals and families that own Native Allotments located near project infrastructure and transportation facilities would be disproportionately impacted if project construction and operations activities reduced the availability or value of subsistence resources on or surrounding the Native Allotments. On the east side of Cook Inlet, the construction and decommissioning of the natural gas pipeline would disturb a small area of approximately 5 acres near the Sterling Highway, distant from communities traditionally pursuing subsistence activities.

During construction and operations, the effects of project activities on resource availability would be primarily localized in the vicinity of project facilities and activities. Although the mine site is in subsistence harvest areas used by five communities (see Section 3.9, Subsistence), it provides relatively poor fish and wildlife habitat. Portions of the transportation corridor, primarily in the vicinity of the Newhalen River, and Gibraltar Lake and River are more heavily used (see Section 3.9 and Appendix K3.9, Subsistence). Truck traffic along these portions of the transportation corridor could displace moose and other land mammals in the immediate vicinity of the access roads, including where the transportation corridor crosses the Gibraltar and Newhalen rivers. Subsistence users that harvest resources in the immediate vicinity of the transportation corridor, particularly those from Iliamna, Newhalen, and Kokhanok, would likely need to make some adjustments to where they harvest some subsistence resources in order to target areas that would be less affected by project activities. Because there would not be population-level decreases to fish and wildlife species, these adaptive approaches would likely sustain harvest levels for affected communities; however, these adaptations would add a burden of increased expense and time needed to harvest subsistence resources and could impact retention and transmission of traditional knowledge and practices related to the areas affected by project activities. The duration of effects would be long term, lasting through the life of the project and closure and they would be certain to occur under Alternative 1a.

Many project features would be removed, reclaimed, or both during closure. Once restoration activities have been completed, impacts on the availability of subsistence resources would be reduced as these areas would revegetate. The pit lake at the mine site would fill during the decades after mine closure. This would introduce a new standing waterbody, and concern about contamination of waterfowl was expressed during scoping. While there would be exceedance of water quality standards for specific metals, during closure (see Appendix K4.18), exposure of wildlife and birds from potential contaminants exposure would be limited and short term. The pit lake would not support habitat that is attractive to many species of waterfowl and shorebirds; alternate habitat, including open water for staging, is common and available in the area. Some project facilities, including the pipeline, power plant, limited camp and storage facilities, access roads, and mine water treatment plant, would remain in use after mine closure as long as needed to support closure activities. Impacts on resource availability would be localized in the vicinity of remaining infrastructure and activities (see Section 4.26, Vegetation; and Section 4.23, Wildlife Values, for discussions on vegetation restoration and impacts to wildlife). Suggested mitigation measures are listed in Appendix M1.0, Mitigation Assessment.

The magnitude and extent of impacts to subsistence resources would be: disturbance, displacement, individual mortality from vehicle collisions and physical loss of stream habitat, and the loss of habitat due to placement of project components.; however, population-level effects to fish and wildlife would not be expected (see Section 4.24, Fish Values; and Section 4.23, Wildlife Values), and similar habitat is generally available. The duration of impacts on subsistence resources would be long term lasting throughout the life of the mine and post closure because a perception of contamination of waterfowl and other species could remain. Impacts from the transportation corridor and associated uses would be intermittent to prolonged over the construction period and 20-year operations period. The duration of impacts would extend beyond the life of the mine but would decrease in intensity after closure. Some impacts on subsistence would be certain to occur under this alternative.

### 4.9.3.2 Changes in Access to Resources

Subsistence harvest patterns are dynamic and strategic, as users concentrate their efforts in areas likely to be productive, with abundance and distribution of resources that change year by year. The figures in Section 3.9 and Appendix K3.9, Subsistence, show the multi-year subsistence use areas and the relative number of subsistence users for the six communities closest to the project components. The magnitude, extent, and duration of impacts would be to impair or restrict access to resources during construction in the immediate vicinity of project components. Such restrictions would affect communities located near project infrastructure that use this land for or to access subsistence fishing, hunting, gathering, education of youth on subsistence traditions, and other customary practices. Construction of linear features, such as the roads and pipeline, could interrupt or impede travel to resources or communities on the other side of the right-of-way (ROW), especially during construction. For example, construction of the natural gas pipeline and port access road could interrupt or impede residents of Kokhanok from accessing subsistence areas south and west of the community during 1 of the 4 years of construction. Additionally, construction-related vessel traffic crossing Iliamna Lake could interrupt other vessel traffic and subsistence activities. Safety considerations and presence of project equipment and personnel may restrict hunting activities near project facilities and would be subject to consultation with potentially affected communities. These impacts would be expected to occur under Alternative 1a.

During the operations phase, the magnitude and extent of impacts would be the restriction of access to subsistence resources at the project footprint of the mine site and in the mine site safety boundary, Iliamna Lake ferry terminals, mine and port access roads, and Amakdedori port. The duration of the impact would be long term, lasting throughout the life of the project and closure. Hunting may be restricted in the vicinity of those areas and a raised gravel road may present a barrier to snowmachine and all-terrain vehicle (ATV) crossing. There could also be disruption to access to marine resources in Cook Inlet from barge activity and pipeline construction; however, such restrictions would have minimal impact on access to subsistence resources because these project components would occupy a relatively small portion of the nearby communities' harvest areas related to the available area, and because mitigating measures would be in place to minimize or avoid impact. These measures, such as providing marked crossing points across the transportation corridor and around the ferry terminals (PLP 2018-RFI 027), are discussed in Chapter 5, Mitigation. These adverse impacts would be long term, lasting for the life of the project, and would be certain to occur if the project is permitted and built.

PLP has stated that they would work with local communities to identify safe, practicable ways for residents to use the access roads, such as scheduled escorted convoys for private vehicle transport, and address hunting guidelines near project facilities. Trails and crossing points would be clearly identified and appropriate traffic controls would be established to ensure public safety (PLP 2018-RFI 027); however, crossing at designated points or avoidance of ferry traffic may add travel time and expense for subsistence users. Once constructed, the transportation corridor roads and the natural gas pipeline corridor ROW could have a positive, long-term effect on access to subsistence resources (depending on the level of access agreed to between the State, PLP, and the Lake and Peninsula Borough [LPB]) because these cleared routes could facilitate some overland travel by ATVs and snowmachines. The use of pipeline ROWs would likely occur.

The magnitude and extent of impacts from the Iliamna Lake ice-breaking ferry would be to disrupt winter travel over the frozen lake by creating a corridor of open water, potentially adding to travel time, complicating travel logistics, increasing the risk of accident and injury, and increasing fuel and vehicle maintenance expenditures for subsistence users. In addition, the open water in the ferry's wake would present a safety hazard for subsistence users. To help mitigate these impacts, PLP has stated that they would work with communities (and supply funding) to provide for the marking and maintenance of snowmachine trails connecting communities across Iliamna Lake when lake ice is thick enough to support such traffic (PLP 2018-RFI 071a) (see Section 3.12, Transportation and Navigation). PLP has stated that they would also work with local communities to find solutions for ferry transportation use (PLP 2018-RFI 027).

At closure, roads in the transportation corridor would remain in place for monitoring purposes and potentially for local traffic; roads could continue to facilitate overland travel for subsistence access. The ferry facilities would be removed and supplies would be transported across the lake using a summer barging operation; therefore, there would be no impacts from ice-breaking ferries after closure. Many of the other project features would be removed and/or reclaimed, greatly reducing adverse impacts on access to subsistence resources.

The magnitude and extent of impacts from the transportation corridor on subsistence users would be potential restrictions to access in the EIS analysis area. The impact would be limited in geographic extent and subsistence users would be able to access other areas for harvest of resources. This is primarily because the mine access road portion of the transportation corridor is identified as a high-overlapping area for subsistence uses for two communities (Iliamna and Newhalen) and is used by two others (Nondalton and Igiugig). Additionally, the Gibraltar River and Lake portion of the transportation corridor is a high-overlapping subsistence use area for Kokhanok that is also used by Igiugig. Impacts from the transportation corridor and associated uses would be intermittent to prolonged over the 24-year period of project construction and operations. The duration of impacts would be long term, extending beyond the life of the mine. In terms of likelihood, the impacts would be certain to occur.

The following sections evaluate project impacts on access to subsistence resource harvest areas for the six communities located closest to the project infrastructure (i.e., Iliamna, Newhalen, Pedro Bay, Nondalton, Igiugig, and Kokhanok) as project facilities and activities may restrict access in areas of overlapping subsistence use by these communities. It is based on reported use of these areas as described by SRB&A (2011b), Fall et al. (2006), and Krieg et al. (2009) (see Section 3.9, Subsistence). For most of the communities, the contemporary harvest areas are similar to the areas that have historically been used to harvest subsistence resources, though harvest areas may fluctuate over time as environmental changes occur or resource populations and location change; this can affect some communities more than others. For example, over the past two decades, the Mulchatna caribou herd population has declined and their range has expanded west and north, resulting in a more scattered and sporadic distribution of caribou. Over the same time period, the expansion of deciduous shrubs has led to increased moose availability in the area. One coping response to these changing conditions has been for subsistence hunters to change their target species from caribou to moose and use different areas (Van Lanen et al. 2018). The figures in Section 3.9 and Appendix K3.9, Subsistence, show the multi-year subsistence use areas and the relative number of subsistence users for the six communities closest to the project components. It is possible that some downriver communities in the Kvichak and Nushagak River drainages may occasionally use the EIS analysis area for subsistence activities, but their high frequency use areas are closer to the location of their communities (see Appendix K3.9, Subsistence).

The impacts to use areas and access to these areas from construction and operations of the natural gas pipeline would be the same as described for the transportation corridor.

The mine site would impact all six of these communities in similar ways. Construction, operations, and closure may affect access to subsistence hunting and fishing on these lands. Project-related activities, such as blasting and operation of heavy equipment and helicopters, would adversely restrict access. Iliamna Lake community residents that may have otherwise traveled through the mine site area to reach subsistence resources farther north, west, and south would have to take alternative routes and potentially travel longer distances to avoid the mine site and infrastructure. However, the mine site is not shown as a high-overlapping use area for any of the six communities.

The magnitude and extent of impacts to accessing the mine site for subsistence use and harvest would be most concentrated near the mine site area and would diminish with distance. The effects would be limited in geographic extent; these areas are broken down by community below. Impacts of the mine site and associated uses would be intermittent to prolonged. The duration of impacts would extend beyond the life of the project with diminishing intensity as the site is reclaimed during closure. The impacts would be certain to occur if the project is permitted and built.

## Iliamna

The mine access road from Eagle Bay would be located in medium- to high-use areas accessed by residents of Iliamna and would likely impact access. There are overlapping use areas near the Newhalen River and farther inland, and near the site of the ferry terminal at Eagle Bay. The south ferry terminal and port access road, including the crossing at the Gibraltar River, would be located in lower overlapping use areas, which Iliamna residents access for resources. There would be no impact to access of subsistence resources from Amakdedori Port.

## Newhalen

The mine access road would be in the vicinity of a medium to high overlapping use area near the Newhalen River and would impact access to resources in the areas inland north of the community. In the winter, the ice-breaking ferry could disrupt access to all resource use areas on the lake. The south ferry terminal and port access road, including the crossing at the Gibraltar River, would be located in an area with lower overlapping uses, which Newhalen residents access for resources. There would be no impact to access to subsistence resources from Amakdedori Port.

## Pedro Bay

The effects of the mine access road and north ferry terminal on subsistence access would be to displace access to a small portion of the overall harvest areas in comparison to the total harvest area available near Eagle Bay, which shows overlapping uses for Pedro Bay harvesters. There would be no impacts to subsistence access from the port access road, including the crossing at Gibraltar River, or Amakdedori port.

## Nondalton

The mine and port access roads of Alternative 1a are likely to impact access to resource harvest areas for Nondalton residents as they would be located in the vicinity of medium overlapping use areas. Access through the mine site area to subsistence areas to the south would be disrupted. Impacts would be similar to those described for Iliamna.

## Igiugig

The south ferry terminal and port access road would be located in areas that Igiugig residents have reported accessing for resources, including the crossing at the Gibraltar River. There is little subsistence activity at the north ferry terminal or along the mine access road.

Ferry traffic would be noticeable to those using Iliamna Lake to access areas at the north east end of the lake, in the Sid Larson Bay and areas around the community of Kokhanok. These areas are all accessed by a low number of subsistence users in Igiugig. The impact would be of higher magnitude in the winter, when the ice-breaking ferry would be operating.

## Kokhanok

The magnitude and extent of impacts from construction and operations of the mine and port access roads and ferry terminals on Kokhanok residents would be to interrupt or impede access to portions of the overlapping harvest use areas in the vicinity of the community as well as the Gibraltar River and Gibraltar Lake areas.

During the winter when the ferry would be breaking ice, ferry traffic would be noticeable to those using Iliamna Lake to access areas at the north east end of the lake, in Sid Larson Bay, and areas around the community of Kokhanok. Traditional access routes used by some Kokhanok residents would be affected.

The magnitude and extent of construction and operations of the Amakdedori port under Alternative 1a would be to interrupt or impede access for residents of Kokhanok to overlapping use areas for taking of marine invertebrates and seals in Kamishak Bay.

### 4.9.3.3 Changes in Competition for Resources

The project would result in employment opportunities for non-local workers during construction and operations. However, such opportunities are unlikely to increase competition for subsistence resources from sport hunting and fishing in areas where project employees are working or housed. Employees would be prohibited from hunting, fishing, and gathering while on site during their two-week shift to minimize competition for local subsistence resources (PLP 2018-RFI 071a). Non-local mine site employees would be transported to and from the mine site by aircraft, enabling them to continue to live outside the region and commute to project work sites. Furthermore, access to and use of project roads and other facilities for non-resident sport hunting would be prohibited. The magnitude of the impact would be that non-local workers would not contribute to an increase in recreational use, although a small number may visit for recreational trips to nearby destinations including for the purpose of sport fishing or hunting when off-duty. After closure, the potential for non-local project employees to visit the area when off duty for the purpose of recreational hunting/fishing would decrease, as fewer people would be getting introduced to the area.

There is the potential for a slight population increase in communities closest to the mine site (see Section 4.3, Needs and Welfare of the People—Socioeconomics), which could increase resource competition among local residents. The magnitude and extent of the effect of an increase in population would be an increase in recreational and sport hunting; however, such activities would be subject to the management of the ADF&G. It is also possible that increased local access and adjustments to hunting areas in response to project facilities and activities could result in an increase in resource competition among local residents. Available areas for subsistence may not be the same habitat or quality as the area's residents could be displaced from, leading to more activity in higher-quality habitat areas. Additionally, if private landowners restrict access, suitable areas of subsistence would be less available, which can increase competition. The largest impacts could occur in Iliamna, which may see a small increase in population related to business development to support the project. The duration of impacts would be long term, lasting for the life of the project.

### 4.9.3.4 Changes in Sociocultural Dimensions of Subsistence

Project construction and operations would result in both beneficial and adverse effects on sociocultural dimensions of subsistence. Subsistence activities are both cash dependent and highly cash-efficient. Cash income is required to pay for equipment, supplies, and operating costs, but modest cash investments can result in successful subsistence harvests and improve well-being. Increased incomes from project employment for local employees would be partially invested in subsistence activities, increasing the efficiency and reliability of subsistence equipment while providing financial resources for a greater level of subsistence activities. Project activities would increase employment opportunities for residents of the analysis area, particularly for those living in communities surrounding Iliamna Lake. The number of local people who would be hired during the construction phase is not known, but PLP intends to prioritize opportunities for area residents or those with close ties to the area (PLP 2018-RFI 027). The magnitude and duration of the effect would be that during operations, an estimated 50 employees would come from communities connected to project sites by road and an additional 200 employees would come from surrounding communities (out of 850 total employees during operations) (PLP 2018-RFI 027). These effects on sociocultural dimensions would be expected to occur if the project is permitted and built.

The effect of income on subsistence success (i.e., subsistence production) is evident among households with unique demographic structures. The magnitude of the effect of income is such that in many communities, 30 percent of households produce 70 percent of the subsistence harvest. These “super households” are distinguished because they include multiple working-age males, tend to have high incomes, and often are involved in commercial fishing. These three factors support high-producing households to be able to combine subsistence activities with paid employment and to arrange considerable labor in flexible ways that maximize harvests of subsistence foods, which are then shared with other households in the community and region. In contrast, the low-producing households usually have lower incomes and are led by a single female or non-Native head of household, are single-person households, or households composed of elders (Wolfe et al. 2010).

At the same time, subsistence activities are labor intensive and require large investments of time and effort in hunting, fishing, and processing subsistence foods. Many subsistence resources are available only at certain times of the year. Harvest effectiveness may decline to the extent that project-related employment reduces the time available for these employees to participate in subsistence activities and to pass on skills and knowledge to the next generation. If high-harvesting members of “super households” find project-related employment and have less time for subsistence activities, the rest of the community and households in other communities could end up receiving less wild food through sharing and trading relationships, which could include vulnerable populations, such as elders. Shift-work schedules, with 2 weeks at the project site and 2 weeks off in the community would likely reduce, but not eliminate, the conflict between project employment and subsistence activities.

Increased employment of adults and changes in work schedules could impact the nature of time spent teaching young people to hunt, fish, gather, process, and preserve subsistence resources. The effect could be a change in the amount and quality of traditional knowledge passed on to younger generations and could potentially result in a long-term or permanent adverse effect to communities. Households and communities would have to adjust to new roles of subsistence labor, changes in sharing networks, and possible changes in harvest levels. Rotational work schedules could affect levels of subsistence in different ways, because some families could adapt positively, while some would find this an adverse effect. Legal hunting seasons are short, and if work schedules conflicted with seasons, then the effect on subsistence harvests could be greater. A high-harvesting hunter’s absence from the community at important times of the season or year could have a greater impact. However, the effects could be reduced, but not eliminated, with planned periods of leave options that allow for continuation of traditional subsistence practices and schedules during subsistence harvest periods.

Out-migration of mine project employees from local communities has been identified as an adverse sociocultural effect on subsistence. At the Red Dog Mine, nearly 50 percent of the workforce from local communities eventually out-migrated to lower cost, to higher amenity communities like Anchorage and Wasilla, because the mine operator provided no-cost transportation to the mine site for workers’ shifts (Tetra Tech 2009). To the extent that high-harvesting households relocated away from the community, the reduction in subsistence foods available in the community would be disproportionately larger. Similarly, the increased availability of jobs for local residents could result in some ex-residents returning to communities. Although a large in-migration or out-migration of population is not anticipated, Alternative 1a may lead to changing population patterns in the region (see Section 4.3, Needs and Welfare of the People—Socioeconomics). The population in some potentially affected communities has been declining due to out-migration. The project could reduce or eliminate the decline because of the increase in employment opportunities and indirect effects improving education and infrastructure. Therefore, the impacts on population and effects to sociocultural changes of subsistence are difficult to anticipate.

Local residents participate in subsistence activities to a high degree. The level of participation may be affected by changes in resource abundance and quality, season and bag limits, changes in physical access, changes in cultural perceptions of resources (e.g., fish and animals are seen as tainted/contaminated, or water as polluted), the physical presence of project facilities in an area that was previously undeveloped and comfort level pursuing subsistence activities in their vicinity, and the time and funds available for subsistence activities. Changes in harvest participation are a leading indicator of cultural changes; continued participation is important to the transfer of knowledge and skills across generations, to the formation of social relationships in and between communities, and to cultural continuity. Salmon provide a large proportion of nutritional food resources for Yup'ik and Dena'ina peoples in the analysis area and represent an essential part of the language, spirituality, and social relations. In particular, subsistence and customary practices are the foundation of culture, maintain the connection of people to their land and environment, and support healthy diet and nutrition (Boraas and Knott 2013; USDA 2004).

Traditional knowledge and skills such as what to harvest, where and when to harvest, how to harvest different resources using specialized tools and techniques, and how to process and preserve wild food efficiently and safely are learned through demonstration and supervision from elders and family members, observation of skilled experts, and a lot of practice. The culture and practice of subsistence is learned by living it. Interruptions and discontinuities that affect implementation and transmission of knowledge may also affect subsistence lifeways in the area. There is no substitute or replacement for this traditional knowledge and how it is passed from generation to generation. Changes ranging from cash-paying employment to resource access and availability can have a compounding effect on the subsistence way of life by decreasing the quality and quantity of time available to engage in subsistence activities and to provide hands-on learning experiences for younger generations. Likewise, adapting to different harvest areas or resources can lead to a loss of knowledge about traditional use and the areas traditionally used for subsistence.

To the extent that project activities would have adverse impacts on resource abundance, availability, quality, and access, corresponding adverse sociocultural impacts on affected communities would occur, related to community health and well-being, spiritual ties to subsistence, experience and enjoyment of subsistence activities, and cultural identity. Under routine operating conditions, the communities affected would likely be limited to those closest to the project's infrastructure and transportation activities: Nondalton, Iliamna, Newhalen, Pedro Bay, Igiugig, and Kokhanok. However, there could still be community concerns regarding the perception of contamination and the safety of subsistence resources in communities downriver from the mine site. Beliefs about subsistence resources being contaminated or unsafe can impact the mental and spiritual health of the community and can interrupt the transmission of traditional knowledge and practices. These impacts would be long term, potentially lasting post-closure, and likely to occur if the project is permitted and constructed.

At closure, both time commitments for and cash income from project employment would cease. Households would have to adjust to reduced cash income to support the maintenance and operating costs of a subsistence lifestyle. Workers who moved out of local communities may choose not to return. The indirect effects of mine employment and income on subsistence practices would decrease. Some long-term impacts may include loss of subsistence knowledge and skills, and a decrease of participation during mine operations continuing after closure.

## 4.9.4 Alternative 1

In general, the type of impacts from changes in resource availability and access to subsistence resources at the mine site would be similar to those under Alternative 1a. Impacts from competition for resources and the changes in the sociocultural dimension of subsistence would be the same as Alternative 1a for all project components. Along the transportation corridor and natural gas pipeline, impacts would be similar to Alternative 1a, except for differences described below.

Changes in resource availability along the transportation corridor and the natural gas pipeline would be of a similar magnitude as Alternative 1a for most subsistence activities but would occur in a different area north of Iliamna Lake. The mine access road and natural gas pipeline would be farther away from the communities of Nondalton, Iliamna, and Newhalen. Along the ferry route there would be a lower magnitude of impact to the availability of and access to freshwater seals than under Alternative 1a because the ferry would pass through fewer seal hunting and haulout areas under Alternative 1. Individual mortality, behavioral disturbance, and displacement of subsistence resources would occur at approximately the same levels as described under Alternative 1a.

### 4.9.4.1 Changes in Access to Resources

Impacts to access to subsistence resources for the six communities closest to the project would be similar to those described for Alternative 1a, as described below.

#### Iliamna

The magnitude and extent of impacts from construction and operations of the mine access road (including a bridge over the Newhalen River) and the north ferry terminal under Alternative 1 would be the disruption of access to a portion of the overall harvest areas near Upper and Lower Talarik creeks, which are medium- to high-use areas for Iliamna subsistence users, particularly for moose and other land mammals. While there are other areas shown as medium- to high-use areas for moose and other land mammals, hunters who traditionally use the Upper and Lower Talarik creek areas would be affected. The south ferry terminal and port access road (including a bridge over the Gibraltar River) would be in lower overlapping use areas that Iliamna residents' access for resources. The duration of impacts would be long term and they would be likely to occur if the project is permitted and built. There would be no impact on access to subsistence resources from Amakdedori Port.

Until Iliamna Lake is connected to Cook Inlet through the transportation corridor at the south ferry terminal, the Williamsport-Pile Bay Road may be used to transport supplies to Iliamna Lake during construction (PLP 2018-RFI 037). If this route were to be used, the volume of traffic on Williamsport-Pile Bay Road would increase during construction, which could affect access to resources.

#### Newhalen

The magnitude and extent of impacts on subsistence use from construction and operations of the mine and port access roads (including a bridge over the Newhalen River) and the north ferry terminal under Alternative 1 may be a disruption of access to a portion of the overall harvest areas near Upper and Lower Talarik creeks, which are medium- to high-use areas for Newhalen subsistence users. Impacts to access would be similar to those described for Iliamna. The south ferry terminal and port access road (including a bridge over the Gibraltar River) would be in an area with lower overlapping uses, which Newhalen residents access for resources. The impacts would be long term and would be likely to occur.

If the Williamsport-Pile Bay Road is used during construction, the volume of traffic on this route would increase, which could affect access to resources.

## Pedro Bay

The magnitude and effects of construction and operations of the mine access road and north ferry terminal under Alternative 1 on subsistence use would be to displace access to a small portion of the overall harvest areas in comparison to the total harvest area available near the Upper and Lower Talarik creeks, which show overlapping uses for Pedro Bay harvesters. The duration of the impact would be long term and it would be expected to occur. There would be no impacts to subsistence access from the port access road, including the crossing at Gibraltar River or Amakdedori Port.

If the Williamsport-Pile Bay Road is used during construction, the volume of traffic on this route would increase, which could affect access to resources in an area accessed by a moderate to high number of residents.

## Nondalton

With respect to the magnitude and extent of the impacts, construction and operations of the mine and port access roads (including bridges over the Newhalen and Gibraltar rivers) and ferry terminals under Alternative 1 would restrict access to the documented subsistence use areas near the Upper and Lower Talarik creeks. Access through the mine site area to subsistence areas to the south would be disrupted. Impacts on access to this area would be similar to those described for Iliamna, and would be long term and certain to occur.

## Igiugig

The magnitude and extent of impacts due to construction and operation of the mine and port access roads (including bridges over the Newhalen and Gibraltar rivers) and the north ferry terminal under Alternative 1 would be the disruption of access to a small portion of the overall harvest areas near Upper and Lower Talarik creeks, although they are low-use areas for Igiugig subsistence users. The impacts would last though the life of the project through closure and would be expected to occur. The south ferry terminal and port access road would be in areas that Igiugig residents have reportedly accessed for resources.

The ferry traffic would be noticeable to those using Iliamna Lake to access areas at the north east end of the lake, in Sid Larson Bay, and areas around the community of Kokhanok. These areas are all used by a low number of subsistence users in Igiugig. The impact would be of higher magnitude in the winter, when the ice-breaking ferry would be operating.

## Kokhanok

The magnitude and extent of impacts from construction and operations of the mine and port access roads (including bridges over the Newhalen and Gibraltar rivers), ferry terminals, and the east Kokhanok ferry terminal on Kokhanok residents would be to interrupt or impede access to portions of the overlapping harvest use areas in the immediate area surrounding the community, and the Gibraltar River and Lake areas. Portions of overlapping use areas near the Upper and Lower Talarik creeks where large land mammals are hunted would also be affected. These impacts would be long term and certain to occur under Alternative 1.

During the winter when the ferry would be breaking ice, ferry traffic would be noticeable to those using Iliamna Lake to access areas at the north east end of the lake, in Sid Larson Bay, and areas around the community of Kokhanok. Traditional access routes used by some Kokhanok residents would be affected.

The magnitude and extent of construction and operations of the Amakdedori port under Alternative 1 would be to interrupt or impede access for residents of Kokhanok to overlapping use areas for taking of marine invertebrates and seals in Kamishak Bay. The impacts would last throughout the life of the project and would occur if the port is permitted and constructed. Construction of the Amakdedori port under Alternative 1 would not be expected to impact access to resources for communities other than Kokhanok because residents of other communities do not harvest resources in that area.

### 4.9.4.2 Alternative 1—Kokhanok East Ferry Terminal Variant

The Kokhanok East Ferry Terminal Variant would result in similar impacts to those described above for changes in resource availability, access to resources, changes in competition for resources, and changes in the sociocultural dimension. However, the east location could cause additional subsistence conflicts compared to the Alternative 1 location.

Under the Kokhanok East Ferry Terminal Variant, snowmachine access to Iliamna Lake would be provided east of the terminal to enable access to the Sid Larson Bay area without crossing the ferry route (PLP 2018-RFI 078). PLP has stated that they would work with local communities to find solutions for ferry transportation use (PLP 2018-RFI 027). The duration of these impacts would be long term and they would be certain to occur if the project is permitted and constructed.

### 4.9.4.3 Alternative 1—Summer-Only Ferry Operations Variant

The Summer-Only Ferry Operations Variant would result in similar impacts to those described above for changes in resource availability, access to resources, changes in competition for resources, and changes in the sociocultural dimension. However, under the Summer-Only Ferry Operations Variant, the magnitude of the impact would be doubling of the volume of haul trucks on the mine and port access roads in the summer, which could result in a greater impact in terms of access to resources and disturbance of wildlife in the use areas near the ferry terminals and access roads. Summer ferry traffic would also double, increasing from one daily round-trip to two; however, boat traffic from subsistence users would be minimally affected by the increase. The impact would last throughout the life of the project and would be expected to occur if the project is permitted and constructed.

The Summer-Only Ferry Operations Variant would not have an impact to winter access, harvest activities, or safety concerns for travel across Iliamna Lake that are associated with the ice-breaking ferry discussed in the Alternative 1 sections above.

### 4.9.4.4 Alternative 1—Pile-Supported Dock Variant

The Pile-Supported Dock Variant would result in similar impacts to those described above for changes in resource availability, access to resources, changes in competition for resources, and changes in the sociocultural dimension.

## 4.9.5 Alternative 2—North Road and Ferry with Downstream Dams

In general, the type of impacts from the changes in resource availability, access to subsistence resources, and competition for resources, would be the similar to Alternative 1a at the mine site. Impacts from the changes in the sociocultural dimension of subsistence would be the same as or similar to Alternative 1a for all project components. Along the transportation corridor and natural gas pipeline, impacts in the availability, access, and competition for resources would be similar to Alternative 1a, with the exception of the differences described below.

Changes in resource availability along the transportation corridor and the natural gas pipeline for Alternative 2 would be similar to Alternative 1a, but would affect a different area for the port access road, ferry, pipeline, and port, and would therefore affect the lake communities to a different degree. Individual mortality, behavior disturbance, and displacement of subsistence resources would occur at approximately the same levels as under Alternative 1a. The primary difference is that there are fewer communities using the area in between Pile Bay and Williamsport for subsistence; therefore, the magnitude of the impact would be less than Alternative 1a and Alternative 1. Based on the areas of overlapping subsistence uses, Nondalton, Newhalen, and Pedro Bay use the mine access road alignment to the Eagle Bay ferry terminal to a lesser degree than Iliamna does (see figures in Section 3.9, Subsistence). Pedro Bay has high use of the area of the Pile Bay terminal and portions of the port access road from Pile Bay to Williamsport. Kokhanok would be affected to a lesser degree. All six analysis area communities use the eastern end of Iliamna Lake for seal hunting to some degree.

Under Alternative 2, there would be an overland natural gas pipeline ROW from Pile Bay to the mine site, including the area between ferry terminals. This could introduce some competition to subsistence users from recreational sport hunting and fishing.

#### 4.9.5.1 Changes in Access to Resources

Impacts to access to subsistence resources for the six communities closest to the project would be similar to those under Alternative 1a, as described below.

**<u>Iliamna</u>**

The mine access road (including a bridge over the Newhalen River) from Eagle Bay would be located in medium- to high-use areas accessed by residents of Iliamna and would be likely to impact access. There are overlapping use areas near the Newhalen River and farther inland, and near the site of the ferry terminal at Eagle Bay. The ferry under Alternative 2 would traverse the eastern portions of Iliamna Lake that are accessed by residents with low to medium overlapping uses. The ice-breaking ferry would disrupt access to these areas, and similar to Alternative 1a, safe winter travel routes would need to be developed with arrangements between PLP and affected communities.

The magnitude of the impact of the addition of a pipeline ROW would be to potentially create an overland route that could be used by Iliamna residents to access additional subsistence resources.

Diamond Point port construction and operations under Alternative 2 could affect Iliamna residents' access to harvests locations in Cook Inlet. However, though long-term, the changes to access would affect areas that are reported as low-use areas for harvested resources near Iliamna Bay and north of Augustine Island.

**<u>Newhalen</u>**

The mine access road of Alternative 2 would be in the vicinity of a medium to high overlapping use area near the Newhalen River and would impact access to resources in the areas inland north of the community. The ferry route would be south of the islands in Iliamna Lake that are accessed by residents, but would not pass close to the islands and would not likely disrupt access in the summer. In the winter, the ice-breaking ferry could disrupt access to all resource use areas on the northeast end of the lake.

The addition of a pipeline ROW would potentially create an overland route that could be used by Newhalen residents to access additional subsistence resources. The duration of the impact would be long term and likely to occur under Alternative 2.

Diamond Point port construction and operations under Alternative 2 would not be expected to affect Newhalen residents' access to harvests locations, as they do not access resources in that location.

## Pedro Bay

The mine and port access roads and use of the Williamsport-Pile Bay Road under Alternative 2 would likely impact access to resource harvest areas for Pedro Bay residents in high overlapping use areas near the community, on Iliamna Lake, inland from Iliamna Lake, and in Pile Bay, and have similar impacts to access as described in Alternative 1a and Alternative 1. Pedro Bay has experience with the adverse and beneficial effects of a road on subsistence access from the existing Williamsport-Pile Bay Road, but the magnitude would be greater with more traffic on the road. The ferry route would be south of the islands in Iliamna Lake that are used by residents of Pedro Bay; therefore, access to those islands and their resources would not be likely to be affected. As described for Iliamna, winter ferry operations would impact traditional access and create travel safety concerns that would need to be mitigated in consultation with PLP.

The addition of a pipeline ROW would potentially create an overland route that could be used by Pedro Bay residents to access additional subsistence resources, particularly during the winter when there is snow cover. The impact would be long term and likely to occur.

The magnitude of effects on access to resources from Diamond Point port construction and operations under Alternative 2 would be to interrupt or impede access to subsistence activities and fishing and marine invertebrate harvesting for Pedro Bay residents in Iliamna Bay and near Augustine Island as the port would be located in the vicinity of these use areas. There is existing vessel traffic to Williamsport during the summer months, and some vessel traffic associated with the quarry at Diamond Point, but the magnitude of impact would increase with project vessel traffic. The impacts would last for the life of the project and would be likely to occur.

This community has a smaller population than the other lake communities and residents do not harvest subsistence resources as far away from their community as residents of the other lake communities do; therefore, disruption form the project could have a greater intensity of impact to this community.

## Nondalton

The mine and port access roads of Alternative 2 (including a bridge over the Newhalen River) are likely to impact access to resource harvest areas for Nondalton residents as they would be located in the vicinity of medium overlapping use areas. Access through the mine site area to subsistence areas to the south would be disrupted. Impacts would be similar to those described for Iliamna. The ferry route would be south of the islands in Iliamna Lake that are used by residents of Nondalton; therefore, access to those islands and their resources would not likely be affected. However, winter subsistence harvest of seals would be affected by ferry operations, similar to impacts discussed for Iliamna.

The addition of a pipeline ROW would potentially create an overland route that could be used by Nondalton residents to access additional subsistence resources. The duration of this impact would be long term and would be likely to occur under Alternative 2.

Diamond Point port construction and operations under Alternative 2 would not be expected to affect Nondalton residents' access to harvests locations as they do not access resources in that location.

**Igiugig**

The transportation corridor, ferry, and Diamond Point port under Alternative 2 are not anticipated to impact access to resource harvest areas for Igiugig residents as fewer subsistence users search for and harvest resources in these areas.

**Kokhanok**

The mine and port access roads of Alternative 2 are less likely to impact access to resource harvest areas for Kokhanok residents as fewer subsistence users search and harvest in areas inland from the north side of Iliamna Lake and closer to the mine site.

The ferry route would be south of islands in Iliamna Lake accessed by residents for seal hunting, but would not pass close to the islands and would not likely disrupt access in the summer. In the winter, the ice-breaking ferry could disrupt access to seal hunting, which is the preferred time of year that this activity occurs.

Diamond Point port construction and operations under Alternative 2 would not be expected to affect Kokhanok residents' access to harvest locations as they do not typically access resources in that location.

### 4.9.5.2 Alternative 2—Summer-Only Ferry Operations Variant

The Summer-Only Ferry Operations Variant would result in similar impacts to those described above for changes in resource availability, access to resources, changes in competition for resources, and changes in the sociocultural dimension. However, under the Summer-Only Ferry Operations Variant, the volume of haul trucks on the mine and port access roads would double in the summer. This could result in a greater magnitude impact in terms of access to resources and disturbance of wildlife in the use areas near the ferry terminals and access roads. Summer ferry traffic would also double, increasing from one daily round-trip to two; however, boat traffic by subsistence users would only be minimally affected by the increase. The duration of the impact would be long term and the impact would occur under this variant.

The Summer-Only Ferry Operations Variant would not impact winter access, harvest activities, or safety concerns for travel across Iliamna Lake associated with the ice-breaking ferry discussed under Alternative 2 sections above.

There would be less impact to freshwater seal hunting with summer-only ferry operations as the seals, which like to haulout at open leads in the lake ice, would not be disrupted by the ice-breaking ferry; summer is not the preferred time for hunting freshwater seals (see Section 4.23, Wildlife Values).

### 4.9.5.3 Alternative 2—Pile-Supported Dock Variant

The Pile-Supported Dock Variant would result in similar impacts to those described above for changes in resource availability, access to resources, changes in competition for resources, and changes in the sociocultural dimension.

### 4.9.5.4 Alternative 2—Newhalen River North Crossing Variant

The Newhalen River North Crossing Variant would result in similar impacts to those described above for changes in resource availability, access to resources, changes in competition for resources, and changes in the sociocultural dimension.

### 4.9.6 Alternative 3—North Road Only

In general, the type of impacts from the changes in resource availability, access to subsistence resources, and competition for resources at the mine site would be similar to Alternative 1a. Impacts from changes in the sociocultural dimension of subsistence would be the same as Alternative 1a for all project components. Along the transportation corridor and natural gas pipeline, impacts would be the same as Alternative 2, except that there would be no ferry operations and access would be provided entirely by road.

Changes in resource availability along the transportation corridor and the natural gas pipeline alignment for Alternative 3 would be similar to Alternative 2. Individual mortality and behavioral disturbance to, and displacement of, subsistence resources would occur at approximately the same levels on land but would avoid impacts to seals in Iliamna Lake. As with Alternative 2, there are slightly fewer communities using the area between Pile Bay and Williamsport for subsistence (Iliamna, Newhalen, Nondalton, and Pedro Bay). However, there are a high number of overlapping use areas along the road corridor of Alternative 3 from Pedro Bay to the mine site for Iliamna and Pedro Bay.

Under Alternative 3, there would be a road from Pile Bay to the mine site, alongside the natural gas pipeline. The magnitude of the effect of this road would be to increase the level of activity along that route compared to Alternative 2. This north access road would be under controlled access, limiting potential competition to subsistence uses of resources from non-local recreational sport hunting and fishing. However, it could facilitate access to subsistence resources for area residents and lead to increased competition along the transportation corridor. The duration of the impact would be long term and would occur under Alternative 3.

Access to subsistence resource use areas would be the similar to Alternative 2 for residents of Iliamna, Newhalen, Pedro Bay, Nondalton, Igiugig, and Kokhanok. The primary difference is the road from Pile Bay to the mine site, which would increase the ease of access to the lands and subsistence resources along the transportation and pipeline ROW corridor. There would be no ferry operations, and therefore no impacts to seal hunting or access on Iliamna Lake, and no disruptions to wintertime travel on the lake caused by the ice-breaking ferries.

#### 4.9.6.1 Alternative 3—Concentrate Pipeline Variant

A concentrate pipeline would be built from the mine site to Diamond Point alongside the natural gas pipeline; additional disturbance to the gas pipeline and road construction corridor would not be expected. Water treatment for dewatering the concentrate would occur at Diamond Point, and would be discharged to marine waters in compliance with state water quality standards. There would be little to no additional effect on subsistence resources or access as compared to Alternative 1a.

### 4.9.7 Cumulative Effects

Potential cumulative impacts to subsistence include changes in resource availability, access to resources, competition for resources, and effects on social and cultural values. The cumulative effects analysis area for subsistence is the same as the EIS analysis area for subsistence, which includes habitat and migration routes for subsistence resources, community subsistence search and harvest areas, and areas used by harvesters to access resources (see Section 3.9, Subsistence).

Only a few of the actions identified in Section 4.1, Introduction to Environmental Consequences, are considered to not have potential to contribute to cumulative effects on subsistence resources in the analysis area. These include offshore-based developments, activities that may occur in the analysis area but are unlikely to result in any appreciable impact on subsistence resources (such as industrial clean-up), or development actions that are not anticipated to occur during the operations timeframe of the project.

### 4.9.7.1 Past and Present Actions

Past and present actions have caused noticeable effects to subsistence resources, access, competition and social and cultural values. Such activities include subsistence activities, sport fishing and hunting, mining exploration, and non-mining related projects, such as transportation, oil and gas development, or community development actions. As described in Section 3.9, Subsistence, the subsistence harvest of sockeye salmon in the Kvichak River drainage has decreased over the past 20 years. Several communities observed that habitat change in southwest Alaska is affecting the Mulchatna caribou herd, causing the herd to move farther away from communities in the EIS analysis area, which impacts subsistence harvest. Habitat changes include warming temperatures and increased shrub habitat, which is preferred by moose. Consequently, these habitat changes have benefitted moose, resulting in increased moose harvest by local residents in the EIS analysis area over the last 10 years. Additionally, Nondalton local residents have noted declines in caribou numbers due to disturbance from helicopters, and declines in caribou and moose numbers due to overharvest by sport hunting. Residents of Pedro Bay also observed a decline in Dolly Varden in the Iliamna River due to overharvest by sport fishing and habitat disturbance from motorized boats. Subsistence harvest of Cook Inlet beluga whales prior to 2000 led to population decline and severe limitation on the subsequent subsistence harvest. Mining and oil/gas exploration have caused some site-specific disturbance to subsistence resources, area-specific limitations to subsistence access, and sociocultural dimension of subsistence, but such effects have been seasonal and short term in nature, with no population-level effects on subsistence resource populations in the analysis area. The same is generally true of community and transportation infrastructure. Construction and operation of the Williamsport-Pile Bay Road disturbed subsistence activities and resources in the vicinity of the road during summer months, and has potentially created some non-resident competition for fish and wildlife resources, particularly in the vicinity of Pedro Bay.

### 4.9.7.2 Reasonably Foreseeable Future Actions

Past, present, and reasonably foreseeable future actions (RFFAs) as described in Section 4.1, Introduction to Environmental Consequences, have the potential to contribute cumulatively to effects on subsistence resources and uses. RFFAs apply to the consideration of cumulative effects on subsistence resources and uses. Each of these RFFAs contribute to the increased potential for impacts on subsistence resources, as each has aspects and associated activities that could lead to the disturbance and displacement of subsistence resources at these locations.

The No Action Alternative would not contribute to cumulative effects associated with changes to resource availability, access to resources, or competition for resources. If there were fewer local employment opportunities associated with future exploration of the Pebble deposit, there could be less income that could contribute to support subsistence activities; however, that could be offset by exploration of other nearby mineral deposits.

The project alternatives with the RFFAs' contribution to cumulative effects on subsistence resources are summarized collectively in Table 4.9-2.

**Table 4.9-2 Contribution to Cumulative Effects on Subsistence**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Pebble Project Expansion Scenario | **Mine Site:** The mine site footprint would have a larger open pit and new facilities to manage water and store tailings and waste rock. The Pebble Project expansion scenario at the mine site would affect more fish habitat in the upper reaches of the North Fork and South Fork of the Koktuli River, as well as Upper Talarik Creek. It would also generate more noise over a slightly larger area for a longer period of time, potentially affecting caribou that might transit the area, and affect subsistence access and user experience, although the mine site area is not heavily used for subsistence. A longer mine life would extend the potential for contamination and perception of contamination through the longer operating period.<br>**Other Facilities:** A north access road, concentrate pipeline, and diesel pipeline would be constructed along the Alternative 3 road alignment, and extended to a new deepwater port site at Iniskin Bay. This would increase both the area of disturbance and availability of local access. The concentrate pipeline would reduce truck traffic to 21 daily round trips (eliminating shipment of copper/gold concentrate by truck), reducing subsistence impacts associated with those project components. Impacts to Pedro Bay would be introduced, although all six lake communities would be affected to some degree over the expanded operating life.<br>**Magnitude:** The Pebble Project expansion scenario project footprint would impact approximately 31,892 acres. Although truck traffic associated with concentrate shipment on the south access road would be eliminated, there would still be some level of truck traffic on both the north and south access roads. Impacts to | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** Similar to Alternative 1a, except that the portion of the access road from the north ferry terminal to the existing Iliamna area road system would not already be constructed. The north access road would be extended east from the Eagle Bay Ferry Terminal to Iniskin Bay. Concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay.<br>**Magnitude:** The magnitude of cumulative impacts to subsistence would be similar as under Alternative 1a, although more intense because of the larger amount of acreage.<br>**Duration/Extent:** The duration/extent of cumulative impacts to subsistence would be similar to those under Alternative 1a, although affecting a larger amount of acreage.<br>**Contribution:** The contribution to cumulative | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** The north access road would be extended east from the Eagle Bay Ferry Terminal to Iniskin Bay. Concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay.<br>**Magnitude:** The Pebble Project expansion scenario and associated contributions to cumulative impacts would be similar to but less than Alternative 1a, because the Amakdedori port and connecting transportation infrastructure would not be built. Under Alternative 2, project expansion would continue to use the existing Diamond Point port facility, would use the same natural gas pipeline, and would use the constructed portion of the access roads. After 20 years, ferry operations would be discontinued; road connections between ferry terminals would be constructed in a manner similar to that described for Alternative 3; and the port | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** Overall expansion would use the existing north access road; concentrate and diesel pipelines would be constructed along the existing road alignment and extended to a new deepwater port site at Iniskin Bay.<br>**Magnitude:** Under Alternative 3, project expansion would continue to use the existing Diamond Point port facility, would use the same natural gas pipeline, and would use the same north access road and Concentrate Pipeline Variant but extend the concentrate pipeline and a service road to Iniskin Bay. The port site and associated facilities would be constructed at Iniskin Bay, as discussed under Alternative 1a. A diesel pipeline from the mine site to Iniskin Bay would be constructed as described under cumulative effects for Alternative 1a.<br>**Duration/Extent:** The duration/extent of cumulative impacts to subsistence would be similar to those |

**Table 4.9-2 Contribution to Cumulative Effects on Subsistence**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | subsistence resources and negative changes in access would potentially increase costs associated with subsistence and reduce cultural opportunities for teaching and sharing of resources. In addition, concerns regarding contamination and safety of consuming subsistence foods would likely continue through the period of expansion and extended operations.<br>**Duration/Extent:** The Pebble Project expansion would contribute to cumulative effects with additional infrastructure (mine site, two access roads, and two ports), habitat loss, subsistence resource disturbance, and positive/negative changes in subsistence access over a longer period of time, up to an additional 58 years depending on the period of post-mining milling and closure.<br>**Contribution:** Additional habitat loss associated with the mine site would affect fish and wildlife that use that habitat (see Section 4.23, Wildlife Values; and Section 4.24, Fish Values). With regard to fish, the Alaska Department of Fish and Game manages escapement and harvest levels with subsistence harvest as the priority over other uses of fish. Mine expansion would not be expected to affect the availability of fish for subsistence purposes, Construction of other facilities can affect the quality and cultural experience of subsistence activities, leading to adverse impacts on subsistence resources that are central to cultural belief systems and the way of life of local people. Effects such as habitat fragmentation, noise, and potential for increased access for recreational hunting and fishing disrupt subsistence cycles, which may result in direct impacts on resource gathering areas and | effects would be slightly more than under the other alternatives. | site and associated facilities would be constructed at Iniskin Bay, as discussed under Alternative 1a. A concentrate pipeline and diesel pipeline would be constructed between the mine site and Iniskin Bay, as discussed under cumulative effects for Alternative 1a.<br>**Duration/Extent:** The duration/extent of cumulative impacts to subsistence would be similar to those under Alternative 1a, although affecting a smaller amount of acreage with a single port/road transportation corridor.<br>**Contribution:** Cumulative impacts from Alternative 2 combined with the Pebble Project expansion scenario to resource availability, access to resources, and competition for resources would be of lesser magnitude and extent than under Alternative 1a because the south transportation system/ferry would not be in place. As a result, potential cumulative subsistence impacts to Kokhanok would also be less under this alternative. | under the other alternatives, although affecting a smaller number of acres.<br>**Contribution:** The Pebble Project expansion site development and associated contributions to cumulative impacts would be similar to the those under other alternatives. Because the Pebble Project expansion scenario would use the north access road system that would already be built under Alternative 3 and would not include any ferry operations, cumulative impacts from Alternative 3 combined with the Pebble Project expansion scenario to resource availability and access to resources would be less than those under the other alternatives. Potentially affected communities would be similar to those under Alternative 2. |

**Table 4.9-2 Contribution to Cumulative Effects on Subsistence**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | harvest quantities. Local residents have observed that there has already been a loss to subsistence opportunities and the way of life due to planning and exploration activities that are associated with the Pebble Project expansion from helicopter traffic, and that there have been disruptions to local wildlife. Concerns regarding contamination and food safety would be extended with the Pebble Project expansion. The cumulative impacts would be long-term over extended operations and decrease in magnitude as closure is implemented. See Section 4.23, Wildlife Values; and Section 4.24, Fish Values, for discussion on cumulative effects to fish and wildlife. | | | |
| Other Mineral Exploration Projects | **Magnitude:** Mining exploration activities would include additional borehole drilling, road and pad construction, and development of temporary camp facilities. Actions that expand mineral exploration near the Pebble deposit and around Iliamna Lake contribute to landscape-level effects, where there is recurring introduction of additional impediments to the movement of people and animals on a seasonal and site-specific basis; increased noise, vibration, and emissions; and increased numbers of people to the area. This would lead to effects to resource availability, access to resources, competition for resources, and sociocultural conditions similar to those described above for the Pebble Project expansion scenario.<br>**Duration/Extent:** Exploration activities typically occur at a discrete location for one season, although a multi-year program could expand the geographic area affected in a specific mineral prospect. Section 4.1, Introduction to Environmental Impacts, identifies seven mineral | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |

**Table 4.9-2 Contribution to Cumulative Effects on Subsistence**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | prospects in the EIS analysis area where exploratory drilling is anticipated (four in relatively close proximity to the project).<br>**Contribution:** Actions that expand mineral exploration near the Pebble deposit and around Iliamna Lake contribute to landscape-level effects, where there is recurring introduction of additional impediments to the movement of people and animals; increased noise, vibration, and emissions; and increased numbers of people to the area. This would lead to effects to resource availability, access to resources, competition for resources, and sociocultural conditions similar to those described above for the Pebble Project expansion scenario. | | | |
| Oil and Gas Exploration and Development | **Magnitude:** Onshore oil and gas exploration activities could involve seismic and other forms of geophysical exploration, and in limited cases exploratory drilling. This has historically occurred south of King Salmon and would not likely have additive or synergistic effects with the project on subsistence. An increase in resource exploration development actions in Cook Inlet could impact the subsistence activities/experience of those communities that use the Amakdedori area.<br>**Duration/Extent:** Seismic exploration and exploratory drilling are typically single-season, temporary activities that may occur over sequential years in specific lease areas.<br>**Contribution:** The cumulative impacts on subsistence from oil and gas exploration activities would be long term and geographically broad in scope (e.g., regional level), but would primarily affect subsistence user experience on the western side of Cook Inlet. | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |

**Table 4.9-2 Contribution to Cumulative Effects on Subsistence**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Road Improvement and Community Development Projects | **Magnitude:** Road improvement projects would take place in the vicinity of communities and have impacts through grading, filling, and potential increased erosion. Communities in the immediate vicinity of project facilities, such as Iliamna, Newhalen, and Kokhanok would have the greatest contribution to cumulative effects. Some limited road upgrades could also occur in the vicinity of the natural gas pipeline starting point near Stariski Creek, or in support of mineral exploration previously discussed.<br>These transportation projects would increase access to the area, which could improve access to subsistence resources, but could also increase traffic in areas previously used for subsistence activities, with potential effects on subsistence resources, competition for resources, and user experience.<br>**Duration/Extent:** Disturbance from road construction would typically occur over a single construction season. The geographic extent would be limited to the vicinity of communities and Diamond Point. Potential effects with increased traffic would be long term.<br>**Contribution:** Road construction would increase access to the area, which could improve access to subsistence resources but also introduce additional disturbance to and competition for resources, affecting all communities in the cumulative effects analysis area. | Similar to Alternative 1a and Alternative 2; greater than Alternative 3. | The footprint of the Diamond Point rock quarry in Alternative 1a coincides with the Diamond Point port footprint in Alternative 2 and Alternative 3. Cumulative impacts would likely be less under Alternative 2 due to project footprints commonly shared with the quarry site. | Similar to Alternative 2; less than Alternative 1a and Alternative 1. |
| Additional RFFAs | Additional RFFAs that have the potential to affect subsistence in the cumulative effects area include energy and utility projects, the Diamond Point rock quarry, and various village infrastructure development projects. These projects would have similar effects to the Pebble | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |

**Table 4.9-2 Contribution to Cumulative Effects on Subsistence**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | Project but would be of lesser magnitude and geographic extent; however, when considered in combination with the Pebble Project, impacts to resource availability, access to resources, and competition for resources would increase. | | | |
| Summary of Project contribution to Cumulative Effects | Overall, the contribution of Alternative 1a to cumulative effects to subsistence, when taking other past, present, and reasonably foreseeable future actions into account, would be from impacts on access to, competition for, and availability of subsistence resources. | Similar to Alternative 1a, although slightly more acreage would be affected by expansion of the Pebble mine. | Similar to Alternative 1a, although slightly fewer acres would be affected by expansion of the Pebble mine. | Similar to Alternative 1a, although fewer acres would be affected by expansion of the Pebble Project than any of the other alternatives. |

Note:
EIS = Environmental Impact Statement
RFFA = reasonably foreseeable future action

## 4.10 HEALTH AND SAFETY

The evaluation of impacts on human health and safety is a component of the National Environmental Policy Act (NEPA) as it pertains to negative and beneficial consequences of a project on potentially affected communities. There are federal and state laws and regulations, such as the Clean Air Act, Clean Water Act, and various Alaska statutes that have been enacted to ensure protection of human health. Compliance with these laws and regulations is taken into consideration in the evaluation of health and safety impacts in an integrated manner; and in a more singular, medium-specific manner in individual sections such as Section 4.20, Air Quality; and Section 4.18, Water and Sediment Quality.

The health and safety evaluation identifies and ranks the project-related positive (beneficial) and negative (adverse) health and safety consequences for the project and alternatives. Health and safety are related and complementary concepts. In the context of evaluating the impacts of a project, “health” is broadly considered to represent a state of physical and mental well-being of communities; while “safety” is more narrowly interpreted as engineering design, operation, and handling of project infrastructure, equipment, and materials in a manner that seeks to reduce hazards and prevent the occurrence of incidents and accidents (IFC 2007). It is also important to note that regulatory programs, agencies, and compliance procedures may be overlapping or very different for the health versus the safety aspects of a project. For example, the Occupational Safety and Health Administration (OSHA) regulations cover health and safety only for workers employed by the project that would have received required and applicable health and safety training by a competent and qualified person. OSHA would not cover untrained workers outside and not employed by the project or the general public.

Scoping comments expressed that the Environmental Impact Statement (EIS) consider or include a Health Risk Assessment or Health Impact Assessment (HIA) to determine the direct, indirect, and cumulative impacts to health; public health concerns related to infrastructure development in rural communities; cancer and non-cancer health effects associated with air toxins and identification of sensitive receptor populations that may be exposed to these emissions; increased risks of accidents and injuries; exposure to hazardous materials; impacts on food nutrition and subsistence (real or perceived); increased potential for infectious diseases, risks to health and human services from population-stressed infrastructure and services; and social and psychological impacts.

This section presents the health and safety evaluation completed for the project for potentially affected communities “outside the fence,” a discussion on safety for project workers “inside the fence,” and cumulative effects. The detailed health and safety evaluation for potentially affected communities is provided in Appendix K4.10. In this section and Appendix K4.10, health is described in a manner that is consistent with the State of Alaska’s guidelines for Health Impact Assessment (ADHSS 2015); safety is discussed in the context of relevant regulatory requirements under OSHA, the Mine Safety and Health Act (MSHA), and other types of hazard assessment and prevention.

### 4.10.1 Summary of Key Issues

Table 4.10-1 presents a summary of key issues, which includes Health Effect Categories (HECs) that received a ranking of Category 2 or greater.

**Table 4.10-1: Summary of Key Issues for Health and Safety**

<table>
<tr><th>Impact-Causing Project Component</th><th>Alternative 1a</th><th>Alternative 1 and Variants</th><th>Alternative 2 and Variants</th><th>Alternative 3 and Variant</th></tr>
<tr><td rowspan="3">All Project Components</td><td>Increase in household incomes, employment, and education attainment (+ Category 3 during construction and operations).<br>Decrease in food cost relative to income (+ Category 2).</td><td>Same as Alternative 1a.<br>The Summer-Only Ferry Operations Variant would lower the cost of living and increase employment opportunities, but not by as much as Alternative 1a and Alternative 1 because of seasonal versus year-round employment.</td><td>Same as Alternative 1a.<br>The Summer-Only Ferry Operations Variant under Alternative 2 would be the same as Alternative 1 Summer-Only Ferry Operations Variant, although impacts would shift more towards Pedro Bay instead of Kokhanok.</td><td>Same as Alternative 1a.<br>The Concentrate Pipeline Variant would have overall decreased employment.</td></tr>
<tr><td colspan="4">Increase and decrease in psychosocial stress (± Category 3 during construction and operations; ± Category 2 during closure).<br>Increase and decrease in family stress and stability (± Category 2 during operations and closure).<br>Increase and decrease in unintentional injury (e.g., falls, cuts, poisoning) (± Category 2).<br>Increase and decrease in access to, quantity of, and quality of subsistence resources (± Category 2 to 3 depending on component and phase).<br>Decrease or increase in food security (± Category 2).<br>Increase or decrease in cancer, respiratory, and cardio-vascular morbidity and mortality rates due to change in diet, nutrition, and physical activity (± Category 2).</td></tr>
<tr><td colspan="4">Decrease in household incomes, employment, and education attainment (- Category 2 during closure).<br>Increase in intentional injury (suicide) (- Category 2).<br>Increased risk of exposure to hazardous chemicals in abiotic media and to bioaccumulated chemicals in subsistence foods (- Category 2 during operations and closure, and during construction for mine site).<br>Decreased access to healthcare and safety services due to emergency situations and overwhelming local and regional healthcare capacities (- Category 2).</td></tr>
<tr><td>Transportation Corridor</td><td>Increase in unintentional accidents and injuries morbidity and mortality rates due to air, surface, and water transportation, particularly regarding winter access across Iliamna Lake from the ice-breaking ferry. Pebble Limited Partnership would put some measures in place to minimize impacts, such as trail marking and crossings.</td><td>Impacts would be similar to Alternative 1a for the port and port access road.<br>The Kokhanok East Ferry Terminal Variant would include access to Sid Larson Bay without crossing the ferry route.<br>The Summer-Only Ferry Operations Variant would eliminate the potential hazards to snowmachine winter lake crossings, but increase summer lake and road traffic (- Category 2).</td><td>Impacts would be similar to Alternative 1a, except that the routes and closest communities affected would be around Pedro Bay instead of Kokhanok.<br>The Summer-Only Ferry Operations Variant could increase the likelihood of surface transportation accidents and injuries along Williamsport-Pile Bay Road from an increase in truck traffic if mitigation measures are not taken to meet the increased mine-related and public summer capacity (- Category 2).</td><td>Impacts would be similar to the other alternatives, except that the elimination of the ferry on Iliamna Lake would shift project-related transportation impacts to the area around Pedro Bay, rather than around Kokhanok. Impacts from the port at Diamond Point would be the same or similar to those as Amakdedori port.<br>The Concentrate Pipeline Variant impacts would remain the same as under Alternative 1a because the effluent would be treated to meet Alaska water quality criteria prior to discharge (- Category 2).</td></tr>
<tr><td>Transportation Corridor and Natural Gas Pipeline</td><td colspan="4">Increase in sexually transmitted infection rates (- Category 2 during construction) and in infectious (respiratory) disease morbidity and mortality rates (- Category 2 during construction).</td></tr>
</table>

## 4.10.2 Health Impacts Methodology

The Alaska Department of Health and Social Services (ADHSS) defines health as "the reduction in mortality, morbidity and disability due to detectable disease or disorder and an increase in the perceived level of health" (ADHSS 2015). Because health is a multi-dimensional concept with physical, mental, and social aspects, the project may affect aspects of health at a localized or individual level, a community level, a regional level, or a statewide level, depending on the nature and extent of the effect. Potential impacts include:

- Potential for increases and/or decreases in household incomes, employment rates, education attainment, stress and family stability, food costs, food security, and access and quantity of subsistence resources
- Potential for increases and/or decreases of unintentional accidents and injuries, intentional injury (suicide rate), infectious diseases, and non-communicable and chronic diseases, as well as access to healthcare
- Potential for increases and/or decreases in illnesses or exacerbation of illnesses due to potential direct or indirect exposure to hazardous materials associated with the project

Human health impacts were evaluated in accordance with NEPA practice, and generally followed the ADHSS methodology. The terminology used for descriptions and rankings of health impacts in this section and Appendix K4.10 generally correspond to the terms and ratings used in the ADHSS HIA guidance. This guidance uses the concept of HECs. An HEC groups similar health effects so that they can be discussed and evaluated more easily and efficiently. A health effect can be a health outcome (e.g., a documented health event, such as a clinic visit, the birth of an infant, incidence of a disease) or a health determinant (a social, environmental, or economic reality that influences health outcomes, such as education level, income, or access to healthcare). By assessing both determinants and outcomes, an evaluation of health status, health needs, health impacts, and mitigation/monitoring recommendations (if warranted) can be developed that are based on a good understanding of the project and its connections with the affected communities.

A characteristic of this guidance is that the individual dimensions of health impacts (i.e., nature of health effect, duration, magnitude, extent, and likelihood) are each given their own descriptive terms for the estimated relative degree of occurrence and a final consolidated health impact rating for each health metric or HEC that is numerical (Category 1 through 4). The guidance suggests that impact ratings of 2 or higher may markedly increase or decrease illness and injury rates, and may warrant interventions, if negative (ADHSS 2015).

In accordance with NEPA practice and ADHSS (2015), the scope of the health and safety evaluation is limited to potentially affected communities "outside of the fence," (outside the mine site and other mine-related components, including material sites). Accordingly, the health and safety evaluation does not include a direct analysis of the anticipated workforce safety and health issues ("inside the fence"), because the project would be governed by the OSHA and MSHA regulations in the areas where project activities would occur. However, this evaluation does consider "crossover issues," such as health impacts where workers may be housed in work camps, or where workforce behaviors result in interactions/overlap with the affected communities. Additionally, the US Army Corps of Engineers cannot commit that the Pebble Limited Partnership (PLP) would comply with MSHA, OSHA, and other regulations.

The analysis of potential consequences to human health for the affected communities using ADHSS (2015) criteria is consistent with the principles of analysis in accordance with NEPA and uses four steps. The first step is to determine the impact score, which takes into consideration four impact dimensions: severity of potential health effects (which can be positive or negative and considers the need for intervention if the impact is negative), duration, magnitude, and extent of the impact (Table 4.10-2). Each component of the impact dimension is assigned a score of 0, 1, 2, or 3 to derive the overall impact rating score.

**Table 4.10-2: Step 1—Impact Dimensions**

| Step 1 | | | | |
|---|---|---|---|---|
| **Impact Rating Score** | **A—Health Effect (±)** | **B—Duration** | **C—Magnitude** | **D—Extent** |
| 0 | Effect is not perceptible | Less than 1 month | Minor | Individual cases |
| 1 | (±) minor benefits or risks to injury or illness patterns (no intervention needed) | Short-term: 1 to 12 months | Those impacted would:<br>1) be able to adapt to the impact with ease and maintain pre-impact level of health; or<br>2) see noticeable but limited and localized improvements to health conditions. | Local: small, limited impact to households |
| 2 | (±) moderate benefits or risks to illness or injury patterns (intervention needed, if negative) | Medium-term: 1 to 6 years | Those impacted would:<br>1) be able to adapt to the health impact with some difficulty, and would maintain pre-impact level of health with support; or<br>2) experience beneficial impacts to health for specific populations; some maintenance may still be required. | Entire Potentially Affected Communities; village level |
| 3 | (±) severe benefits or risks: marked change in mortality and morbidity patterns (intervention needed, if negative) | Long-term: more than 6 years/life of project and beyond | Those impacted would:<br>1) not be able to adapt to the health impact or to maintain pre-impact level of health; or<br>2) see noticeable major improvements in health and overall quality of life. | Extends beyond Potentially Affected Communities; regional and statewide levels |

Source: ADHSS 2015

Next, the severity and likelihood of each type of impact is evaluated, and those ratings are used to develop an overall significance impact rating category of 1, 2, 3, or 4 (Table 4.10-3). Recommended actions for negative impacts are listed by category below:

- Category 1: Actions to reduce negative impacts are not needed.
- Category 2: Recommend that decision-makers assess whether actions to reduce negative impacts would be helpful for negative impacts.
- Category 3: Recommend that decision-makers develop and implement actions to reduce negative impacts.
- Category 4: Strongly recommend that decision-makers develop and implement actions to reduce negative impacts.

**Table 4.10-3: Steps 2, 3, and 4—Likelihood and Overall Impact Ratings**

| **Step 2** | **Step 3** | | | | | | |
|---|---|---|---|---|---|---|---|
| **Impact Severity Level (Sum Scores from Step 1 to choose range)** | **Likelihood Rating** | | | | | | |
| | **Extremely Unlikely (<1%)** | **Very Unlikely (1-10%)** | **Unlikely (10-33%)** | **About as likely as Not (33-66%)** | **Likely (66-90%)** | **Very Likely (90-99%)** | **Virtually Certain (>99%)** |
| 1 to 3 | ♦ | ♦ | ♦ | ♦ | ♦♦ | ♦♦ | ♦♦ |
| 4 to 6 | ♦ | ♦ | ♦ | ♦♦ | ♦♦ | ♦♦ | ♦♦♦ |
| 7 to 9 | ♦♦ | ♦♦ | ♦♦ | ♦♦♦ | ♦♦♦ | ♦♦♦ | ♦♦♦♦ |
| 10 to 12 | ♦♦♦ | ♦♦♦ | ♦♦♦ | ♦♦♦♦ | ♦♦♦♦ | ♦♦♦♦ | ♦♦♦♦ |
| **Step 4** | **Impact Rating** | | | | | | |
| | Category 1 = ♦ | | Category 2 = ♦♦ | | Category 3 = ♦♦♦ | | Category 4 = ♦♦♦♦ |

Source: ADHSS 2015

For each alternative, the consequences of the project activities, both beneficial and adverse, are described with regard to relevant issues and concerns associated with the eight HECs described in the HIA guidance (ADHSS 2015) and Section 3.10, Health and Safety:

- **HEC 1: Social Determinants of Health**, evaluated potential impacts to household incomes, employment and education attainment, as well as potential impacts to psychosocial stress of individuals, and to family stress and stability.
- **HEC 2: Accidents and Unintentional Injuries**, covered potential impacts to rates of accidents and unintentional injuries (e.g., transportation accidents, falls, fires, drownings, food poisoning).
- **HEC 3: Exposure to Potentially Hazardous Materials**, evaluated the potential for increases and decreases in illness, or exacerbation of illnesses commonly associated with exposure to site-related chemicals of potential concern through inhalation, physical (dermal) contact, and direct or indirect ingestion (e.g., incidental soil ingestion or ingestion of impacted subsistence foods).
- **HEC 4: Food, Nutrition, and Subsistence Activity**, evaluated the potential impacts on food costs, food security, and impacts to access to and quantity of subsistence resources (real or perceived).
- **HEC 5: Infectious Diseases**, covered the potential impacts on rates of infectious diseases, including sexually transmitted infections, to the affected communities, as well as workers living at the on-site camp.
- **HEC 6: Water and Sanitation**, evaluated the potential impacts of increases in morbidity and mortality rates due to the availability and quality of water and sanitation services.
- **HEC 7: Non-Communicable and Chronic Diseases**, covered the potential impacts of increases in non-communicable and chronic morbidity, as well as mortality rates (e.g., cancer, cardiovascular, and respiratory).
- **HEC 8: Health Services and Infrastructure and Capacity**, evaluated the potential impacts on access to routine healthcare, as well as potential impacts to healthcare from large-scale emergency situations and overwhelming local and regional healthcare capacities.

The health and safety evaluation performed for the project falls between a “desktop” HIA (qualitative and brief assessment) and a “rapid appraisal” HIA (more in-depth than desktop) as defined in the HIA guidance (ADHSS 2015), using available or accessible health information, limited stakeholder engagement, and key informant information, but without conducting new field surveys. Although all project components (mine, transportation corridor, port, and natural gas pipeline) were considered, the project was primarily analyzed as a whole because effects could not be attributed to a single component (there was overlap of affected communities for multiple components). Finally, the health consequences are summarized by HEC for each alternative as a whole, and expressed as Category 1, 2, 3, or 4. ADHSS does not provide narrative descriptions for these numeric impact category rankings, and only suggests that they be used to propose recommendations for actions. Appendix K4.10 presents the detailed health and safety evaluation “outside the fence” for the potentially affected communities and worker crossover issues with discussion of consequences per HEC, as well as associated uncertainties.

For the purposes of this evaluation, the EIS analysis area is defined as an area that may be affected by physical releases to the environment from project-related activities, or changes in economic, subsistence, and health resources and activities. Overall, it includes eight communities in the Lake and Peninsula Borough (LPB), seven communities in the Dillingham Census Area, three communities in the Kenai Peninsula Borough, two communities in Bristol Bay, as well as the surrounding regions and the Municipality of Anchorage. Not all communities are assessed for all health effects because some effects may be more relevant to some communities than others. A complete listing of the communities in the EIS analysis area, and the HECs for which they are evaluated, is provided in Section 3.10, Health and Safety.

## 4.10.3 No Action Alternative

Under the No Action Alternative, federal agencies with decision-making authorities on the project would not issue permits under their respective authorities. The Applicant's Preferred Alternative would not be undertaken, and no construction, operations, or closure activities specific to the Applicant’s Preferred Alternative would occur. Although no resource development would occur under the Applicant's Preferred Alternative, PLP would retain the ability to apply for continued mineral exploration activities under the State's authorization process (ADNR 2018-RFI 073) or for any activity not requiring federal authorization. In addition, there are many valid mining claims in the area, and these lands would remain open to mineral entry and exploration by other individuals or companies.

It would be expected that current State-authorized activities associated with mineral exploration and reclamation, as well as scientific studies, would continue at levels similar to recent post-exploration activity. The State requires that sites be reclaimed at the conclusion of their State-authorized exploration program. If reclamation approval is not granted immediately after the cessation of activities, the State may require continued authorization for ongoing monitoring and reclamation work as it deems necessary.

The purpose of the health and safety evaluation is to assess the impacts of the project and its alternatives against baseline conditions, as represented by the No Action Alternative. The current baseline condition is assumed as a reasonable proxy to qualitatively evaluate the future in the No Action Alternative. As a result, no quantitative discussion (i.e., rating) is presented for this alternative. Although there may be some uncertainty associated with the many factors and variables that could impact the health of communities in the EIS analysis area in the future, current trends can be assumed to continue in the absence of the project.

The No Action Alternative would have direct impacts related to the PLP exploration activities, as discussed in Section 4.3, Needs and Welfare of the People–Socioeconomics. PLP exploration-related employment and income, which were realized in the Bristol Bay region over the previous decade, have ceased. The PLP employed around 100 to 150 local community members annually at the site during the pre-development phase of the project, which ended in 2012 (Loeffler and Schmidt 2017). Since then, PLP has had a minimal number of workers at the site for exploration and maintenance activities. The exploratory phase of the project revealed that the income earned by residents employed by the project was an important part of the total income earned in local communities, especially those communities close to the mine site; and the income earned by residents close to the mine was greater than the income earned for commercial fishing, indicating that even the limited employment during the exploratory phase had large impacts on the communities. In communities that were further from the mine site, commercial fishing was a larger part of total income. Overall, the current number of direct and indirect jobs would remain roughly the same, and there would be no impact to the regional economy.

Human health impacts associated with the loss of employment opportunities (and subsequent decrease in median household income) primarily concern potential impacts on social determinants of health (SDH) (e.g., income, psychosocial stress, substance abuse, violent crime, and family stress and stability). Changes in SDH, if any, would be relatively small in magnitude, relative to the baseline, and would largely be confined to the communities closest to the mine site (Nondalton, Iliamna, and Newhalen). There would be no impact to more distant communities in the lower Bristol Bay watershed, such as Dillingham, other than removing uncertainty about the fate of this project. Other health factors would likely be similar to current conditions (baseline), such as potential rates of accidents and injuries, communicable and non-communicable diseases, exposure to hazardous constituents, and access to healthcare services.

Health impacts from the No Action Alternative would not be perceptible, or those impacted would be able to adapt to the impact with ease and not require medical intervention. Direct effects would be largely similar to baseline levels of health. Current health conditions and trends, as described in Section 3.10, Health and Safety, would continue in the EIS analysis area.

## 4.10.4 Alternative 1a

This section presents the environmental consequences to health and safety for Alternative 1a. The health and safety evaluation includes potential impacts (both beneficial and adverse) to the affected communities from the project during all three phases (construction, operation, and closure). The communities potentially affected by the project range from small, remote rural communities to larger regional and urban centers, as discussed in Section 3.10, Health and Safety. The eight communities identified in the LPB would be most closely affected by multiple project components. In addition, three Nushagak/Bristol Bay communities in the Dillingham Census Area were also identified as potentially affected by project components. As noted in Section 4.3, Needs and Welfare of the People—Socioeconomics, the Kenai Peninsula Borough and Anchorage would also be potentially affected economically by all components of the project, but at a relatively minor level due to their larger populations. In addition, more communities have been identified as using the EIS analysis area for subsistence; therefore, these communities could also be potentially affected by all of the components of the project (see Section 3.9, Subsistence). The consequences for all project components would be expected to be more noticeable in smaller, rural communities, and less perceptible in Anchorage.

A summary of the impact ratings for the HECs under Alternative 1a is presented in Table 4.10-4. Human health impacts resulting from Alternative 1a would be more noticeable in smaller, rural communities and less perceptible in the Municipality of Anchorage, as discussed in Section 3.3, Needs and Welfare of the People—Socioeconomics; and Section 4.4, Environmental Justice. Appendix K4.10 presents the detailed discussion of consequences per HEC, as well as associated uncertainties.

**Table 4.10-4: Summary of Alternative 1a Impact Levels by HEC**

| Health Effects Categories[1] | Summary Impact Category | Beneficial (+)or Adverse (-) Rating |
|---|---|---|
| **HEC 1: Social Determinants of Health** | | |
| Increase in household incomes, employment, and education attainment | 2 to 3 | ± |
| Psychosocial stress (substance abuse, crime, mental health, and suicide) | 2 to 3 | ± |
| Family stress and instability | 1 to 2 | ± |
| **HEC 2: Accidents and Injuries** | | |
| Increase in unintentional accidents and injuries, morbidity, and mortality rates due to transportation/navigation | 2 | - |
| Increase in other unintentional injury (falls, poisoning, etc.) | 2 | ± |
| Increase in Intentional Injury (suicide rate) | 2 | - |
| **HEC 3: Exposure to Potentially Hazardous Materials** | | |
| Air quality impacts | 1 to 2 | - |
| Surface water and sediment impacts | 1 to 2 | - |
| Groundwater impacts | 1 to 2 | - |
| Soil impacts | 1 to 2 | - |
| Bioaccumulated chemicals in subsistence foods | 1 to 2 | - |
| **HEC 4: Food, Nutrition, and Subsistence Activity** | | |
| Decrease in food costs relative to income | 2 | + |
| Access to and quantity of subsistence resources | 2 to 3 | ± |
| Decrease or increase in food security | 2 | ± |
| **HEC 5: Infectious Disease** | | |
| Increase in rates of sexually transmitted infections (gonorrhea, chlamydia, etc.) | 1 to 2 | - |
| Increase in rates of respiratory disease morbidity and mortality (influenza, pneumonia, etc.) | 1 to 2 | - |
| Increase in rates of foodborne illness and zoonotic disease | 1 | - |
| **HEC 6: Water and Sanitation** | | |
| Increase in morbidity and mortality rates due to the availability and quality of water and sanitation facilities | 1 | - |
| **HEC 7: Non-communicable and Chronic Disease** | | |
| Increase or decrease in cancer, respiratory, and cardiovascular morbidity rates due to changes in diet, nutrition, and physical activity | 2 | ± |
| Increase in cancer, respiratory, and cardiovascular morbidity and mortality rates due to exposure from hazardous chemicals | 1 | - |
| **HEC 8: Healthcare and Safety Services Infrastructure and Capacity** | | |
| Access to routine healthcare and safety services | 1 | ± |
| Access to healthcare and safety services due to large-scale emergency situations and overwhelming local and regional capacities | 2 | - |

Note:

HEC = Health Effect Category

This section does not independently evaluate the human health impacts from potential spills or failures because evaluations of potential impacts are provided in Section 4.27, Spill Risk. The potential health impacts from exposure to chemicals due to a spill or failure are of low likelihood, and are typically short-term, acute exposures, but may also lead to chronic exposure, depending on the nature, duration, migration testing, and monitoring of the spill. The following text summarizes the health and safety evaluation included in Section 4.27, Spill Risk. Hypothetical spills of diesel fuel, natural gas, copper-gold ore concentrate, chemical reagents, bulk and pyritic tailings, and untreated contact water are assessed using estimates of release rates, volume, and likelihood of occurrence, based on their spill potential and potential spill consequences (see Section 4.27, Spill Risk). Project design features, Standard Permit Conditions, and best management practices would be implemented for reducing impacts from potential spills (see Chapter 5, Mitigation). Health impacts related to spills may include psychosocial stress and anxiety regarding the possible or actual occurrence of spills; potential temporary releases of hazardous chemicals to air, water, and soil; and possible exposures to chemicals by subsistence resources that are ultimately consumed by humans. Planned and recommended measures to address these potential impacts include prompt measures for spill containment, rapid community outreach and notifications, and testing and monitoring of environmental media such as air, water, and subsistence food resources. Additional details are provided in Section 4.27, Spill Risk.

Overall, the economic and health benefits of improvements in economic status are expected to be substantial for the residents of the affected communities. Project-related economic benefits are rated Category 3 (construction and operations phases), and would be expected to result in benefits to many supplementary aspects of human health and well-being of residents, including increased income, employment, and educational attainment due to increased income. Economic benefits would likely have positive effects on helping to stem the current trend of out-migration, increasing or maintaining the number of schools in the region, and other indirect economic benefits (e.g., taxes, sales/revenue, and other fiscal effects to the regional and local communities). The benefits would be more apparent in the small, rural communities closest to the mine site (LPB communities), where even small changes in their economies could have a measurable impact on their overall health and well-being. Impacts on psychosocial stress (construction and operations); and access to, quantity of, and quality of subsistence resources (mine site construction and operations for all components) were rated Category 3 for both positive and negative effects.

Benefits that are rated as Category 2 include reduced food costs relative to income for those members of the community who would realize economic benefits from the project. Negative health consequences rated as Category 2 may be related to cessation of economic benefits (at mine closure) due to job losses and decreased income; potential transportation-related accidents and injuries for all phases (due to accidents by air, water, and surface transportation); intentional injuries (suicide); increased risk of exposure to potentially hazardous chemicals in the air, soil, surface water, groundwater, and bioaccumulated[1] in subsistence foods (during operations and closure); increase in sexually transmitted infections (during construction); decreased access to healthcare in emergency situations if adequate project emergency planning and periodic monitoring of the adequacy of emergency preparedness services is not maintained, and increased infectious (respiratory) diseases rates (during transportation infrastructure and pipeline construction) from proximity and likely increased interaction with the affected communities. Impacts on psychosocial stress (at mine closure); family stress and stability (during operations and closure); other unintentional injuries (e.g., falls, poisoning); access to, quantity of, and quality of subsistence resources; food security; and impacts on rates of non-communicable diseases due

[1] Bioaccumulation is the accumulation over time of a substance, and especially a contaminant (such as a pesticide or heavy metal), in a living organism.

to changes in diet, nutrition, and activity are also rated Category 2 for both positive and negative effects. Intentional injuries are rated as Category 2, primarily because of the severity of the consequence, although it is considered very unlikely to occur, relative to baseline conditions. Other potential impacts were rated Category 1.

Alternative 1a, as a whole, is rated as a Category 2 for both adverse and beneficial potential impacts. These effects determinations take into account the implementation of impact-reducing design features proposed by PLP, and also the Standard Permit Conditions and best management practices that would be implemented (see Chapter 5, Mitigation).

### 4.10.4.1 Safety

Safety requirements are a condition of obtaining regulatory permits and approvals to construct, operate, and close the project. Safety issues are typically addressed under state and federal regulatory programs designed to ensure physical safety pertaining to engineering design and structural integrity of the project components and infrastructure and safe storage, use, transportation, and disposal of materials, product, and waste streams. It also includes operational safety for workers, and the safety of visitors to the facility and the general public in the vicinity.

The project would be governed by relevant safety regulations in the areas where project activities would occur (all project components). For this project, relevant safety requirements would be followed and compliance would be achieved with the regulations of the MSHA, OSHA, Alaska Department of Transportation and Public Facilities (ADOT&PF), and other relevant regulatory programs. The project would provide safety training for all employees by a competent and qualified person, and health and safety plans would be developed, implemented, and followed to address worker exposures and safety. No subsistence, recreational, or transportation access would be allowed beyond the mine site safety boundary. The boundary would be reduced during the post-closure phase of the project.

As noted earlier, potential project impacts to the safety of the potentially affected communities "outside the fence" were included with the health and safety evaluation in Appendix K4.10 (e.g., impacts to transportation health and safety under HEC 2, and health and safety services under HEC 8).

#### Pipeline Reliability and Safety

The pipeline and related appurtenances would be designed, constructed, and operated in accordance with the applicable requirements of 49 Code of Federal Regulations Part 192 for subsurface pipelines. PLP would incorporate pig launching and receiving facilities (receipt, midpoint, and delivery site), main line valves, cathodic protection, leak detection, external coating, and supervisory control into the pipeline system. Periodic inspections of the pipeline facilities would be conducted to verify site security.

If a subsequent increase in population density adjacent to the right-of-way indicates a change in class location for the pipeline, PLP would have to reduce the maximum allowable operating pressure or replace the segment with pipe of sufficient grade and wall thickness, if required, to comply with the US Department of Transportation code of regulations for the new class location.

Although pipeline wall thickness would comply with the requirements for the designated line class, additional measures may be required in areas where geotechnical hazards are present unless a system-specific special permit was granted by the Pipeline and Hazardous Materials Safety Administration. Geotechnical hazards include areas prone to thaw settlement, frost heave, and fault zones. The pipeline would be designed to withstand the stress that could occur during a seismic event, including liquefaction. Similarly, a greater wall thickness may be required for pipe that would be laid in areas requiring additional strength during pressure testing because of large elevation changes or requiring buoyancy control in wetlands.

There is a low likelihood of pipe damage from liquefaction, and there would be no active fault crossing effects.

## 4.10.5 Alternative 1

Impacts from the project would be the same as or similar to Alternative 1a with few exceptions. The area of Iliamna Lake used for the ferry would be different and the route would be slightly shorter, because the ferry would travel to the north ferry terminal instead of the Eagle Bay ferry terminal. The mine access road alignment would route from the north ferry terminal to the mine site, with a spur road to Iliamna, and the port access road would be the same as Alternative 1a. This alternative's natural gas pipeline alignment would follow the transportation corridor for its entirety, and have a slightly shorter route across Iliamna Lake; however, impacts would be the same as Alternative 1a. Impacts from the Amakdedori port would be the same as Alternative 1a. Socioeconomic impacts under this Alternative would be similar to impacts under Alternative 1a.

The HEC for which Alternative 1 consequences may be slightly different from Alternative 1a is HEC 2: Accidents and Injuries due to transportation because the mine access road alignment is different, including a slightly shorter ferry route and pipeline crossing of Iliamna Lake. However, even given the slight differences noted above, the overall transportation operational aspects would be the same or similar (i.e., number of trucks, year-round operation, similar use of roads/ crossings, and similar distance to communities); therefore, the transportation-related accidents and injury summary impact to human health would remain the same, and would be Category 2 for all phases and transportation types (see Appendix K4.10).

Alternative 1 would have the same impacts to safety as Alternative 1a.

### 4.10.5.1 Alternative 1—Kokhanok East Ferry Terminal Variant

Under this variant, the creation of an alternate winter travel route along the Kokhanok east spur road with an access point to the lake east of the terminal would mitigate impacts from the ice-breaking ferry, but may add travel time, distance, and fuel costs. Navigation on Iliamna Lake at the Kokhanok east ferry terminal site would be more sheltered from wind and waves, but would contain more navigational hazards such as shallow water and a longer ferry route (HEC 2).

Despite these differences, the Kokhanok East Ferry Terminal Variant would have the same overall impact levels by HEC as described above in Alternative 1 for health and safety impacts.

### 4.10.5.2 Alternative 1—Summer-Only Ferry Operations Variant

The Summer-Only Ferry Operations Variant would lower the income earned by community members in the EIS analysis area. Overall, the high cost of living for the communities near the transportation corridor would still be lowered under this variant, but not to the extent of the proposed year-round ferry operations (HEC 1). There would not be an impact to winter transportation across the lake, eliminating those impacts (HEC 4). Truck and ferry trips would double in the summer, meaning winter snowmachine traffic across the lake would not be interrupted by an ice-breaking ferry, but vessels on the lake in the summer would experience double the ferry traffic (HEC 2).

Despite these differences, this variant would have the same overall impact levels by HEC as described above in Alternative 1 for health and safety impacts.

#### 4.10.5.3 Alternative 1—Pile-Supported Dock Variant

The Pile-Supported Dock Variant would have the same impact levels by HEC as described above in Alternative 1 for health and safety impacts (see Appendix K4.10).

### 4.10.6 Alternative 2—North Road and Ferry

Impacts to health and safety from the project would be the same as or similar to Alternative 1a with few exceptions. The area of Iliamna Lake used for the ferry would be different, because it encompasses the areas at the northern end of the lake around Pedro Bay (as opposed to Kokhanok). This alternative's natural gas pipeline alignment would follow the north road alignment, and not cross Iliamna Lake; therefore, there would be no hazards or impacts at Iliamna Lake during construction of the pipeline, as would occur under Alternative 1a. Impacts from the port at Diamond Point port would be the same as or similar to those for Amakdedori port.

Overall, the HEC for which Alternative 2 consequences may be slightly different from Alternative 1a is HEC 2: Accidents and Injuries due to transportation. However, even given the differences noted above, the transportation-related accidents and injury summary impact to human health would remain the same, and would be Category 2 for all phases and transportation types (see Appendix K4.10).

Alternative 2 would have the same impacts to safety as Alternative 1a.

#### 4.10.6.1 Alternative 2—Summer-Only Ferry Operations Variant

Under the Summer-Only Ferry Operations Variant, transportation impacts on the lake would be eliminated during the winter, but double during the summer. The likelihood of accidents and injuries for surface transportation may increase under this variant, because traffic on Williamsport-Pile Bay Road would include doubled mine-related summer traffic, and continuing or increasing levels of public boat portage. The potential for a greater likelihood of accidents would be reduced if the road was built to handle this increased summer capacity (HEC 2).

Despite these differences, this variant would have the same impact levels by HEC as described above in Alternative 2 for health and safety impacts.

#### 4.10.6.2 Alternative 2—Pile-Supported Dock Variant

The Pile-Supported Dock Variant would have the same impact levels by HEC as described above in Alternative 2 for health and safety impacts.

#### 4.10.6.3 Alternative 2—Newhalen River North Crossing Variant

The Newhalen River North Crossing Variant would have the same impact levels by HEC as described above in Alternative 2 for health and safety impacts.

### 4.10.7 Alternative 3—North Road Only

Impacts to health and safety from the project would be the same as or similar to Alternative 1a with few exceptions. The use of Iliamna Lake for a ferry would be eliminated, shifting project-related transportation impacts to the area around Pedro Bay, rather than around Kokhanok. Impacts from the port at Diamond Point would be the same as or similar to those for Amakdedori port. For the region as a whole, the impacts on the cost of living for Alternative 3 would be largely the same as the impacts of Alternative 1a, and would likely lower the high cost of living for the communities near the transportation corridor, similar to Alternative 2. However, because of the different alignments of the transportation corridor and natural gas pipeline, Kokhanok would likely experience less of a benefit, while Pedro Bay would likely experience more of a benefit over the long term.

Similar to Alternative 2, the HEC for which Alternative 3 consequences may be slightly different from other alternatives is HEC 2: Accidents and Injuries due to transportation. However, even given the differences noted above, the transportation-related accidents and injury summary impact to human health would remain the same, and would be Category 2 for all phases and transportation types (see Appendix K4.10).

Alternative 3 would have the same impacts to safety as Alternative 1a.

### 4.10.7.1 Alternative 3—Concentrate Pipeline Variant

The Concentrate Pipeline Variant would build a concentrate slurry pipeline from the mine to the port, and include a dewatering and treatment plant at Diamond Point so that the slurry water could be discharged at the port, or returned to the mine site for reuse, by constructing a second pipeline. Potential hazardous materials impacts would remain the same as under Alternative 1a, because the effluent would be treated to meet the Alaska water quality criteria prior to discharge (HEC 3). This variant would likely decrease employment of truck operators and increase employment at the water treatment plant and dewatering facility, but with lower overall employment (HEC 1).

Despite these differences, this variant would have the same impact levels by HEC as described above in Alternative 3 for health and safety impacts.

## 4.10.8 Cumulative Effects

Impacts to health and safety would include those related to negative and beneficial consequences to human health. As described above, “health” is broadly considered to represent a state of physical and mental well-being of communities; while “safety” is more narrowly interpreted as engineering design, operation, and handling of project infrastructure, equipment, and materials in a manner that seeks to reduce hazards and prevent the occurrence of incidents and accidents (IFC 2007). The cumulative effects analysis area for Health and Safety encompasses the same area used for evaluation of direct and indirect effects. For the purposes of this evaluation, the EIS analysis area is defined as an area that may be affected by physical releases to the environment from project-related activities, or changes in economic, subsistence, and health resources and activities. Overall, it includes eight communities in the LPB, seven communities in the Dillingham Census Area, three communities in the Kenai Peninsula Borough, two communities in Bristol Bay, as well as the surrounding regions and the Municipality of Anchorage. Not all communities are assessed for all health effects, because some effects may be more relevant to some communities than others. A complete listing of the communities in the EIS analysis area and the HECs evaluated is provided in Section 3.10, Health and Safety.

Potential cumulative impacts to health and safety include impacts to transportation (e.g., increase in Cook Inlet and Iliamna Lake vessel traffic, Williamsport-Pile Bay Road), water and soil quality (e.g., other sources of contamination), socioeconomics (e.g., increased household income from other employment opportunities), and subsistence (e.g., real or perceived impacts on cultural resources and disturbance of wildlife). In addition, based on these categories, there would be contributions to cumulative psychosocial stress at the family, community, and regional levels from concerns about additional development activities.

Past, present, and reasonably foreseeable future actions (RFFAs) in the cumulative impact study area have the potential to contribute cumulatively to impacts on health and safety. These potential future actions are similar to the proposed alternatives in that each may result in direct and indirect effects to the project-affected communities. To varying degrees, all the RFFAs identified in

Section 4.1, Introduction to Environmental Consequences, have the potential to impact cumulative health and safety.

### 4.10.8.1 Past and Present Actions

Past and present actions have contributed to the current state of baseline health status in the affected communities. They have the most noticeable impacts affecting health and safety in the areas relating to socioeconomics, subsistence, and transportation. Past and present actions that have contributed to the existing socioeconomic conditions of potentially affected communities include natural resource extraction, commercial and subsistence fishing activities, commercial recreation and tourism, community development and infrastructure, mining exploration activities, and the construction and operation of the Williamsport-Pile Bay Road, as discussed.

Commercial fishing has been the mainstay of the regional economy, although there are geographic differences in the distribution of benefits. These benefits and associated psychosocial stress have varied over time based on factors such as run size and fish price. Subsistence is a cultural and economic foundation of the region and its communities, and has seen cycles in availability of and access to resources, which results in beneficial and adverse health impacts. Community and transportation improvements have improved the quality of life through increased access to education and social services, and lowering the cost of living to a degree. Construction of the Williamsport-Pile Bay Road has decreased the cost of transported goods for some communities such as Pedro Bay, and facilitated transport of commercial and personal goods from Cook Inlet into the region. Mineral exploration has provided seasonal employment opportunities, but also created aircraft and ground noise, and restricted access to subsistence resources on a site-specific basis. Concerns regarding development of mineral resources in the Bristol Bay watershed, and potential impacts on environment, commercial fishing, and subsistence, have created a substantial amount of discussion and psychosocial stress. At the same time, the limited number of jobs and economic opportunities, particularly in Iliamna Lake communities, has contributed to outmigration, population declines, and closing of some local schools. This also contributes to the psychosocial stress in the region.

Finally, past and present actions may be perceived to have the potential to add to the cumulative health impacts relating to exposure to hazardous materials for nearby communities. However, pre-existing contaminated sites are relatively limited and under regulatory oversight, as are contaminants associated with mining exploration activities. Therefore, the potential for hazardous chemicals–related impacts to affected communities is expected to be low.

### 4.10.8.2 Reasonably Foreseeable Future Actions

RFFAs in the EIS analysis area closest to the project have the greatest potential to impact health and safety to the aforementioned affected communities, discussed below in Table 4.10-5.

The No Action Alternative would not contribute to cumulative effects on the regional and state economy, infrastructure, cost of living, and population characteristics; nor would it contribute to cumulative effects associated with changes to resource availability, access to resources, or competition for subsistence resources. Although there may be fewer local employment opportunities associated with future exploration of the Pebble Project, exploration activities could continue at a reduced level, and result in less income to support households and subsistence activities and maintain the current level of health. However, these could be offset by exploration of other nearby mineral deposits. The No Action Alternative would not contribute to cumulative effects on community health.

Collectively, the project alternatives and the RFFAs that contribute to cumulative effects on health and safety are summarized in Table 4.10-5.

**Table 4.10-5 Contribution to Cumulative Effects on Health and Safety**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Pebble Project expansion scenario | **Mine Site:** Pebble Project expansion scenario would extend the life of the project to 78 years to recover more of the estimated reserves. The following evaluation is limited to generalized impacts of the buildout scenario. The scenario would increase the geographic area affected by the project by combining project elements of Alternatives 1 and 3. Under Alternative 1a, project expansion would continue to use the existing natural gas pipeline; and would construct an access road and concentrate/diesel pipelines to a new port at Iniskin Bay. This has the potential to impact the cumulative impacts to subsistence resource availability, and access to resources, competition, and sociocultural dimensions of subsistence, as discussed in Section 4.9, Subsistence. It would also have the potential to result in increased health impacts over this larger geographic area, especially from increased duration of impacts, and possibly increased releases and affected community exposure to potentially hazardous materials. The health impacts of the expanded development would likely not only affect the four HECs considered most relevant to Alternative 1a (SDH, Accidents and Injuries, Exposure to Hazardous Materials, Diet/Nutrition/Subsistence), but could also result in impacts to the remaining HECs (Water and Sanitation, Infectious Diseases, Noncommunicable Diseases, and Healthcare Infrastructure).<br>Direct exposure of the affected communities to hazardous materials may not be noticeably altered by the expansion scenario if the cumulative magnitude of all emissions and releases to air, soil, and water are less than the appropriate screening levels for human health | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** Similar to Alternative 1a, except that the portion of the access road from the north ferry terminal to the existing Iliamna area road system would not already be constructed. The north access road and concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay.<br>**Magnitude:** The magnitude would be similar to that under Alternative 1a.<br>**Duration/Extent:** The duration/extent of cumulative impacts to health and safety would be similar to those under Alternative 1a, although they would affect a larger area.<br>**Contribution:** The contribution to cumulative effects would be slightly more than that under Alternative 1a, Alternative 2, and Alternative 3. | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** Similar to Alternative 1a. Concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay.<br>**Magnitude:** Expanded mine site development and associated contributions to cumulative health, and contributing factors such as socioeconomics, subsistence, and transportation and navigation impacts to the region, would be similar to but less than those under Alternative 1a in magnitude. Under Alternative 2, project expansion would continue to use the existing Diamond Point port facility; would use the same natural gas pipeline; and would connect the access road between ferry terminals, and build the concentrate and diesel pipelines to a new port in Iniskin Bay. Cumulative impacts from Alternative 2, combined with the Pebble Project expanded development scenario, would likely result in tradeoffs regarding local employment | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** Overall expansion would use the existing north access road; Concentrate and diesel pipelines would be constructed along the existing road alignment and extended to a new deepwater port site at Iniskin Bay.<br>**Magnitude:** Expanded mine site development and associated contributions to cumulative health, and contributing factors such as socioeconomics, subsistence, and transportation and navigation impacts, would be similar to those under the other alternatives. Because the Pebble Project expanded development scenario would use the north access road system that would already be built under Alternative 3 and not include any ferry operations, cumulative impacts from Alternative 3, combined with the expanded development scenario would likely result in tradeoffs regarding local employment opportunities compared to Alternative 1a; negative impacts to subsistence resource availability and |

**Table 4.10-5 Contribution to Cumulative Effects on Health and Safety**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | (refer to Section 4.14, Soils; Section 4.18, Water and Sediment Quality; and Section 4.20, Air Quality). Project area communities with pre-existing industrial pollutants and contaminated sites have the potential to add to the cumulative health impacts from exposure to potentially hazardous materials in communities where PLP proposes construction and operations support activities. If the Pebble Project expanded development scenario were pursued, a separate EIS would be required, which may include mitigation measures expected to minimize or mitigate exposure because it would include common BMPs and industry standards that are designed to reduce impacts to the environment. In addition, PLP would be required to operate the mine in compliance with all federal, state, and local requirements, including all mitigation and monitoring requirements identified through the NEPA and permitting processes. The cumulative impacts would be long term over extended operations and decrease in magnitude as closure is implemented.<br>**Other Facilities:** A north access road and concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment to a new deepwater port site at Iniskin Bay. The road additions and improvements would increase both the area of disturbance and availability of local access for subsistence resources (see Section 4.9, Subsistence), which in turn affect associated diet and nutrition trends, as well as cultural identity and mental health. However, continued exposure of wild foods that might be exposed to bioaccumulative metals from project activities could increase human exposure to hazardous chemicals in the long term, and may | | opportunities compared to Alternative 1a; but negative impacts to subsistence resource availability, access to resources, and competition for resources would be of lesser magnitude than those under Alternative 1a (see Section 4.3, Needs and Welfare of the People–Socioeconomics; Section 4.9, Subsistence; and Section 4.12, Transportation and Navigation). Under this scenario, Kokhanok would not experience positive effects associated with a road connection to Cook Inlet.<br>**Duration/Extent:** The duration/extent of cumulative impacts to health and safety would be similar to those under Alternative 1a, although to an extent affecting a smaller amount of acreage because the Amakdedori port and connecting transportation infrastructure would not be built.<br>**Contribution:** The contribution to cumulative impacts would be similar to that under Alternative 1a, without the potential effects associated with operating two road access corridors. | access to resources would be less than those under the other alternatives (see Section 4.9, Subsistence). Cumulative tax generation and cost-of-living benefits would be similar to those under Alternative 2, because employment opportunities associated with truck traffic would be lower, and the facilities would not generate additional taxable income (Section 4.3, Needs and Welfare of the People–Socioeconomics). Impacts to health would be similar to those under the other alternatives.<br>**Duration/Extent**: The duration/extent of cumulative impacts to health and safety would be similar to those under the other alternatives.<br>**Contribution:** The contribution to cumulative impacts would be similar to that under the other alternatives. |

**Table 4.10-5 Contribution to Cumulative Effects on Health and Safety**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | benefit from surveys and monitoring efforts to confirm that exposures are limited.<br>**Magnitude:** No major cumulative impacts would be expected for health-related impacts in the area of Water and Sanitation, Infectious Diseases, and Healthcare Infrastructure and Access as long as the expansion continued to ensure self-sufficient, on-site water supplies, worker housing, infectious disease education, treatment, training, and monitoring programs; and operated their own health clinics and healthcare facilities. Cumulative impacts on non-communicable diseases such as incidence of morbidity and mortality due to cancer, lifestyle behavioral factors (including mental health), and non-infectious non-cancer diseases might decrease further in those segments of the local population that enjoy long-term increases in income and quality of life, but may increase among those who may be excluded from project benefits, or whose lifestyles are altered in the direction of less activity or less nutritious diets, or perceive or experience negative impacts to their subsistence lifestyle and have increased concerns about exposure to project-related hazardous chemical exposure (to the environment, wildlife, and human population, including sensitive subpopulations).<br>**Duration/Extent:** The expansion would continue, and likely increase, the beneficial and adverse socioeconomic impacts that would be realized from the project through the 78-year expansion period. Pedro Bay would experience greater socioeconomic impacts under the expanded development scenario than if just the project were implemented alone (see Section 4.3, Needs and Welfare of the People—Socioeconomics). Health benefits related to a longer period of increased | | | |

**Table 4.10-5 Contribution to Cumulative Effects on Health and Safety**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | income and employment for the local communities may result in multi-generational improvements in educational attainment, and increased access to affordable healthcare, as well as possible expansion of healthcare facilities, due to increased public revenues. However, psychosocial stress related to further mineral development and anxiety regarding the health of the salmon runs and environmental degradation may be intensified. Maintaining cultural ties within families and to the land could be more difficult, depending on access accommodation to areas of traditional subsistence use and flexibility of employment to pursue subsistence activities.<br>**Contribution:** The potential for additional surface and water-related accidents and injuries would increase, because the expansion would also create additional annual vessel and truck traffic over an extended period of time, particularly in Iniskin Bay and Cook Inlet. The access road to Diamond Point, if open to non-mining traffic, could be beneficial for business, but would increase traffic overall through the Williamsport-Pile Bay Road corridor, and could be permanent. Construction of the diesel and concentrate pipelines and access road to a deepwater port in Iniskin Bay would increase the magnitude, duration, and extent of transportation impacts (see Section 4.12, Transportation and Navigation). These additional infrastructure elements have the potential to have positive impacts for the affected communities (e.g., road improvements and increased safety), as well as negative impacts related to accidents and injuries based on the level of public access and interaction. The ferry would cease operations at year 20, and the concentrate pipeline would | | | |

**Table 4.10-5 Contribution to Cumulative Effects on Health and Safety**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | reduce truck traffic associated with shipment of copper/gold concentrate, reducing transportation and subsistence impacts associated with those project components. | | | |
| Other Mineral Exploration Projects | **Magnitude:** Mining exploration activities would include additional borehole drilling, road and pad construction, and development of temporary camp facilities. Impacts to health and safety would be similar to those described for the Pebble Project expanded development scenario, except at a smaller and site-specific scale.<br>**Duration/Extent:** Exploration activities typically occur at a discrete location for one season, although a multi-year program could expand the geographic area affected within a specific mineral prospect. Section 4.1, Introduction to Environmental Consequences, identifies seven mineral prospects in the EIS analysis area where exploratory drilling is anticipated (four of which are relatively close to the Pebble Project).<br>**Contribution:** This contributes to cumulative effects of health and safety. Additional helicopter traffic could contribute to concerns about impacts on subsistence and stress among local residents. Assuming compliance with permit requirements, contributions to negative effects to health and safety would be minimal. | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |
| Oil and Gas Exploration and Development | **Magnitude:** Onshore oil and gas exploration activities could involve seismic and other forms of geophysical exploration, and in limited cases exploratory drilling. These activities could have both positive and negative effects on health and safety, but to a lesser extent than the Pebble Project expanded development scenario due to a shorter duration. | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |

**Table 4.10-5 Contribution to Cumulative Effects on Health and Safety**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | **Duration/Extent:** Seismic exploration and exploratory drilling are typically single-season, temporary activities. The location of previous activities are to the south of King Salmon, and would have minimal contributions to health and safety in the immediate project area.<br>**Contribution:** Onshore oil and gas exploration activities would be required to minimize surface disturbance; this would occur in the analysis area, but distant from the project. The project would have minimal contribution to cumulative effects. | | | |
| Road Improvement and Community Development Projects | **Magnitude:** Road improvement projects would take place in the vicinity of communities and have impacts through grading, filling, and potential increased erosion. Communities in the immediate vicinity of project facilities, such as Iliamna, Newhalen, and Kokhanok, would have the greatest contribution to cumulative effects. Some limited road upgrades could also occur in the vicinity of the natural gas pipeline starting point near Stariski Creek, or in support of mineral exploration previously discussed. These improvements would improve overland routes in the region (access to Nondalton) and inter-regionally from Cook Inlet to Iliamna Lake. These in turn could reduce the cost of living through reduced transportation costs of goods.<br>Impacts on health would be affected by impacts on other contributing factors, such as transportation, socioeconomics, and subsistence. These improvements could have positive cumulative effects on ease of transportation with Alternative 1a (e.g., road improvement and overall increased safety), but may also result in increased traffic in certain areas. This may result in increases in accidents and injuries related to surface transportation. Cumulative impacts would | Similar to Alternative 1a and Alternative 2; greater than Alternative 3. | Cumulative effects of these activities would be similar to those discussed under Alternative 1a, except that the north access road and road to Nondalton could connect with the pipeline corridor, creating an overland access route for Iliamna, Newhalen, and Nondalton to Pedro Bay and Cook Inlet. The magnitude, geographic extent, and duration of cumulative impacts in Alternative 2 would be greater than in Alternative 1a, as discussed in Section 4.12, Transportation and Navigation.<br>The footprint of the Diamond Point rock quarry coincides with the Diamond Point port footprint in Alternatives 2 and 3. Cumulative impacts would likely be less under Alternative 2, due to | Overall, cumulative health effects of these activities would be similar to those discussed under Alternative 2, but less than those under Alternative 1a and Alternative 1. |

**Table 4.10-5 Contribution to Cumulative Effects on Health and Safety**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | also occur associated with surface transportation between the communities for subsistence and recreational uses, in addition to the ongoing LPB, rural Alaska Village Grant Program, and other village projects. These transportation projects would increase access to the area, which could improve access to subsistence resources, but also introduce additional disturbance to and competition for resources, affecting all communities in the cumulative effects analysis area. The projects could also create small-scale construction and operations employment opportunities, improve services, and potentially lower the cost of living. Community construction projects are a particularly important source of seasonal employment and income for small communities. One of the net effects of increased access and interaction among these communities is that the smaller, more rural and remote communities may become more socially and culturally connected with other communities, with consequent positive and negative impacts on SDH.<br>The proposed Diamond Point rock quarry has potential to contribute both positive and negative impacts on health and safety.<br>**Duration/Extent:** Disturbance from road construction would typically occur over a single construction season. The geographic extent would be limited to the vicinity of communities and Diamond Point.<br>**Contribution:** The scheduling of the project implementation could affect the magnitude of impacts to health and other factors. If these projects were implemented, the magnitude of adverse effects on transportation could increase the rates of accidents and injuries; however, if the | | commonly shared project footprints with the quarry site. | |

**Table 4.10-5 Contribution to Cumulative Effects on Health and Safety**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | project improvements occurred before or after the construction phase of Alternative 1a, the magnitude would be far less, and the duration would be unchanged. The socioeconomic impacts would be anticipated to be greater if the project is implemented, which could increase development as support-related businesses take advantage of the additional opportunities provided by the mine. Subsistence impacts from these other projects would have effects similar to those of the project, but would be of lesser magnitude and geographic extent. The impacts to health and safety would be similar to those under Alternative 1a, with a similar mix of positive and negative impacts, but of lower magnitude and spatial extent. | | | |
| Summary of Project contribution to Cumulative Effects | Overall, the health impacts of the expanded project may be summarized as extending spatially to a larger affected population, with both positive and negative effects lasting for longer duration in comparison to Alternative 1a without expansion. | Similar to Alternative 1a. | Similar to Alternative 1a, although there would not be the positive and adverse effects associated with operating two port-access road systems under the expanded mine scenario. | Similar to Alternative 1a, although there would not be the positive and adverse effects associated with operating two port-access road systems under the expanded mine scenario. |

Notes:
BMP = best management practice
EIS = Environmental Impact Statement
HEC = Health Effect Category
LPB = Lake and Peninsula Borough
NEPA = National Environmental Policy Act
PLP = Pebble Limited Partnership
SDH = social determinants of health

## 4.11 AESTHETICS

Aesthetic impacts include those that could result from changes in the visual landscape (including night sky), soundscape, or olfactory attributes. For this analysis, visual impacts are defined as changes to the scenic attributes of the landscape resulting from the introduction of visual contrasts (discharge of dredge for fill material in wetlands or other waters), and the associated changes in the human visual experience of the landscape (NPS 2014b). The analysis was based on conclusions presented in Section 4.22, Wetlands and Other Waters/Special Aquatic Sites, including permanent impacts to wetlands, open waters, and streams. Impacts to soundscape are defined by changes in A-weighted decibel (dBA) levels that alter soundscape from a "wilderness ambient" character using the information described in Section 3.19 and Section 4.19, Noise. Impacts to soundscape included potential noise generation from the mine, and ground-based transportation corridors and overflights. Because changes in olfactory attributes are subjective, this aesthetic attribute is not analyzed in detail. It is assumed that localized changes to smells could result from project-related activities that alter the natural smells that exist under current conditions. Potential impacts to contemporary, traditional, and cultural uses of areas are discussed in Section 4.7, Cultural Resources, and Section 4.9, Subsistence.

The Environmental Impact Statement (EIS) analysis area for aesthetic resources extends westward from Happy Valley on the Kenai Peninsula and the Bristol Bay and Cook Inlet drainages to the eastern side of the Iniskin Peninsula, encompassing Iliamna Lake and the surrounding communities. For each alternative, the EIS analysis area includes a 50-mile radius from the mine site; a 10-mile radius from the ferry terminals, a 20-mile buffer from the transportation corridor and natural gas pipeline, and a 25-mile radius around the port. For night-lighting impacts, the EIS analysis area includes a 20-mile radius around the mine site, and a 13-mile radius around ferry terminals and port locations. A discussion of potential visual and auditory impacts from overflights is provided.

Scoping comments expressed concern that the project would have permanent and significant impacts on the appearance of the landscape as viewed from Key Observation Points (KOPs), and that this would impact use and enjoyment of the area. Comments also requested that visual impacts of the mine, roads, and Amakdedori port include recreation; and secondary industries like flightseeing and wildlife viewing.

Mitigation measures and Best Management Practices (BMPs) to be followed to reduce impacts to visual resources and aesthetics are described in Chapter 5, Mitigation.

### 4.11.1 Summary of Key Issues

**Table 4.11-1: Summary of Key Issues for Aesthetic Resources**

| Project Component | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alterantive 3 and Variant |
|---|---|---|---|---|
| Mine Site | Aesthetic resources would be affected by moderate to strong visual contrast that would appear dominant in the landscape. Impacts would be limited in geographic extent by rugged topography. Impacts from lighting would be visually evident, particularly during winter months. Night sky could be affected as far as 20 miles from the mine site. Impacts to soundscape would be limited to within 10 miles of the mine site. | | | |
| Transportation Corridor | Aesthetic resources would be affected by weak to moderate visual contrast impacts that would be visually evident in the | Impacts would be similar to Alternative 1a.<br>Under the Kokhanok East Ferry Terminal | Impacts would be similar to Alternative 1a; however, the northern route would affect | Impacts would be the same as described in Alternative 2, with the exception of those pertaining to ferry |

**Table 4.11-1: Summary of Key Issues for Aesthetic Resources**

| Project Component | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alterantive 3 and Variant |
|---|---|---|---|---|
| | landscape. Movement of vehicles and ferries could be more apparent during dark sky conditions, because lighting would be evident. Night sky could be affected as far as 13 miles from the ferry terminals. Impacts to soundscape would be limited to within 0.5 mile of the transportation corridor.<br>Kokhanok, Iliamna, and Newhalen would be affected by the transportation corridor and ferry activities. | Variant, potential impacts to aesthetic resources would be similar to those described for the south ferry terminal; however, the perception of impacts would be higher due to the close proximity of viewer and noise receptors to the ferry route.<br>Under the Summer-Only Ferry Operations Variant, the visual contrast would not be created from open water on the lake where the icebreaking ferry crosses. Impacts to the night sky would also be much less. | residents of Iliamna, Newhalen, and Pile Bay due to proximity to the access route and ferry terminals. Impacts would include those that result from movement and lighting.<br>Under the Summer-Only Ferry Operations Variant, reduction of season-specific impacts to aesthetic resources during winter months would be similar to Alternative 1; however, reduction in impacts would be experienced by residents in the communities along the northern shore of Iliamna Lake.<br>Under the Newhalen River North Crossing Variant, the bridge would be just as visible, and perhaps more visible, from Roadhouse Mountain as Alternative 2. | terminals. Impacts would occur in the community of Pedro Bay due to the proximity to the transportation route. |
| Amakdedori Port and Diamond Point Port | Aesthetic resources would be affected by weak to moderate visual contrast that would be visually evident when viewed within 5 miles. Scale dominance of the port facility would decrease with distance. Night sky could be affected as far as 13 miles from the ports. Soundscape-related impacts could extend to almost 2 miles from the port. | | Impacts would be similar to those described for Alternative 1a; however, the port site would be in Iliamna Bay, where steep topography would limit geographic extent of visual and soundscape-related impacts. | |
| Natural Gas Pipeline | The magnitude of impacts from the pipeline would be greatest between the junction with the mine access road and where the pipeline comes ashore north of Newhalen, because visual contrast of the cleared ROW would contrast the existing natural landscape. There would be no impacts on the night sky, and no impacts to the soundscape would be expected. | Because the natural gas pipeline corridor would follow the transportation corridor, it would not introduce additional impacts to visual resources, the night sky, or the soundscape distinct from the road. | The magnitude of impacts from the pipeline would be greatest between the junction with the Eagle Bay ferry terminal access road, because visual contrast of the cleared ROW would contrast the existing natural landscape. There would be no impacts on the night sky, and no impacts to the soundscape would be expected. | Same as Alternative 1. |

**Table 4.11-1: Summary of Key Issues for Aesthetic Resources**

| Project Component | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alterantive 3 and Variant |
|---|---|---|---|---|
| All Components | Visual impacts would appear dominant to viewers in recreational or local low-altitude aircraft. When viewed from the air, the project would result in moderate to strong visual contrast due to vegetation removal and ground disturbance in access roads and the mine site. For air-based viewers flying to recreational destinations such as the McNeil River State Game Refuge, and the western end of Lake Clark National Park and Preserve, the transportation corridor would be visually evident. Visual impacts are expected to be of medium to high magnitude, and would decrease with distance from the facilities. There would be some minimal impacts to the soundscape from project-related aircraft. | Visual impacts from all components would be similar to those described for Alternative 1a. There would be some small impacts to the soundscape from project-related aircraft. | Visual impacts from all components would be similar to those described for Alternative 1a. There would be some small impacts to the soundscape from project-related aircraft. | Visual impacts from all components would be similar to those described for Alternative 2, with the exception of ferry terminals and operations; however, the magnitude of impacts would be greater due to operation of the north access road. The road would be visually evident, appearing as a curvilinear line with contrasting color and texture against the surrounding landscape. There would be some small impacts to the soundscape from project-related aircraft. |

Note:
ROW = right-of-way

## 4.11.2 Visual Impacts

Visual impacts were assessed by first determining the magnitude and geographic extent of visual contrast and scale dominance, and then assessing perceived impacts based on viewer duration, geometry, and distance. Impacts from the project to the night sky were analyzed using estimated skyglow.

**Magnitude and Geographic Extent**—The magnitude of impacts on aesthetics and visual resources was assessed by determining the overall change in landscape character based on visual contrast and scale dominance. The geographic extent of the effects was measured by the range of moderate to strong visual contrast, and was summarized as localized, extended, or regional.

- **Visual Contrast:** The Bureau of Land Management (BLM) Contrast Rating Procedure was used to determine visual contrast that could result from construction and operation of the project (BLM 1986). The project would not directly affect federal land; however, the BLM Contrast Rating Procedure is an established and developed methodology commonly used to assess visual impacts. This method assumes that the extent to which a project results in adverse effects on visual resources is a function of the visual contrast between the project components and the existing landscape character. Levels of contrast are defined as follows:
    - None—The element contrast is not visible or perceived.

- Weak—The element contrast can be seen but does not attract attention.
- Moderate—The element contrast begins to attract attention and to dominate the characteristic landscape.
- Strong—The element contrast demands attention, would not be overlooked, and is dominant in the landscape.

- **Scale Dominance:** The contrast created by a project is directly related to its size and scale, as compared to the surroundings in which it is placed. Scale dominance refers to the scale of an object relative to the visible expanse of the landscape that forms its setting (BLM 1986). A dominant feature of a landscape tends to attract attention, and becomes the focal point of the view. Where two or more features both attract attention and have generally equal visual influence over the landscape, they are considered co-dominant. An object or feature that is easily overlooked or absorbed by the surrounding landscape is considered subordinate. Scale dominance was classified using the following metrics:
  - Not Visually Evident (NVE), where "evident" refers to that which is noticeable, apparent, conspicuous, or obvious.
  - Visually Subordinate (VS), where "subordinate" refers to landscape features that are inferior to, or placed below, another in size, importance, brightness, and other relevant factors.
  - Visually Evident (VE), where "evident" refers to that defined above.
  - Dominant (D), where "dominant" refers to that defined above.

**Visual Impacts—**Potential visual impacts perceived by viewers were assessed at each KOP identified in Section 3.11, Aesthetics, based on the level of exposure to moderate or high-magnitude impacts, viewer sensitivity to change, the potential for those effects to alter the human experience of the landscape, and the context of the impact. Exposure was measured based on viewer duration, viewer geometry, and distance from the project component. These metrics were assessed as follows:

- **Viewer Duration:** Viewer duration or exposure refers to the length of time project features may be in view. This description discloses whether expected viewer exposure would be limited to a short duration and/or small number of viewpoints, or would be of a prolonged duration and/or experienced from multiple viewpoints.
- **Viewer Geometry:** Viewer geometry refers to the spatial relationship of the observer to the viewed object (i.e., the project), including both the vertical and horizontal angles of view (BLM 2013). The vertical angle of view refers to the observer's elevation relative to the viewed object. The horizontal angle of view refers to the compass direction of the view from the observer to the object. Visibility is typically greater for observers whose viewing angle is directed toward a project feature than for those with a lateral view.
  - Superior geometry occurs when the viewer is elevated with respect to the facility (looking down on it).
  - Inferior geometry occurs when the viewer is lower in elevation than the facility (looking up at it).
  - At-grade geometry occurs when the view is level with the facility (looking across it).
- **Distance:** The degree of perceived visual contrast and scale dominance of an object is influenced by the object's distance from the viewer. As viewing distance increases,

the project appears smaller and less dominant; likewise, the apparent contrast of color decreases (BLM 1986). Distance from project components is classified as follows:

- Immediate foreground (less than 3 miles)
- Foreground–middle ground (3 to 5 miles)
- Background (5 to 15 miles)
- Seldom seen (beyond 15 miles)

**Night Sky—**Night-lighting associated with project components could result in light pollution, which is defined as the change to natural night-lighting levels from human-caused sources (Falchi et al. 2016a). Light pollution effectively reduces visibility of natural sources of light at night, such as moonlight, starlight from individual stars and planets, the Milky Way, the zodiacal light, the aurora borealis, and meteors. Project components would result in light pollution in the form of glare when viewed from short distances and over water, but would have further-reaching effects from skyglow, which is defined as the brightening of the night sky over areas with artificial lighting (NPS 2016g). Because a lighting plan is not available for the project, impacts are evaluated qualitatively, and the magnitude and geographic extent of impacts are estimated using existing data in the New World Atlas of Artificial Night Sky Brightness (Falchi et al. 2016a, b). Development of a lighting plan has been added to Appendix M1.0, Mitigation Assessment, to propose ways to minimize impacts. Some impacts may be minimized through BMPs, such as orienting lights downward. To estimate the distance that skyglow would be observed from the mine site, data were used from the Red Dog Mine in northwestern Alaska. To estimate the distance that skyglow would impact the night sky from the ferry terminals and ports, data from the Red Dog Port were used. These two facilities were used as proxies for estimating night-lighting impacts from the mine site, ferry terminals, and ports because of their similar size and type of operations to the Pebble project and associated facilities. These data are summarized in Table 4.11-2 below.

**Table 4.11-2: Estimated Night-Sky Effects by Distance from Artificial Lighting**

| Distance from Mine Site[1,2] | Distance from Ferry Terminals and Ports[1,3] | Ratio to Natural Brightness[4] | Description of Effects |
|---|---|---|---|
| 20 miles | 13 miles | 1% | In areas protected for scenic or wilderness character, a significant impact on the values of solitude and the absence of visual intrusion of human development occurs. Attention should be given to protect the site from future increase in light pollution. |
| 8 miles | 5 miles | 8% | Area is considered polluted from an astronomical point of view. Visibility of stars and other astronomical observations are affected. |
| 2 miles | <1 mile | 128% | Visibility of the Milky Way during winter months is affected. |
| <1 mile | N/A[5] | >512% | Sky has same luminosity as a natural sky at twilight; true night conditions are never experienced. |

Notes:
[1] Data estimated from Falchi et al. 2016a, b.
[2] Distance based on data for Red Dog Mine in northwestern Alaska.
[3] Distance based on data for Red Dog Port.
[4] Ratio (in percent) between the artificial brightness and the natural background sky brightness.
[5] An increase in sky brightness of 512 percent or greater over existing conditions is not anticipated to result from the ferry terminals or ports at any distance, based on impacts from the Red Dog Port per the New World Atlas of Artificial Sky Brightness.
Source: Falchi et al. 2016a, b

The National Park Service (NPS 2013b) monitoring report also includes photographs that depict natural air glow, as well as monitoring data and narrative, including the Bortle Class, based on the Bortle Dark-Sky Scale as reported by NPS observers at Keyes Point in Lake Clark National Park and Preserve. The Bortle Dark-Sky Scale is a nine-step scale used to rate sky conditions at an observation site; with Class 1 indicating an excellent dark-sky site, and Class 9 indicating an inner-city sky (Bortle 2001).

Data from these two sources were used to estimate existing night-sky quality in the EIS analysis area.

## 4.11.3 No Action Alternative

Under the No Action Alternative, federal agencies with decision-making authorities on the project would not issue permits under their respective authorities. The Applicant's Preferred Alternative would not be undertaken, and no construction, operations, or closure activities specific to the Applicant's Preferred Alternative would occur. Although no resource development would occur under the Applicant's Preferred Alternative, Pebble Limited Partnership (PLP) would retain the ability to apply for continued mineral exploration activities under the State's authorization process (ADNR 2018-RFI 073) or for any activity not requiring federal authorization. In addition, there are many valid mining claims in the area, and these lands would remain open to mineral entry and exploration by other individuals or companies.

It would be expected that current State-authorized activities associated with mineral exploration and reclamation, as well as scientific studies, would continue at levels similar to recent post-exploration activity. The State requires that sites be reclaimed at the conclusion of their State-authorized exploration program. If reclamation approval is not granted immediately after the cessation of activities, the State may require continued authorization for ongoing monitoring and reclamation work as it deems necessary. No additional direct or indirect effects on aesthetics would be expected as a result of the project.

PLP would reclaim any remaining sites at the conclusion of their exploration program. The state determines reclamation approval, which may include continued authorization for ongoing monitoring and reclamation work as deemed necessary. Reclamation would benefit the aesthetics of the setting.

## 4.11.4 Alternative 1a

Due to the remoteness of the project and the distribution of components across a large geographic area, many of the components are geographically isolated; therefore, visual impacts of the project may be limited to that caused by one component. For example, viewers situated on Cook Inlet may only be exposed to potential impacts from Amakdedori port, but would not experience potential impacts from activities at the mine site. However, some viewer locations may be characterized by broader or expansive views (i.e., from higher elevations or aircraft), and therefore have the potential for exposure to more than one project component. To address this, potential visual and aesthetic impacts are provided below by project component, and collectively for all project components.

Note that because views of the EIS analysis area from aircraft would include all project components, potential impacts from this viewer position are described under a separate heading below, "All Components."

### 4.11.4.1 Mine Site

#### Visual Impacts

Specific mine site components would result in variable levels of visual contrast and scale dominance. In terms of magnitude and extent, the open pit mine, tailings storage facility overburden stockpiles, material sites, and quarries would create strong visual contrast in form, line, color, and texture due to alterations in the existing natural contours of the landscape and removal of vegetation. Smooth texture and the reflective surface of water management ponds would result in strong contrast against the coarse textures and natural matte colors of the landscape. Milling and processing facilities, along with supporting infrastructure such as the power plant, water treatment plants, camp facilities, and storage facilities, would appear industrial. These industrial straight lines and geometric forms would contrast against the softer, less-angular lines of the landscape. These features would be visually evident and appear dominant on the landscape when viewed from within background distance zones.

Collectively, and where visible in the background distance zone (5 to 15 miles), the mine site would appear dominant in the landscape, and would alter scenic quality. Viewshed models indicate that visibility of mine components from ground-based locations would be limited by topography and vegetation screening (see Appendix K4.11 for figures of the viewshed). Visibility would generally be limited to high-elevation areas on Sharp Mountain and Groundhog Mountain, and the upper Stuyahok River Valley. The mine site could also be visible from higher elevations west of Lake Clark (but outside of Lake Clark National Park and Preserve); however, visual contrast is expected to attenuate to a weak level at this distance (approximately 20 miles away). See Appendix K4.11 for visual simulations of the project at defined KOPs. At Iliamna Lake, views of the mine site would largely be screened by vegetation and topography. The mine would be highly visible to passengers in overflights. See Appendix K3.12, Transportation and Navigation, for common flightpaths over the area.

In terms of magnitude and extent, impacts of the mine site perceived by residents, recreationists, or subsistence users in the EIS analysis area for the mine site would be of moderate to strong visual contrast, have VE or D scale dominance, and occur in the immediate foreground, due the remoteness of the site and the existing topographic and vegetation screening. Viewer duration would be intermittent to prolonged, depending on the activity of the viewer. If remote recreation or subsistence use should occur in the foreground or middle-ground distance zone of the mine site and in the seen area, the magnitude of impacts would increase as a function of distance. The duration of impacts would be long-term, extending beyond the life of the project. The likelihood of impacts would be certain.

#### Night Sky

Mine site facility lighting would have a strong contrast level against the existing night sky. Lighting could be visible at distances from high-elevation locations due to the lack of existing night-lighting and high quality of night sky. During periods of snow cover, lighting at the mine site would reflect against the snow, thereby creating a halo effect that could extend outward to background distance zones and contribute to skyglow. Increases in brightness and associated impacts to night sky would be noticeably greater during periods of snow cover. Conversely, impacts would be less noticeable during summer months, when daylight hours are longer and there is no snow cover.

Due to the lack of viewing locations in the foreground or middleground distance zones, the mine site would not produce glare visible from any KOPs; however, glare could be observed by overhead flights. Mine lighting could be directly visible from locations in the modeled viewshed, such as high-elevation areas on Sharp Mountain and Groundhog Mountain, the upper Stuyahok River Valley, and higher elevations west of Lake Clark National Park and Preserve.

Skyglow from the mine site would brighten the night sky, affecting the human eye from fully adapting to the dark; and reduce visibility of stars and other astronomical observations at some distances. The magnitude and extent of the impact would be that areas 8 to 20 miles from the mine site could begin to experience skyglow from artificial lighting (Table 4.11-2). Impacts may not be readily apparent; however, the introduction of this visual intrusion into an otherwise pristine night sky would begin to put the integrity of the night sky at risk. In terms of magnitude and extent, about 1 percent of the Lake Clark National Park and Preserve would experience these types of effects, as shown in Table 4.11-3. No areas in the Katmai National Park and Preserve, McNeil River State Game Refuge, or the Alaska Maritime National Wildlife Refuge would be impacted. No change to Bortle Class is expected at these distances from the mine site lighting alone, and the magnitude of impacts would be low.

**Table 4.11-3: Estimated Night-Sky Effects from the Mine Site**

| Distance from Mine Site[1] | Total Acres Affected | Affected Acres in Lake Clark National Park and Preserve |
|---|---|---|
| 8 to 20 miles | 846,074 | 54,487 |
| 2 to 8 miles | 208,143 | 0 |
| 1 to 2 miles | 21,755 | 0 |
| <1 mile | 23,640 | 0 |

Notes:
[1] Data estimated from Falchi et al. 2016a, b. The ratio of natural brightness as a function of distance was assumed to be the same as data measured from the artificial light produced from Red Dog Mine.
Source: Falchi et al. 2016 a, b

The magnitude of additional effects would be that nighttime views in areas 2 to 8 miles from the mine site would begin to experience reduced visibility of stars and other astronomical observations, and could become affected (degraded) in these areas. However; the number of viewers experiencing these effects would be low, and no areas in national parks and preserves, state game refuges, or national wildlife refuges would experience impacts of this magnitude.

In areas 1 to 2 miles from the mine site, effects to the night sky would become apparent to casual observers; the magnitude of impacts would increase and the Bortle Class would be affected. However, the number of viewers experiencing these effects would be low, and no areas in national parks and preserves, state game refuges, or national wildlife refuges would experience impacts of this magnitude.

In terms of extent, areas less than 1 mile from the mine site would experience a sky that would never appear darker than twilight, and true night conditions would never be experienced. In terms of magnitude, this would be considered strong visual contrast. The Bortle Class would be degraded; however, the number of viewers experiencing these effects would be low, and no areas in national parks and preserves, state game refuges, or national wildlife refuges would experience impacts of this magnitude. The duration of impacts to the night sky would be long-term, lasting through the life of the mine; and they would be certain to occur under Alternative 1a.

## Soundscape

Operations at the mine site would involve noise-producing activities (including those related to discharge of fill) and processes that include blasting and extracting rock at the pit and transporting rock material to milling facilities or the pyritic tailings storage facility/potentially acid-generating storage facility. Section 4.19, Noise, describes anticipated noise-related impacts that could result from construction, operation, and closure of the mine. Based on the results of the noise analysis, it was determined that—in terms of magnitude and extent—the existing "wilderness ambient" soundscape would be unaffected beyond a distance of 10 miles from the mine site. Within approximately 18,450 feet, the estimated operational noise level would be at least 30 dBA equivalent continuous sound level ($L_{eq}$), and therefore would risk causing sleep disturbance for recreationists and subsistence hunters sleeping outdoors during any seasonal activities on lands considered "wilderness ambient." Within approximately 12,900 feet, the estimated operational noise level would be at least 45 times day-night sound level (dBA $L_{dn}$) at a building exterior. These impacts to the soundscape would last for the duration of project operations. See Section 4.19, Noise, for more information.

During construction, impacts to soundscape could also result from increases in project-related flights that could occur between Anchorage and Iliamna to transport material and personnel. The magnitude of the impact would be seven low-elevation flightpaths (lower than 14,000 feet) between these two locations that cross sensitive receptors at Lake Clark National Park and Preserve and communities (see Appendix K3.12, Transportation and Navigation, for flightpaths). If these routes are used frequently for the project, there could be additional impacts to the soundscape from these flights. Project-related flights into and out of Iliamna and Kokhanok would increase noise levels in those communities and surrounding areas for the life of the project, and would be expected to occur, as discussed in Section 4.5, Recreation. During operations, there would be fewer flights traveling to Iliamna, because materials would be shipped via barge and not flown, and there would be fewer employees.

## Reclamation

Following reclamation, the magnitude and extent of visual contrast and scale dominance of the mine site is expected to decrease due to removal of mine components, and regrading and replanting of vegetation. However, the mine site would still be visually evident in the foreground-middleground, resulting in high-magnitude impacts when viewed from this distance zone. Magnitude of impacts would decrease with distance to medium in background distance zones. Night sky and soundscape-related impacts would be reduced, because operation of the mine would cease.

### 4.11.4.2 Transportation Corridor

## Visual Impacts

Specific components of the transportation corridor would result in variable levels of visual contrast and scale dominance. In terms of magnitude, access roads could result in strong visual contrast in form, line, color, and texture against the surrounding landscape, because linear/curvilinear lines and gray-brown color and coarse texture of the road would contrast surrounding natural color, textures, and lines of the landscape. Mine-related traffic on the roadway could be visually evident due to movement and associated dust plumes. Vehicle traffic may be visible from areas along the Gibraltar and Newhalen rivers where recreational and subsistence fishing takes place, especially where the port and mine access roads would cross the rivers. Movement of vehicles would be more apparent during dark sky conditions, because vehicle lighting would be evident.

The magnitude and extent of these impacts would be greatest when viewed from higher elevation or superior viewer positions (such as overflights) in the western end of Lake Clark National Park and Preserve, because roads would not be screened by vegetation, and visual contrast of the cleared vegetation of the roadway would contrast to the surrounding landscape. When viewed from Nondalton, the mine access road would be expected to result in weak visual contrast, because viewers would be primarily situated at a similar grade to the road, and visibility would be minimized by vegetation screening. In terms of geographical extent, the mine access road would be greater than 5 miles from this community, thereby further minimizing the potential for visual contrast or scale dominance. The magnitude of impacts from the mine access road would be strong visual contrast when viewed from higher elevations on Roadhouse Mountain. Approximately 3 miles from Roadhouse Mountain, the road would appear as a discrete curvilinear line that results in strong visual contrast against the landscape and would be visually evident. The crossing of the Newhalen River would also be visible (see Appendix K4.11).

The magnitude of impacts resulting from both the Eagle Bay and south ferry terminals would be a moderate to strong visual contrast when viewed in the foreground-middleground distance zone from Iliamna Lake or higher-elevation locations (see Appendix K4.11 for visual simulations from defined KOPs). Ferry terminal facilities would be NVE or VS from villages on the shoreline of Iliamna Lake, because the communities are either outside of the seen area, or are situated greater than 25 miles away. The south ferry terminal would be within 2 miles of the mouth of the Gibraltar River, where the terminal and the ferry traffic could be seen by recreationist and subsistence users. From Iliamna Lake, the ferry terminals would appear distinct against the shoreline, because the form and line of the structures would contrast with the natural character of the surrounding landscape. Visual contrast would primarily result from the angular lines, varied colors, and smooth texture of cargo containers where they would be stockpiled at the terminals. Strong visual contrast would result from night-lighting where direct views of artificial lighting for the Eagle Bay and south ferry terminals would be experienced. Reflection and glare off Iliamna Lake would further increase the visual contrast from the artificial lighting at the ferry terminals. In terms of geographic extent, reflections off the lake could potentially be viewed by individuals living and recreating in/near Newhalen, Iliamna, and Kokhanok. There are commercial lodges in/near each of these communities that would also experience effects from night-lighting.

Ferry traffic would appear dominant from Kokhanok, Newhalen, and Iliamna, because these communities are within 5 miles of the ferry route. Other communities are more than 10 miles from the route; given the size and low stature of the ferries, the magnitude of visual contrast is expected to be weak, and ferries would appear visually subordinate.

Season-specific operational impacts to aesthetic resources during winter months primarily pertain to lighting, the visual contrast created from ice break on the lake where the ferry would cross, and ferry noise associated with icebreaking. The magnitude and extent would be visual impacts experienced by residents of Kokhanok, Newhalen, and Iliamna due to the proximity of villages to the ferry terminal and crossing route. Individuals engaged in winter subsistence activity may also experience impacts from vehicle lighting on access roads and facility lighting at the ferry terminals.

The magnitude of impacts of the mine and port access roads perceived from residents, recreationists, or subsistence users in the EIS analysis area would be of weak to strong visual contrast and NVE to D dominance; the geographic extent would be foreground-middleground, due to screening of the road corridor by vegetation and the low stature of the ferry terminals (see Appendix K4.11 for project viewshed models). The visual contrast would be greater under dark sky conditions due to the contrast of night-lighting described below. Viewer exposure to the transportation corridor and associated uses would be intermittent to prolonged, depending on the activity of the viewer. The duration of impacts would be long-term, extending beyond the life of the project. Visual impacts would not impact viewers in areas identified as special management areas (e.g., national parks or wildlife management areas). The likelihood of impacts would be certain under Alternative 1a.

## Night Sky

The magnitude of impacts on the night sky would be strong visual contrast resulting from night-lighting where direct views of artificial lighting for the Eagle Bay and south ferry terminals would be experienced. Reflection and glare off Iliamna Lake would further increase the visual contrast from the artificial lighting at the ferry terminals. In terms of geographic extent, reflections off the lake could potentially be viewed by individuals living and recreating in/near Newhalen, Iliamna, and Kokhanok. There are commercial lodges in/near each of these communities that would also experience effects from night-lighting.

Skyglow from the Eagle Bay and south ferry terminals would brighten the night sky, affecting the human eye's ability to fully adapt to the dark; and would reduce visibility of stars and other astronomical observations at some distances. In terms of geographical extent, areas 5 to 13 miles from the ferry terminals could begin to experience effects to skyglow from artificial lighting (Table 4.11-4). Impacts may not be readily apparent; however, the introduction of this visual intrusion into an otherwise pristine night sky would begin to put the integrity of the night sky at risk. The magnitude and extent of impacts from skyglow would result in less than 1 percent of the Lake Clark National Park and Preserve and Katmai National Park and Preserve experiencing these types of effects from the Eagle Bay and south ferry terminals. Therefore, no change to night-sky quality or Bortle Class is expected at these distances from the ferry terminals' lighting alone.

**Table 4.11-4: Estimated Night-Sky Effects from Eagle Bay and South Ferry Terminals**

| Distance from Ferry Terminal[1] | Eagle Bay Ferry Terminal[2] | | South Ferry Terminal[3] | |
|---|---|---|---|---|
| | Total Acres Affected | Acres in Lake Clark National Park and Preserve Affected | Total Acres Affected | Affected Acres in Katmai National Park and Preserve |
| 5 to 13 miles | 293,680 | 30,911 | 295,133 | 10,021 |
| 1 to 5 miles | 50,355 | 0 | 51,073 | 0 |
| <1 mile | 2,546 | 0 | 2,741 | 0 |

Notes:
[1] Data estimated from Falchi et al. 2016a, b. The ratio of natural brightness as a function of distance was assumed to be the same as data measured from the artificial light produced from Red Dog Port.
[2] Eagle Bay ferry terminal would have no night-sky impacts to Katmai National Park and Preserve.
[3] The south ferry terminal would have no night-sky impacts to the Lake Clark National Park and Preserve.
Source: Falchi et al. 2016a, b

In terms of magnitude and extent, areas 1 to 5 miles from the ferry terminals would begin to experience reduced visibility of stars and other astronomical observations. The night-sky quality could become degraded in these areas. The community of Kokhanok could experience these types of effects. No areas in national parks and preserves, state game refuges, or national wildlife refuges would experience impacts of this magnitude.

Also, in terms of magnitude and extent, effects to the night sky would become apparent to casual observers with reduced visibility in areas less than 1 mile from either ferry terminal. The night-sky quality would be degraded. No areas in Lake Clark National Park and Preserve, Katmai National Park, communities, or commercial lodges would experience these types of effects (Table 4.11-4). Therefore, the number of individuals experiencing impacts of this magnitude would be low.

## Soundscape

During operations, truck traffic, light vehicles, and maintenance along the mine access road (including those related to construction, dredge, or fill material) could result in impacts to soundscape that extend up to 0.5 mile from the road corridor, as measured by the potential for a 45 dBA $L_{max}$ value, assuming a 15 miles per hour (mph) speed limit for large diesel-engine vehicles, and a 30 mph speed limit for passenger vehicles (maximum value level) (see Section 4.19, Noise, for more information). The presence of dense vegetation or terrain features like ridgelines or hills could narrow this distance. Impacts to soundscape from the access route would endure for as long as the project is in the operations phase, and would be expected to occur.

Primary impacts to soundscape from operation of the ferry terminals would result from continuous (day and night) operation of the power supply (generator) at each ferry terminal. The magnitude of impacts from this feature would be the production of a reference sound level no greater than 70 dBA $L_{eq}$ at 50 feet (see Section 4.19, Noise, for more information). In terms of extent, within approximately 2,250 feet from the ferry terminal, the estimated operational noise level would be at least 30 dBA $L_{eq}$, and therefore would risk causing sleep disturbance for any recreationists and subsistence users sleeping outdoors during their seasonal activities on lands considered "wilderness ambient." Also in terms of extent, within approximately 1,000 feet, the estimated operational noise level would be at least 45 dBA $L_{dn}$ at a building exterior. Other indirect impacts to soundscape may result from icebreaking as the ferry crosses the lake during winter operations. Anticipated impacts to soundscape would persist through operations, and would be expected to occur under Alternative 1a.

Following reclamation, visual contrast and scale dominance of the transportation corridor would persist, because roads would remain operational. Visual impacts associated with ferry terminals and ferry transportation would cease, because these facilities would be removed. Ferry terminals would be replaced with contoured gravel landings. Although landings would appear distinct from the natural shoreline, they would not be visually evident beyond the foreground-middleground. Night sky–related impacts would be reduced, because landings would not be outfitted with night-lighting. Soundscape-related impacts would also be reduced due to the limited and intermittent use of barge operations and lack of generators.

### 4.11.4.3 Amakdedori Port

## Visual Impacts

The magnitude and visual contrast of the Amakdedori port would be similar to those described for the Eagle Bay and south ferry terminals. The port facility would be larger in size, and involve different types and frequencies of vessel operations. Visual contrast may be stronger when viewed from close proximity or overflights, due to the larger stature of this facility. Vertical lines and geometric shape of the facility would contrast against the low marshlands, with the backdrop of the rolling hills and mountains. As a result of the unobstructed horizon of Cook Inlet, the geographic extent of impacts would continue until moderate to strong contrast attenuated to a weak level (anticipated beyond 10 miles). See Appendix K4.11 for project viewshed models. Development of the port would result in direct effects to aesthetics by changing the configuration of the shoreline and creating an industrial feature in an otherwise natural landscape in Kamishak Bay. The geographical impact of indirect effects would be that increased project-related boat traffic on Kamishak Bay in Cook Inlet would be visually evident from the foreground, middleground, and background distance zones. The port would not be visible from the mouth of McNeil River at the edge of McNeil State Game Refuge; however, vessel traffic (including lighting) at the southern location would be evident, and could be a dominant part of the viewers' experience when vessels are present. Visual impacts could affect viewers in areas identified by special designations; namely, the McNeil River State Game Refuge (including Chenik Lagoon) and Alaska Maritime National Wildlife Refuge. These impacts would primarily affect visitors during the summer season. Peak visitation and viewing is from early summer into fall, and would be extremely low during the winter. Such impacts could indirectly affect the naturalness of the recreation experience at this destination. Although seasonal, the duration would be considered long-term, because impacts would occur throughout the life of the project.

## Night Sky

The magnitude and extent of impacts from glare and skyglow would be similar to those described for the Eagle Bay and south ferry terminals. As discussed for ferry terminals, strong visual contrast would be expected to result from night-lighting and the potential for haloing during winter months, when lighting is reflected off the snow's surface. Increases in brightness and associated impacts to night sky would be noticeably greater during periods of snow cover. Reflection off of Cook Inlet would occur, although it would only be visible to a small number of viewers.

The magnitude and geographical extent of impacts on the night sky would be such that areas 5 to 13 miles from Amakdedori port could begin to experience effects to skyglow from artificial lighting that would begin to put the integrity of the existing pristine night sky at risk. In terms of magnitude, about 38 percent of the McNeil River State Game Refuge, and less than 1 percent of the Alaska Maritime National Wildlife Refuge would experience moderate to strong visual contrast from night-lighting. No specific communities or commercial lodges were identified that would be impacted.

In terms of magnitude and geographical extent, areas 1 to 5 miles from Amakdedori port would begin to experience reduced visibility of stars and other astronomical observations, and the night-sky quality could become degraded in these areas. No national parks and preserves, communities, or commercial lodges would experience these impacts. About 7 percent of the McNeil River State Game Refuge and less than 1 percent of the Alaska Maritime National Wildlife Refuge would experience impacts of the same magnitude (Table 4.11-5).

In terms of magnitude and extent of impacts, effects to the night sky would become apparent to casual observers in areas less than 1 mile from Amakdedori port, and the Bortle Class night-sky quality would be degraded. No national parks and preserves, national wildlife refuges, state game refuges, communities, or commercial lodges would experience effects of this magnitude (Table 4.11-5). Therefore, the number of individuals experiencing impacts of this magnitude would be low.

**Table 4.11-5: Estimated Night-Sky Effects from Amakdedori Port[1]**

| Distance from Port[2] | Total Acres Affected | Acres in McNeil River State Game Refuge Affected | Affected Acres in Alaska Maritime National Wildlife Refuge |
|---|---|---|---|
| 5 to 13 miles | 304,492 | 49,941 | 286 |
| 1 to 5 miles | 55,770 | 9.073 | 105 |
| <1 mile | 4,126 | 0 | 0 |

Notes:

[1] Amakdedori port would have no night-sky impacts to the Lake Clark National Park and Preserve or Katmai National Park and Preserve.

[2] Data estimated from Falchi et al. 2016a, b. The ratio of natural brightness as a function of distance was assumed to be the same as data measured from the artificial light produced from Red Dog Port.

Source: Falchi et al. 2016a, b

**Soundscape**

Although the equipment and types of vehicles used are different, the technique used for estimating noise exposure attributable to Amakdedori port operations is similar to and uses the same conservative assumptions as the technique used for estimating aggregate noise emissions from mine site operations. In addition, noise from vessel operations, whether during lightering or transit of ore concentrate vessels, could also be audible to people in coastal areas of McNeil River State Game Refuge and the Alaska Maritime National Wildlife Refuge. The magnitude and extent of impacts determined from the predictive analysis, and considering sound attenuation with distance and other factors, would be:

- Within approximately 9,750 feet, the estimated operations-attributed noise level would be at least 30 dBA $L_{eq}$, and therefore would risk causing sleep disturbance for any recreationists and subsistence hunters sleeping outdoors during their seasonal activities on lands considered "wilderness ambient."
- Within approximately 5,800 feet, the estimated operational noise level would be at least 45 dBA $L_{dn}$ at a building exterior, and therefore would be 10 dBA greater than the existing outdoor ambient sound level.

The duration of impacts in the two latter above-stated distance buffers would be long-term throughout port operations. See Section 4.19, Noise, for more detailed analysis.

**Reclamation**

Following reclamation, the magnitude and extent of visual contrast and scale dominance of the Amakdedori port would be considered not visually evident, because most port facilities would be removed. Because the remaining terminal would no longer operate with the same frequency of vessel traffic, soundscape-related impacts would also be reduced. Likewise, because the terminal would no longer be outfitted with night-lighting, night-sky impacts would be eliminated.

### 4.11.4.4 Natural Gas Pipeline Corridor

Because the natural gas pipeline corridor would follow much of the transportation corridor, it would not introduce additional visual contrast in form, line, color, or texture that is distinct from the port and mine access roads.

The exception would be the segment from the northern shore of Iliamna Lake to the mine access road. In that segment, visual moderate-strong contrast of the cleared right-of-way (ROW) would contrast the existing natural landscape. As described in the transportation corridor, visual contrast would be perceived by viewers situated in close proximity to the pipeline, or in elevated viewer positions. The pipeline ROW would follow, roughly, the route of an existing road, although not co-located. Viewers from high elevations would see both the ROW clearing and the existing road. Some portions of the cleared ROW would be visible to those traveling along the road.

Pipeline construction activities for this segment would create noise in conjunction with construction, which would be of limited duration. Residents of Newhalen and Iliamna would hear the construction noise within 0.5 mile of activities. Gas traveling through the buried pipeline would not emit audible noise.

In terms of magnitude, the compressor station on the Kenai Peninsula would result in weak visual contrast against the surrounding landscape, and would be visually subordinate against the natural landscape. In terms of geographical extent, the compressor station would not be seen from Anchor River State Recreation Area or Stariski Campground, and therefore would be unlikely to occur. The impacts on visual contrast would be long-term, lasting though the life of the project.

Although pipeline construction activities would create noise in conjunction with road construction, the duration would be limited to 2 years. No noise-producing sources would be situated along the pipeline corridor during pipeline operation. Gas traveling through the buried pipeline would not emit audible noise. The compressor station on the Kenai Peninsula would produce some noise, but would not be expected to impact sensitive receptors; therefore, no noise impacts associated with pipeline operations would occur under Alternative 1a.

The natural gas pipeline corridor is not expected to have any impacts on the night sky.

### 4.11.4.5 All Components

Due to the scale of the project, many of the components are geographically isolated from each other and from population centers or areas of frequent visitation; as a result, opportunity to experience visual contrast of more than one component is limited. An exception to this limitation applies to those experiencing views of the project from recreational or local low-altitude aircraft, as well as skyglow effects. Fourteen low-elevation flightpaths cross the analysis area that could experience views of the project, as shown in Appendix K3.12, Transportation and Navigation (FAA 2018). In terms of magnitude when viewed from the air, the project would result in moderate to strong visual contrast due to vegetation removal and ground disturbance in access roads and the mine site. For air-based viewers flying to recreation destinations such as the McNeil River State Game Refuge, the transportation corridor and Amakdedori port would be visually evident. Additionally, skyglow effects from different project components could also be visible from one location, which together could increase the magnitude of effects to night sky. The magnitude and duration of visual impacts would be moderate to strong visual contrast that would last for the life of the project. The extent of impacts would decrease with distance from the facilities.

During construction, impacts to the visual environment and soundscape could also result from increased project-related air traffic. As described in Section 4.12, Transportation and Navigation, in terms of magnitude and extent, a Twin Otter or similar aircraft would make 20 to 40 flights per month (average of 5 to 10 flights per week) to Amakdedori port, before the Kokhanok airstrip could be accessed by road. Once the Kokhanok spur road was established, there would be up to 10 flights per month by Twin Otters to Kokhanok. The duration of impacts would be intermittent, but long-term, and could affect important scenic resources at the Lake Clark or Katmai National Parks and Preserves, McNeil River State Game Refuge, Alaska Maritime National Wildlife Refuge, communities, or commercial lodges.

During operations, the magnitude of project flights would include those transporting employees on 2-week rotations, as well as cargo flights. Section 4.12, Transportation and Navigation, includes details on the number and location of project flights. In terms of extent, increases of air traffic have the potential to be observed by visitors to Lake Clark National Park and Preserve, where small aircraft are the primary transportation for park visitors. The potential for impacts would be reduced, however, because flights from Anchorage to Bristol Bay generally fly over Iliamna Lake or the project area (FAA 2018) (see Section 3.12, Transportation and Navigation), rather than the preserve, and therefore would be unlikely to occur. Additionally, the project-related air traffic would not conflict with small planes, which fly at lower altitudes and use narrow passes, such as Lake Clark Pass. The duration of impacts from helicopter traffic would remain throughout operations, because helicopters would be used to perform ongoing environmental monitoring (variable by frequency and season) and aerial inspections of the transportation corridor (weekly or monthly) (PLP 2018-RFI 027b). These effects would be long-term, occurring through the life of the project under Alternative 1a.

The magnitude, extent, and duration of impacts from air traffic would be intermittent, but lasting though the life of the project, and could affect important scenic resources at the Lake Clark or

Katmai National Parks and Preserves, McNeil River State Game Refuge, Alaska Maritime National Wildlife Refuge, communities, or commercial lodges.

Following reclamation, visual contrast and scale dominance of the project would be reduced; however, the remaining roadway, airstrips, and mine site infrastructure would remain visually evident. When viewed from the air, the project would result in moderate visual contrast due to ground disturbance in access roads and the mine site. Night-sky impacts are expected to be reduced to a low-medium level, largely due to removal of lighting from ferry terminals and the port. During project closure, impacts from overflights would decline, because fewer personnel would travel to and from the project area.

## 4.11.5 Alternative 1

The magnitude, duration, extent, and likelihood of impacts to aesthetic resources (visual, including night sky, and soundscape) at the mine site, south ferry terminal, port access road, and Amakdedori port under Alternative 1 under construction, operations, and reclamation would be the same as or similar to those described for Alternative 1a.

### 4.11.5.1 Transportation Corridor

The transportation corridor under Alternative 1 would result in variable levels of visual contrast and scale dominance, as described under Alternative 1a. Impacts from the port access road would be the same as Alternative 1a, including the crossing of the Gibraltar River. Impacts from the mine access road would be similar to those for Alternative 1a: the magnitude and extent of impacts would be greatest when viewed from higher elevation or superior viewer positions—such as overflights—and roads not screened by vegetation; and visual contrast of the cleared vegetation of the roadway would contrast to the surrounding landscape.

As described for the Eagle Bay and south ferry terminals in Alternative 1a, in terms of magnitude and extent, the north ferry terminal and the south ferry terminal would result in moderate to strong visual contrast when viewed in close proximity (3 to 5 miles) from Iliamna Lake or higher-elevation locations. From this distance zone, the ferry terminals would appear distinct against the shoreline, because the form and line of the structures would contrast with the natural character of the surrounding landscape. Impacts to the community of Kokhanok would be the same as described under Alternative 1a. Other villages on Iliamna Lake would be greater than 10 miles from the ferry terminals and route. Given the size and low stature of the ferries, the magnitude and extent of visual contrast would be weak, and ferries would appear visually subordinate.

The magnitude, geographical extent, and duration of impacts to the night sky from the north ferry terminal would be similar to those described for the Eagle Bay and south ferry terminals in Alternative 1a. There would be no impacts to the night sky from the land-based transportation corridor. Reflection off Iliamna Lake would occur, but it would only be visible to a small number of viewers. Areas 5 to 13 miles from the ferry terminals could begin to experience effects to skyglow from artificial lighting (Table 4.11-6). Impacts may not be readily apparent; however, the introduction of this visual intrusion into an otherwise pristine night sky would begin to put the integrity of the night sky at risk. Impacts to the McNeil River State Game Refuge are discussed with the port access road under Alternative 1a.

The magnitude, duration, extent, and likelihood of impacts to soundscape would be similar to those described for Alternative 1a. Noise-related impacts would not be expected to affect local communities, because communities are more than 0.5 mile from the transportation corridor.

The magnitude, duration, extent, and likelihood of impacts following reclamation would be similar to those described for the transportation corridor under Alternative 1a.

**Table 4.11-6: Estimated Night-Sky Effects from North and South Ferry Terminals**

| Distance from Ferry Terminal[1] | North Ferry Terminal[2] | South Ferry Terminal | |
|---|---|---|---|
| | Total Acres Affected | Total Acres Affected | Affected Acres in Katmai National Park and Preserve |
| 5 to 13 miles | 292,285 | 295,133 | 10,021 |
| 1 to 5 miles | 49,651 | 51,073 | 0 |
| <1 mile | 2,366 | 2,741 | 0 |

Notes:
[1] Data estimated from Falchi et al. 2016a, b. The ratio of natural brightness as a function of distance was assumed to be the same as data measured from the artificial light produced from Red Dog Port.
[2] The north ferry terminal would have no night-sky impacts to the Katmai National Park and Preserve.
Source: Falchi et al. 2016a, b

### 4.11.5.2 Natural Gas Pipeline Corridor

The magnitude, duration, extent, and likelihood of impacts under Alternative 1 would be the same as those described above for the transportation corridor, because these components would be co-located. The magnitude, duration, extent, and likelihood of impacts expected to result from the compressor station on the Kenai Peninsula would be the same as Alternative 1a.

Impacts following reclamation would be similar to those described for the natural gas pipeline under Alternative 1a.

The natural gas pipeline corridor is not expected to have any impacts on the night sky.

### 4.11.5.3 All Components

The magnitude, duration, extent, and likelihood of visual impacts would be similar to those described for Alternative 1a for the mine site, port access road, south ferry terminal, and Amakdedori port. The magnitude, duration, extent, and likelihood of visual impacts from the mine access road would be similar to those described for the port access road. The proximity of the port and mine access roads to popular recreation destinations could result in viewer exposure to those features. For example, the transportation corridor, pipeline corridor, and Amakdedori port would be visually evident for air-based viewers flying to recreation destinations such as the Lake Clark National Park and Preserve, McNeil River State Game Refuge, Katmai National Park and Preserve, and area sport fishing lodges. The magnitude of visual impacts would be expected to be of moderate to strong visual contrast, and would decrease with distance from the facilities.

The magnitude, duration, extent, and likelihood of impacts following reclamation would be similar to those described for all components under Alternative 1a.

### 4.11.5.4 Alternative 1—Kokhanok East Ferry Terminal Variant

The magnitude, duration, and extent of potential impacts to visual resources and soundscapes would be similar to those described for the south ferry terminal; however, the perception of impacts would be greater due to the close proximity of the ferry traffic to residential viewers and noise-receptors in Kokhanok. Kokhanok and commercial lodges in the vicinity would be approximately 5 miles from the Kokhanok east ferry terminal; therefore, visibility of stars and other astronomical observations from these areas would be affected. All these impacts would be long-term, occurring through the life of the project, and would be certain to occur under this variant.

Impacts following reclamation would be similar to those described above for ferry terminals, because similar reduction of visual contrast and scale dominance would occur. Likewise, similar reduction in impacts to night-lighting and soundscape would be expected.

#### 4.11.5.5 Alternative 1—Summer-Only Ferry Operations Variant

Under the Summer-Only Ferry Operations Variant, in terms of magnitude and extent, visual and soundscape impacts from ferry operations would not occur during the winter, but would be more intense during the summer, with twice the number of ferry trips. Impacts to night sky would be substantially less than other alternatives due to the use of less lighting and less visibility from lighting from extended daylight hours. The duration of impacts, although seasonal, would be long-term, lasting for the life of the project, and they would be certain to occur under this variant.

Under the Summer-Only Ferry Operations Variant, the magnitude of impacts from the transportation corridor would be less in the winter due to the decrease in lighting-related impacts, the reduction of truck traffic, and the lack of ice breaks from the ferry operations. This would be offset to some degree by the doubling of truck traffic during the summer, with accompanying visual and noise impacts. The reduction in impacts would be primarily experienced under the Kokhanok East Ferry Variant, because residents of this community would experience the greatest visual and soundscape-related impacts during winter months, when the transportation corridor was operational; due to proximity of these receptors to the port; and due to increased number of trips.

Impacts following reclamation would be similar to those described above for ferry terminals, because similar reduction of visual contrast and scale dominance would occur. Likewise, similar reduction in impacts to night-lighting and soundscape would be expected.

#### 4.11.5.6 Alternative 1—Pile-Supported Dock Variant

In terms of magnitude, duration, extent, and likelihood, the Pile-Supported Dock Variant would result in similar impacts to those described above for visual impact, night sky, and soundscape for the Amakdedori port.

Also, impacts following reclamation would be similar to those described above for ferry terminals, because similar reduction of visual contrast and scale dominance would occur. Likewise, similar reduction in impacts to night-lighting and soundscape would be expected.

### 4.11.6 Alternative 2—North Road and Ferry with Downstream Dams

The magnitude, duration, extent, and likelihood of impacts to aesthetic resources (visual, including night sky, and soundscape) at the mine site under Alternative 2—North Road and Ferry with Downstream Dam would be the same as or similar to those described for Alternative 1a under construction, operations, and reclamation.

#### 4.11.6.1 Transportation Corridor

<u>**Visual Impacts**</u>

The transportation corridor under Alternative 2 would result in variable levels of visual contrast and scale dominance, as described under Alternative 1a. The magnitude and extent of impacts from the mine access road would be the same as discussed under Alternative 1a.

Between Pile Bay and Diamond Point port, the magnitude and extent of impacts of operation of the port access road would be weak visual contrast, particularly in areas where the new access road would lie in the same location as the existing roads.

As described for the north and south ferry terminals, in terms of magnitude and extent, the ferry terminals at Eagle Bay and Pile Bay would result in moderate to strong visual contrast when viewed in close proximity (3 to 5 miles) from Iliamna Lake or higher-elevation locations. From this distance zone, the ferry terminals would appear distinct against the shoreline, because the form and line of the structures would contrast with the natural character of the surrounding landscape.

The communities of Newhalen and Iliamna are the only residential areas within approximately 10 miles of the ferry terminals. From these locations, the magnitude and extent of visual contrast would be weak, and the facilities would not be visually evident under daylight conditions. Noise from ferry icebreaking activities could be apparent to these communities.

Other villages on Iliamna Lake would be greater than 15 miles from the ferry terminals and route. Given the size and low stature of the ferries, the magnitude and extent of visual contrast would be weak, and ferries would appear visually subordinate. There is one small research camp on the peninsula of Pedro Bay. From this location, passing ferry traffic would be considered visually evident.

As described in Alternative 1a, the magnitude and extent of season-specific impacts to aesthetic resources during winter months primarily pertain to those that would result from lighting, and the visual contrast created from ice break on the lake where the ferry crosses. The extent of visual impacts would be primarily experienced by residents of Iliamna, Newhalen, and Pedro Bay due to the proximity of these communities to the ferry terminals and crossing route. Individuals engaged in winter subsistence activity would also experience impacts from vehicle lighting on access roads and facility lighting at the ferry terminals.

The duration of viewer exposure to visual impacts would be intermittent to prolonged at any given time depending on the activity of the viewer, but would be long-term, extending beyond the life of the project. Visual impacts would not impact viewers in areas identified by special designations (see the project viewshed models in Appendix K4.11). The likelihood of impacts would be certain under Alternative 2.

## Night Sky

The magnitude, duration, and geographical extent of impacts to the night sky from the Eagle Bay ferry terminal would be the same as described in Alternative 1a, and the Pile Bay ferry terminal would be similar. There would be no impacts to night sky from the land-based transportation corridor. Reflection off of Iliamna Lake would occur, but it would only be visible to a small number of viewers.

Areas 5 to 13 miles from Eagle Bay or Pile Bay ferry terminals, in terms of magnitude and extent, could begin to experience effects to skyglow from artificial lighting that would begin to put the integrity of the existing pristine night sky at risk. Less than 1 percent of the Lake Clark National Park and Preserve would be affected by the Eagle Bay and Pile Bay ferry terminals (Table 4.11-7). Pedro Bay and commercial lodges in the vicinity would also experience these impacts.

The magnitude and extent of impacts to areas 1 to 5 miles from Eagle Bay or Pile Bay ferry terminals would be the beginning of reduced visibility of stars and other astronomical observations, and the Bortle Class night-sky quality could become degraded. No communities, national parks, state game refuges, or national wildlife refuges would experience this level of impacts. Therefore, the number of individuals experiencing these effects would be low.

**Table 4.11-7: Estimated Night-Sky Effects from Eagle Bay and Pile Bay Ferry Terminals**

| Distance from Ferry Terminal[1] | Eagle Bay Ferry Terminal | | Pile Bay Ferry Terminal | |
|---|---|---|---|---|
| | Total Acres Affected | Acres in Lake Clark National Park and Preserve Affected | Total Acres Affected | Affected Acres in Lake Clark National Park and Preserve |
| 5 to 13 miles | 293,680 | 30,911 | 293,682 | 6,425 |
| 1 to 5 miles | 50,355 | 0 | 50,345 | 0 |
| <1 mile | 2,546 | 0 | 2,545 | 0 |

Notes:
[1] Data estimated from Falchi et al. 2016a, b. The ratio of natural brightness as a function of distance was assumed to be the same as data measured from the artificial light produced from Red Dog Port.
Source: Falchi et al. 2016a, b

Also in terms of magnitude and extent, effects to the night sky would become apparent to casual observers, because visibility of the night sky would be reduced in areas less than 1 mile from Eagle Bay or Pile Bay ferry terminals. The night-sky quality would be degraded at distances 1 mile or less from the ferry terminals. No areas in national parks and preserves, state game refuges, or national wildlife refuges or communities would experience impacts of this magnitude; therefore, the number of individuals experiencing these effects would be low. These impacts on the night sky would be long-term, lasting through the life of the project. Their likelihood of occurrence would be certain under Alternative 2.

## Soundscape

The magnitude, duration, extent, and likelihood of impacts to soundscape would be similar to those described for Alternative 1a; however, noise-related impacts would not be expected to affect local communities, because communities are more than 0.5 mile from the transportation corridor.

**Reclamation:** The magnitude, duration, extent, and likelihood of impacts following reclamation would be similar to those described for the transportation corridor under Alternative 1a.

### 4.11.6.2 Diamond Point Port

## Visual Impacts

The magnitude of impacts from the Diamond Point port would be less than that described for the Amakdedori port under Alternative 1a because of the level of existing development. Visual contrast would appear strong when viewed from the foreground distance zone due to the larger stature of this facility; the vertical lines and geometric shape of the facility would contrast against the natural backdrop of Iliamna Bay. The geographic extent of impacts would be more limited than Amakdedori port due to the steep landforms and enclosure of views created by topography surrounding the bay (see Appendix K4.11 for project viewshed models). For viewers situated in the bay, the port would appear dominant and focal due to the enclosure of the landscape in the bay.

Increased project-related boat traffic in Cook Inlet would be visually evident from the foreground, middleground, and background distance zones. The port would be visible from the Alaska Maritime National Wildlife Refuge, and vessel traffic would be evident and could dominate the viewers' experience. The duration of impacts would be long-term, extending beyond the life of the project if the port remains in operation. Visual impacts could impact viewers in areas identified by special designations, including the Alaska Maritime National Wildlife Refuge. In terms of likelihood, the impacts would be expected to occur under Alternative 2.

## Night Sky

The magnitude, duration, and extent of impacts to the night sky from the Diamond Point port would be similar those described for Amakdedori port. There would be no impacts to night sky from the land-based transportation corridor.

In terms of magnitude and extent, areas 5 to 13 miles from Diamond Point port could begin to experience effects to skyglow from artificial lighting that would begin to put the integrity of the existing pristine night sky at risk.

The Lake Clark and Katmai National Parks and Preserves, and McNeil River State Game Refuge and all identified communities and commercial lodges are further than 13 miles from Diamond Point port; less than one-tenth of 1 percent of the Alaska Maritime National Wildlife Refuge falls within that distance.

These impacts on the night sky from the Diamond Point port would be long-term, lasting through the life of the project (Table 4.11-8). Their likelihood of occurrence would be certain under Alternative 2.

**Table 4.11-8: Estimated Night-Sky Effects from Diamond Point Port for Alternative 2**

| Distance from Port[1] | Total Acres Affected | Affected Acres in Alaska Maritime National Wildlife Refuge |
|---|---|---|
| 5 to 13 miles | 303,601 | 92 |
| 1 to 5 miles | 55,322 | 14 |
| <1 mile | 3,874 | 1 |

Notes:

[1] Data estimated from Falchi et al. 2016a, b. The ratio of natural brightness as a function of distance was assumed to be the same as data measured from the artificial light produced from Red Dog Port.

Source: Falchi et al. 2016a, b

## Soundscape

The magnitude, duration, extent, and likelihood of impacts to the soundscape would be similar to those described for Amakdedori port (see Section 4.19, Noise, for more information). Noise-related impacts would be largely contained in Iliamna Bay due to the steep topography of the surrounding landforms.

## Reclamation

The magnitude, duration, extent, and likelihood of impacts following reclamation would be similar to those described for the Amakdedori port under Alternative 1a.

### 4.11.6.3 Natural Gas Pipeline Corridor

## Visual Impacts

The magnitude of impacts from the pipeline would be greatest between the junction with the Eagle Bay ferry terminal access road and the Pile Bay ferry terminal access road because visual moderate-strong contrast of the cleared right-of-way would contrast the existing natural landscape. As described in the transportation corridor, visual contrast would be perceived by viewers situated in close proximity to the pipeline, or in elevated viewer positions (e.g., Roadhouse Mountain). Visual contrast of the segment between Diamond Point port and Ursus Cove would be weak-moderate because of the rugged topography of the Chigmit Mountains. Individuals traveling between Dutton and Meadow Lake would be exposed to visual contrast where the pipeline crossed the access trail. Air-based viewers would perceive moderate contrast of this feature when viewed from low-elevation aircraft. Where aligned with the exiting Williamsport-Pile Bay Road, the pipeline would result in weak to moderate visual contrast resulting primarily from roadway upgrades.

**Night Sky**

The natural gas pipeline corridor is not expected to have any impacts on the night sky.

**Soundscape**

As described for Alternative 1a, pipeline construction activities would create noise in conjunction with road construction, the duration of which would be limited to 2 years. No noise-producing sources would be situated along the pipeline corridor during pipeline operation. Gas traveling through the buried pipeline would not emit audible noise, and the compressor station on the Kenai Peninsula would not be expected to impact sensitive receptors; therefore, no noise impacts associated with pipeline operations would occur under Alternative 2.

### 4.11.6.4 All Components

The magnitude, duration, extent, and likelihood of visual impacts from all components would be similar to those described for Alternative 1a; however, the proximity of the port and mine access roads to popular recreation destinations could result in increased viewer exposure to those features. For example, the transportation corridor, pipeline corridor (including between Diamond Point port and Ursus Cove), and Diamond Point port would be visually evident for air-based viewers flying to recreation destinations such as the Lake Clark National Park and Preserve, McNeil River State Game Refuge, Katmai National Park and Preserve, and area sport fishing lodges, although not as visually evident as the Amakdedori port under Alternative 1a. The magnitude of visual impacts would be expected to be of moderate to strong visual contrast, and would decrease with distance from the facilities.

Frequency and impacts of flights to and from Iliamna would be the same as Alternative 1a. Construction cargo and passenger flight frequencies to the airstrip in Pile Bay would be similar to flight frequencies to Kokhanok under Alternative 1a. Impacts to Pedro Bay and Pile Bay would be similar to those discussed for Kokhanok in Alternative 1a, including the use of the airport at Pedro Bay during construction. Potential effects on Kokhanok would be limited to resident crew change flights. PLP would not construct a new airstrip at Diamond Point, but would improve the existing airstrip near Pile Bay for limited use during construction. In terms of likelihood, these impacts would be expected to occur under Alternative 2.

**Reclamation**

The magnitude, duration, extent, and likelihood of impacts following reclamation would be similar to those described for all components under Alternative 1a.

### 4.11.6.5 Alternative 2—Summer-Only Ferry Operations Variant

Under the Summer-Only Ferry Operations Variant, visual and soundscape impacts from ferry operations would not occur during the winter, but would be more intense during the summer with twice the number of ferry trips. The magnitude of impacts to night sky would be substantially less than other alternatives due to the extended daylight hours. The duration of impacts would be long-term.

The magnitude, duration, extent, and likelihood of impacts following reclamation would be similar to those described for Summer-Only Ferry Operations Variant under Alternative 1.

#### 4.11.6.6 Alternative 2—Pile-Supported Dock Variant

The Pile-Supported Dock Variant would result in similar impacts in terms of magnitude, duration, extent, and likelihood to those described above for visual resources, soundscape, and night sky.

Impacts following reclamation would be similar to those described for the Pile-Supported Dock Variant under Alternative 1.

#### 4.11.6.7 Alternative 2—Newhalen River North Crossing

The Newhalen River North Crossing Variant would result in similar impacts in terms of magnitude, duration, extent, and likelihood to those described above for visual resources, soundscape, and night sky. The river crossing would be just as visible, and perhaps more visible, from Roadhouse Mountain as Alternative 2.

### 4.11.7 Alternative 3—North Road Only

The magnitude, duration, extent, and likelihood of impacts to aesthetic resources (visual, including night sky and soundscape) at the mine site under Alternative 3—North Road Only would be the same as or similar to those described for Alternative 1a under construction, operations, and reclamation.

#### 4.11.7.1 Transportation Corridor

The magnitude, duration, extent, and likelihood of impacts from the transportation corridor under Alternative 3 would be similar to Alternative 2 in portions of the network that are the same under both alternatives (mine site to junction leading to Eagle Bay ferry terminal; Pile Bay to Diamond Point port). However, because the access road would extend along the northern shore of Iliamna Lake, impacts would be of greater magnitude and larger geographic extent (see Appendix K4.11 for project viewshed models). Visual contrast would be strong, and the road would appear dominant when viewed from the foreground-middleground of the community of Pedro Bay; from areas within 3 miles of the shoreline of Iliamna Lake; and from high points in Lake Clark National Park and Preserve. The magnitude, duration, extent, and likelihood of impacts to night sky would be the same as those under Alternative 2.

Given the proximity of the access road to Pedro Bay, noise from construction activities and operational truck traffic could be heard in the community up to 3,000 feet from the activity.

**Reclamation**

Impacts following reclamation would be similar to those described for the transportation corridor under Alternative 1a.

#### 4.11.7.2 Diamond Point Port

The duration, extent, and likelihood of impacts under Alternative 3 would be similar those described for Alternative 2. The magnitude of visual impacts would be higher than Alternative 2 because the development at the port site would be in addition to the development of the quarry at Diamond Point. There would be no impacts to night sky from the land-based transportation corridor. Impacts following reclamation would be similar to those described for Amakdedori port under Alternative 1a.

In terms of magnitude and extent, areas 5 to 13 miles from Diamond Point port could begin to experience effects to skyglow from artificial lighting that would begin to put the integrity of the existing pristine night sky at risk.

The Lake Clark and Katmai National Parks and Preserves, and McNeil River State Game Refuge and all identified communities and commercial lodges are further than 13 miles from Diamond Point port; less than one-tenth of 1 percent of the Alaska Maritime National Wildlife Refuge falls within that distance.

These impacts on the night sky from the Diamond Point port would be long-term, lasting through the life of the project (Table 4.11-9). Their likelihood of occurrence would be certain under Alternative 3.

**Table 4.11-9: Estimated Night-Sky Effects from Diamond Point Port for Alternative 3**

| Distance from Port[1] | Total Acres Affected | Affected Acres in Alaska Maritime National Wildlife Refuge |
|---|---|---|
| 5 to 13 miles | 309,829 | 91 |
| 1 to 5 miles | 58,572 | 14 |
| <1 mile | 4,647 | 2 |

Notes:

[1] Data estimated from Falchi et al. 2016a, b. The ratio of natural brightness as a function of distance was assumed to be the same as data measured from the artificial light produced from Red Dog Port.

Source: Falchi et al. 2016a, b

### 4.11.7.3 Natural Gas Pipeline Corridor

The magnitude, duration, extent, and likelihood of impacts under Alternative 3 would be the same as those described above for the transportation corridor, because these components would be co-located. The magnitude, duration, extent, and likelihood of impacts expected to result from the portion of the pipeline between Diamond Point port and Ursus Cove would be the same as those described under Alternative 2.

Impacts following reclamation would be similar to those described for the natural gas pipeline under Alternative 1a.

### 4.11.7.4 All Components

The magnitude, duration, extent, and likelihood of visual impacts from all components would be similar to those described for Alternative 2; however, the magnitude of visual impacts would be greater due to operation of the north access road. The road would be visually evident, appearing as a curvilinear line with contrasting color and texture against the surrounding landscape.

Frequency of flights, and associated magnitude of effects, to and from Iliamna would be the same as for Alternative 1a. Flight frequencies to Pedro Bay, and associated magnitude of effects, would be similar to Alternative 2; but the connecting of Pedro Bay by road to the Cook Inlet would affect frequency of flights after construction, if the road leads to more traffic through Pedro Bay. Potential effects on Kokhanok would be limited to resident crew change flights. These impacts would last for the life of the project, and would be expected to occur under Alternative 3.

Impacts following reclamation would be similar to those described for all components under Alternative 1a.

#### 4.11.7.5 Alternative 3—Concentrate Pipeline Variant

The Concentrate Pipeline Variant would result in impacts similar in magnitude, duration, extent, and likelihood to those described above for visual impacts, soundscape, night sky, and reclamation.

### 4.11.8 Cumulative Effects

As described above for the analysis of direct and indirect effects, impacts to aesthetics would include those that could result from changes in the visual landscape (including night sky), soundscape, or olfactory attributes. For this analysis, visual impacts are defined as changes to the scenic attributes of the landscape resulting from the introduction of visual contrasts (e.g., development), and the associated changes in the human visual experience of the landscape (NPS 2014b). Impacts to soundscape are defined by changes in dBA levels that alter soundscape from a "wilderness ambient" character (see Section 3.19, Noise). Potential impacts to traditional and cultural use of areas are discussed in Section 4.7, Cultural Resources.

The cumulative effects analysis area for aesthetics encompasses Iliamna Lake and the surrounding communities and west to Cook Inlet. For night-sky impacts, the cumulative effects analysis area would be 140 miles from the mine site and 50 miles from the ferry terminals and ports.

A number of the actions identified in Section 4.1, Introduction to Environmental Consequences, are considered to have no potential of contributing to cumulative effects on aesthetic and visual resources because they are outside the EIS analysis area, or are the type of activities that do not create a permanent change in visual or aesthetics effects, or there is no indication that development would occur during the operations timeframe of the project.

Potential cumulative impacts to aesthetics and soundscape include visual impacts from the air, ground, and water transport and activities. Visual impacts at nighttime would be different than during the day, because development often includes lighting features.

#### 4.11.8.1 Past and Present Actions

Currently, there is little development outside of communities in the EIS analysis area. Other activities in the region that impact aesthetics include subsistence, recreation, and mining exploration activities. Mining exploration activities have been supported by aircraft, which generate temporary but regular noise that has been noticeable to local residents, as documented in scoping comments. Temporary mining exploration camps in support of drilling programs have also generated visual and noise impacts in their immediate area. Support of commercial recreation by guides, lodges, and air taxis has generated aircraft and small boat noise in the vicinity of their activities. Transport of fishing vessels and cargo over the Williamsport-Pile Bay Road has historically generated summer truck traffic and increased vessel traffic on Iliamna Lake during the summer, which is noticeable to local residents and non-resident recreational users. These would be expected to continue to contribute to the cumulative impacts of aesthetics, although impacts are low in intensity and generally seasonal in duration. The Iliamna Airport has introduced skyglow to the night sky, extending approximately 6 miles from the airport.

### 4.11.8.2 Reasonably Foreseeable Future Actions

Reasonably foreseeable future actions (RFFAs) in the cumulative impact analysis area identified in Section 4.1, Introduction to Environmental Consequences, have the potential to contribute cumulatively to impacts on aesthetics that are carried forward in this analysis. These include contiguous mining claims located roughly between Iliamna Lake and the Chuitna River, as well as more geographically isolated claims in the watershed, oil, and gas development in Cook Inlet, and smaller-scale onshore oil and gas, as summarized below.

The No Action Alternative would not contribute to cumulative effects on Aesthetics.

Collectively, the project alternatives with RFFAs' contribution to cumulative effects on aesthetics are summarized in Table 4.11-10.

**Table 4.11-10: Contribution to Cumulative Effects on Aesthetics**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Pebble Project Expansion Scenario | **Mine Site:** The mine site footprint would have a larger open pit and new facilities to manage water and store tailings and waste rock, and would contribute to the cumulative impacts of aesthetics in the region. Expansion of the open pit and tailings/waste rock storage facilities would increase the visual and noise impacts that could be experienced by local subsistence hunters in the area, and by recreational users that are dropped off and float the upper reaches of the Koktuli and Stuyahok rivers.<br>**Other Facilities:** A north access road and concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay. The transportation corridors between the mine site/Amakdedori port and the mine access road would operate concurrently, affecting those communities in the vicinity of both routes, although truck traffic to Amakdedori would decrease because concentrate would be transported to the Iniskin deepwater port by pipeline. Concentrate and diesel pipelines from the mine site to the Iniskin port facility would be in the access road corridor, and would not noticeably increase the visual impact of that corridor. The prolonged use of the Amakdedori port facility and port access road would continue to contribute adverse effects to the cumulative impacts in the region, and the development of a port in Iniskin Bay would have additive effects that alter landscape character from naturally evolving to industrial across a large geographic extent during the day and at night. Such impacts could be experienced by recreationists in Cook Inlet and would be of moderate magnitude, and dominant when viewed from high elevations, flightpaths, and nearby vessels. Operations would be audibly apparent within a | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** Similar to Alternative 1a, except that the portion of the access road from the north ferry terminal to the existing Iliamna area road system would need to be constructed. The north access road would be constructed from the mine site to the Pile Bay terminus of the Williamsport-Pile Bay Road. Concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay.<br>**Magnitude:** The magnitude of cumulative aesthetic and visual impacts would be similar to the magnitude of Alternative 1a, although affecting a larger geographic area.<br>**Duration/Extent:** The duration and extent of cumulative aesthetic and visual impacts would be similar to duration and extent of Alternative 1a.<br>**Contribution:** The contribution to cumulative | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** Under Alternative 2, there would be a road constructed between the ferry terminals along the north access road corridor described under Alternative 3, adversely impacting aesthetics by introducing development and use in a natural area. Impacts from the Diamond Point port would also continue, and development in Iniskin Bay would impact aesthetics in the same ways as Alternative 1a. The addition of a service road would add to the adverse impacts for the region's aesthetics.<br>**Magnitude:** Overall expansion would affect fewer acres than Alternative 1a, given that a portion of the north access road and all of the gas pipeline would already be constructed. Aesthetic and visual impacts from mine expansion would be less than Alternative 1a in that one road/pipeline corridor would be constructed and operated rather than two. | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** Under Alternative 3, project expansion would continue to use the existing Diamond Point port facility; would use the same natural gas pipeline; and would use the same north access road and the Concentrate Pipeline Variant infrastructure, but extend the concentrate pipeline to Iniskin Bay. The port site and associated facilities would be constructed at Iniskin Bay, as discussed under Alternative 1a. A diesel pipeline from the mine site to Iniskin Bay would be constructed, as discussed under cumulative effects for Alternative 1a.<br>**Magnitude:** Overall, expansion would affect fewer acres than Alternative 1a, given that the north road and gas pipeline would already be constructed. Aesthetic and visual impacts from mine expansion would be less than Alternative 1a, or Alternative 1 and Alternative 2. |

**Table 4.11-10: Contribution to Cumulative Effects on Aesthetics**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | certain distance of facilities. There would be further impacts to the region from the pipeline ROW from the mine site to Iniskin Bay, and the development of a road to Diamond Point. Impacts to the night sky from the Iniskin Bay port would be similar to impacts from the Diamond Point port in magnitude and geographic extent.<br>**Magnitude:** The Pebble Project expansion scenario project footprint would impact approximately 31,892 acres under Alternative 1a. The magnitude of impacts would be greater due to the larger mine site footprint and construction and operation of two separate access roads. The direct and indirect analysis conservatively assumed skyglow effects similar to Red Dog Mine. The Pebble Project expansion scenario is not expected to exceed the magnitude and geographic extent of those effects.<br>**Duration/Extent:** The Pebble Project expansion scenario would extend the impacts to aesthetics for a longer duration (78 total years of mining, with another 20 years of processing), and over a larger geographic area based on the operation of two road corridors and port systems.<br>**Contribution:** There would be additive effects to the viewshed for visitors flying over the region, because the landscape as a whole is more visible from a higher elevation, and the mine site would be more noticeable as it expands. With increased production, the frequency of vessel traffic to the Iniskin port facility would also increase. Similarly, impacts to night sky would have a longer duration. The operation of two road corridors would expand visual and audible effects over a larger geographic area, although truck traffic associated with shipping concentrate would cease along the south access road after 20 years of initial operations. | effects would be slightly less than Alternative 1, but more that Alternative 2 and Alternative 3. | **Duration/Extent:** The duration and extent of cumulative aesthetic and visual effects would be similar to duration and extent of Alternative 1a.<br>**Contribution:** Cumulative effects of construction disturbance would be similar to those discussed under Alternative 1a. Overall, cumulative impacts to aesthetics from Alternative 2, combined with the Pebble Project expansion scenario, would be of lesser magnitude and geographic extent than Alternative 1a, because the south access road system/ ferry would not be in place. | **Duration/Extent:** The duration and extent of cumulative aesthetic and visual effects would be similar to the duration and extent of Alternative 1a.<br>**Contribution:** Because the Pebble Project expansion scenario would use the north access road system that would already be built under Alternative 3 and not include any ferry operation, cumulative impacts to aesthetics from Alternative 3, combined with the Pebble Project expansion scenario, would be less than Alternative 1a or Alternative 1 and Alternative 2. |

**Table 4.11-10: Contribution to Cumulative Effects on Aesthetics**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Other Mineral Exploration Projects | **Magnitude:** Reasonably foreseeable locatable mineral exploration in the project area of Iliamna Lake and the Chuitna River, and east to Lake Clark, could contribute cumulatively to visual and audible impacts across a large geographic extent. These would be associated with helicopter support traffic and temporary camp facilities. Such impacts could be experienced by communities close to mineral deposits, and recreationists in Lake Clark National Park and Preserve and surrounding areas.<br>**Duration/Extent:** Exploration activities typically occur at a discrete location for one season, although a multi-year program could expand the geographic area affected in a specific mineral prospect. Table 4.1-1 in Section 4.1, Introduction to Environmental Consequences, identifies seven mineral prospects in the EIS analysis area where exploratory drilling is anticipated (four are in relatively close proximity to the Pebble Project).<br>**Contribution:** There would be additive effects to the viewshed for visitors flying over the region, because the activity would be more visible from a higher elevation. There would be increased impacts to recreationists and subsistence users in the area. Impacts to night sky would be of low magnitude, because activity for most mineral exploration projects would occur during summer months, and work is anticipated to be sporadic and of low intensity. Noise from helicopter support traffic would be audible along the flight path, in the vicinity of mining exploration activities, and near airports used for support, including at Iliamna. | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |
| Oil and Gas Exploration and Development | **Magnitude:** Oil and gas development in Cook Inlet would contribute cumulatively to impacts in Cook Inlet, with the magnitude dependent on the level of on- and offshore oil and gas development. Marine | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |

**Table 4.11-10: Contribution to Cumulative Effects on Aesthetics**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | support vessel and helicopter traffic may be visible and audible to marine and coastal recreational users. Lighting required would create reflection and glare on the surface of Cook Inlet, which—in combination with impacts from the Amakdedori port—would increase nighttime glare in the inlet. Night-lighting from the alternative oil and gas exploration and development could also increase overall skyglow in the vicinity. Construction of the Alaska LNG or the ASAP projects would increase ship traffic in the vicinity of Cook Inlet during the period of construction. Operation of the Alaska LNG project would generate monthly Alaska LNG carrier traffic for the duration of operations.<br>**Duration/Extent:** Seismic exploration and exploratory drilling are typically single-season temporary activities that have an increase in vessel traffic. Visual and audible effects associated with ship traffic from either Alaska LNG or ASAP would occur for the life of operations of those projects.<br>**Contribution:** Helicopter traffic associated with offshore development, combined with concentrate shipment from project development, and increased ship traffic would be noticeable to local residents and visitors using coastal areas along Cook Inlet in the vicinity of the project. | | | |
| Road Improvement and Community Development Projects | **Magnitude:** Road improvements projects would take place in the vicinity of communities, and have visual and aesthetics impacts through grading, filling, and potential increased erosion. Communities in the immediate vicinity of project facilities, such as Iliamna, Newhalen, and Kokhanok, would have the greatest contribution to cumulative effects. Some limited road upgrades could also occur in the vicinity of the natural gas pipeline starting point near Stariski | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |

**Table 4.11-10: Contribution to Cumulative Effects on Aesthetics**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | Creek, or in support of mineral exploration previously discussed.<br>**Duration/Extent:** The project would contribute to cumulative impacts, and there would be no difference across alternatives. Impacts to night sky would be minimal, because the majority of projects would be upgrades or improvements, and increase in night-lighting would be minimal. Night-lighting associated with new road corridors is also anticipated to be minimal.<br>**Contribution:** Transportation and infrastructure development in communities would contribute to cumulative impacts to a minor extent; however, when combined with other RFFAs, these actions would contribute to overall change in character in the region from one that is more remote and undeveloped to one that is more developed. | | | |
| Summary of Project contribution to Cumulative Effects | Overall, the contribution of Alternative 1a to cumulative aesthetic and visual effects, when taking other past, present, and RFFAs into account, would be minimal. There would be additive effects to the viewshed for visitors flying over the region, because the landscape as a whole is more visible from a higher elevation, and the mine site would be more noticeable as it expands. Similarly, impacts to night sky would have a longer duration. The analysis conservatively assumed skyglow effects similar to Red Dog Mine. The Pebble Project expansion scenario may exceed the magnitude and geographic extent of those effects. | Similar to Alternative 1a. | Similar to Alternative 1a, but of lesser magnitude and geographic extent than Alternative 1a, because the ferry infrastructure would not have been constructed. | Similar to Alternative 2, but would be of lesser magnitude and geographic extent, because ferry infrastructure would not have been constructed. |

Notes:
ASAP = Alaska Stand Alone Pipeline
EIS = Environmental Impact Statement
LNG = liquefied natural gas
RFFA = reasonably foreseeable future action
ROW = right-of-way

## 4.12 TRANSPORTATION AND NAVIGATION

The Environmental Impact Statement (EIS) analysis area for this section includes the transportation and navigation resources that could be affected by the mine site, port, transportation corridor, material sites, and natural gas pipeline corridor for each alternative. This includes surface transportation from the mine site to Cook Inlet and a small section of the Sterling Highway, air transportation from airports across the region (Dillingham to Anchorage), and water transportation on Cook Inlet, Iliamna Lake, and navigable rivers from the mine site to Cook Inlet. Navigation also includes deepwater port construction and usage from local to global users. Local and regional land, air, and water transportation systems and activities in the EIS analysis area are included. Potential impacts include:

- Additional vehicle traffic in the road-connected communities of Iliamna, Newhalen, Kokhanok, Nondalton, and Pedro Bay
- Off-road transportation access to subsistence areas
- Beneficial alternative routes for transporting goods
- Increased flight frequency to affected airports and communities
- Additional vessel traffic on Cook Inlet, with a higher volume during construction, and increased marine traffic in the port area
- Additional vessel traffic on Iliamna Lake
- Impediment of navigation along navigable rivers
- Re-routes of winter over-ice traffic on Iliamna Lake due to creation of open water

The magnitude of impacts from the project is determined by the amount of surface, air, and water traffic that would be interrupted or displaced. The duration and geographic extent of impacts depends on the location and season in which the disturbance occurs during construction, operations, or closure. Long-term impacts would last throughout the life of the project (i.e., years to decades); short-term effects would be temporary, lasting only through the construction phase, or months to years. The potential or likelihood of impacts is related to how likely the project would be to impact surface, air, and water transportation. Impacts from releases of diesel and other substances can be found in Section 4.27, Spill Risk.

### 4.12.1 Summary of Key Issues

**Table 4.12-1: Summary of Key Issues for Transportation and Navigation**

| Transportation Mode | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| **Surface Transportation** | Kokhanok, Iliamna, and Newhalen would experience an increase in volume of road traffic due to new road connections in the project area through operations.<br>There would be 35 round trips by truck per day on the mine access road and the port access road. | South of Iliamna Lake, impacts would be the same as Alternative 1a. North of Iliamna Lake, the impacts would be truck traffic on the mine access road from the north ferry terminal to the mine site. Construction impacts would be the same as Alternative 1a, except the road would not cross the Newhalen River Road. | Same as Alternative 1a, except impacts from traffic at Kokhanok would occur at Pedro Bay instead.<br>During operations, the pipeline ROW may create a route for ATV or snowmachine traffic between ferry terminals.<br>The Williamsport-Pile Bay Road would experience a high- | Same as Alternative 2, except that the road from Diamond Point to the mine site would be routed through Pedro Bay. During operations and closure, this road would increase traffic in Pedro Bay from mine operations and also from the public, because this road would connect the |

**Table 4.12-1: Summary of Key Issues for Transportation and Navigation**

| Transportation Mode | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | | The Kokhanok East Ferry Terminal Variant would change the terminus of the port access road but would not change traffic volume.<br>The Summer-Only Ferry Operations Variant would double truck traffic in the summer and eliminate it in winter.<br>The Pile-Supported Dock Variant would not affect surface transportation. | volume increase in traffic that would last the life of the project.<br>The Summer-Only Ferry Operations Variant and Pile-Supported Dock Variant would have similar effects to surface transportation as these variants under Alternative 1. | communities on the northern side of Iliamna Lake over land to each other and to Cook Inlet.<br>The Concentrate Pipeline Variant would reduce truck traffic on the transportation corridor from 35 round trips per day to 18; a controlled access service road would be constructed along the extension of the pipeline to Iniskin Bay. |
| **Air Transportation** | During construction, 10 flights per week would land at the Kokhanok airport. During operations, increased air traffic of up to 10 employee flights and one scheduled cargo flight per week would affect Iliamna and Kokhanok airports, plus additional unscheduled cargo flights. Kokhanok Airport would need improved navigation systems and lighting. | Same as Alternative 1a.<br>The variants would not affect air transportation. | Iliamna air traffic would be the same as under Alternative 1a. This alternative would use the Pile Bay Airstrip instead of the Kokhanok Airport, and the construction cargo and passenger flight frequencies to Pile Bay would be similar to flight frequencies to Kokhanok under Alternative 1a. Impacts to Pedro Bay and Pile Bay would be similar to those discussed for Kokhanok under Alternative 1a, including the use of the airport at Pedro Bay during construction. | Same as Alternative 2. |
| **Water Transportation** | The Amakdedori port and lightering system would add new structures to Cook Inlet that would increase the risk of vessel allision[1]. There would be a noticeable increase in barge and vessel traffic during operations. The new structures and additional marine traffic would not be expected to restrict water transportation.<br>Bridges over the Newhalen and Gibraltar rivers would introduce pilings and the height of the bridges as obstacles, which would increase the | Impacts from Amakdedori port and effects to Cook Inlet would be the same as Alternative 1a.<br>Impacts on Iliamna Lake water transportation would be the same as in Alternative 1a in frequency of traffic, but the ferry route and pipeline placement would be different and therefore change the specific pattern of traffic across Iliamna Lake.<br>Winter travel over Iliamna Lake would be impacted from open water caused by the ice- | A new port at Diamond Point would add similar structures in Cook Inlet and also require dredging, which would increase the risk of vessel allision. These new structures and existing vessel traffic in Iliamna Bay would not be expected to restrict water transportation.<br>Bridges over the Newhalen River, Pile River, and Iliamna River would introduce pilings and bridges that would increase the risk of vessel allision, although they are not | Effects on Cook Inlet and rivers would be the same as Alternative 2.<br>Alternative 3 would not require a ferry and would eliminate effects on winter traffic on Iliamna Lake that would occur under Alternative 1a, Alternative 1, and Alternative 2.<br>The Concentrate Pipeline Variant would not change the impacts to water transportation. |

**Table 4.12-1: Summary of Key Issues for Transportation and Navigation**

| Transportation Mode | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | risk of vessel allision. The bridges are not expected to restrict water transportation.<br>The ferry terminals would add new structures to Iliamna Lake that could increase the risk of vessel allision and there would be additional traffic. The new structures and additional traffic would not be expected to restrict water transportation.<br>Winter travel over Iliamna Lake would be impacted from open water caused by the ice-breaking ferry. | breaking ferry. This effect would not take place with the Summer-Only Ferry Operations Variant.<br>Impacts from the Kokhanok East Ferry Terminal Variant would be similar but in a different location. The Summer-Only Ferry Operations Variant would have the same in-water structures but would increase ferry trips from one to two round trips per day in the summer, and zero in the winter. This variant would not be expected to restrict water transportation. | expected to restrict water transportation.<br>The Summer-Only Ferry Operations Variant would have similar impacts to this variant under Alternative 1.<br>Winter travel over frozen Iliamna Lake would be impacted, but this ferry route experiences fewer average days of ice than the route under Alternative 1a. This effect would not take place with the Summer-Only Ferry Operations Variant.<br>The Newhalen River North Crossing Variant would have the same impacts as Alternative 2. | |
| **Navigation** | The Amakdedori port and lightering system would add new structures to Cook Inlet that would increase the risk of vessel allision. The new structures would not be expected to restrict navigation.<br>Bridges over the Newhalen and Gibraltar rivers would introduce pilings and the height of the bridges as obstacles, which would increase the risk of allision. The bridges are not expected to limit navigation.<br>The ferry terminals would add new structures to Iliamna Lake that could increase the risk of vessel allision and there would be additional traffic. The new structures and additional traffic would not be expected to restrict navigation. | Same as Alternative 1a. Frequency of traffic would remain the same. Location of the north ferry terminal and pipeline in Iliamna Lake would cause a difference in the traffic pattern on Iliamna Lake.<br>Impacts from the Kokhanok East Ferry Terminal Variant would be similar but in a different location. The Summer-Only Ferry Operations Variant would have the same in-water structures. This variant would not be expected to restrict navigation. The Pile-Supported Dock Variant would have the same impacts to navigation as Alternative 1. | A new port at Diamond Point would add similar structures in Cook Inlet and also require dredging, which would increase the risk of vessel allision. These new structures in Iliamna Bay would not be expected to restrict navigation.<br>Bridges over the Newhalen River, Pile River, and Iliamna River would introduce pilings and bridges that would increase the risk of vessel allision, although they are not expected to restrict navigation.<br>The Summer-Only Ferry Operations Variant would have similar impacts as this variant under Alternative 1. The Newhalen River North Crossing Variant would have the same impacts as Alternative 2. | Effects on Cook Inlet and rivers would be similar to Alternative 2. This alternative would not require a ferry and would eliminate the impacts to Iliamna Lake navigation that would occur under Alternative 1a, Alternative 1 and Alternative 2.<br>The Concentrate Pipeline Variant would not change the impacts to navigation for this alternative. |

Notes:
[1] Allision is a nautical term for when a vessel strikes a fixed object.
ATV = all-terrain vehicle
ROW = right-of-way

## 4.12.2 No Action Alternative

Under the No Action Alternative, federal agencies with decision-making authorities on the project would not issue permits under their respective authorities. The Applicant's Preferred Alternative would not be undertaken, and no construction, operations, or closure activities specific to the Applicant's Preferred Alternative would occur. Although no resource development would occur under the Applicant's Preferred Alternative, Pebble Limited Partnership (PLP) would retain the ability to apply for continued mineral exploration activities under the State's authorization process (ADNR 2018-RFI 073) or for any activity not requiring federal authorization. In addition, there are many valid mining claims in the area, and these lands would remain open to mineral entry and exploration by other individuals or companies.

It would be expected that current State-authorized activities associated with mineral exploration and reclamation, as well as scientific studies, would continue at levels similar to recent post-exploration activity. The State requires that sites be reclaimed at the conclusion of their State-authorized exploration program. If reclamation approval is not granted immediately after the cessation of activities, the State may require continued authorization for ongoing monitoring and reclamation work as it deems necessary. The level of activity and use of transportation systems in the region would be assumed to remain the same as the past 10 years.

Scoping comments expressed concerns about increased use and user conflicts at Iliamna Lake, Kamishak Bay, and Cook Inlet. Concerns were also expressed regarding how the ferry crossing and vessel traffic could impact local boaters and access, and whether snowmachine travel on Iliamna Lake would be impacted. High winds on Iliamna Lake and their potential to impact the ferry crossing were also noted. The following sections address these and other issues.

## 4.12.3 Alternative 1a

Alternative 1a would use the port access road between Amakdedori port and the south ferry terminal at Kokhanok. The ferry would cross Iliamna Lake between the south ferry terminal west of Kokhanok to the ferry terminal at Eagle Bay. The natural gas pipeline would be located in the transportation corridor from Amakdedori port to the south ferry terminal, cross Iliamna Lake, then come ashore between Iliamna and Newhalen, traveling north until co-locating with the mine access road to the mine site

### 4.12.3.1 Surface Transportation

**Mine Site**

Alternative 1a would involve the construction and use of roads in the mine site, and connection of mining areas with the locations of facilities and material sites.

During project construction, operations, and closure, public access to or through the mine site would be restricted at the mine site safety boundary (PLP 2018-RFI 058). Such a restriction to public access would be long term, lasting through the life of the project. The area is not commonly used by the public; however, subsistence overland travel that occurs in the area of the mine site would require adjustments to traditional routes (PLP 2018-RFI 088) (see Section 4.9, Subsistence, for impacts on access to subsistence resources). The likelihood of impacts related to travel restrictions would be certain under Alternative 1a.

Project construction, operations, and closure activities would introduce additional vehicles and road use patterns in the mine site area. The magnitude and extent of this adverse effect would be the amount of displacement of existing surface transportation modes (primarily all-terrain vehicle and snowmachine trails). Impacts in the analysis area would be long term for the life of the project and would be certain to occur if the project is permitted and built. Impacts would include the need to take alternate overland routes around the mine site and would be most apparent during construction and operations.

## Transportation Corridor

During construction, the port access road would be constructed from the Amakdedori port site to the southern shore of Iliamna Lake and the mine access road would be constructed from the northern shore of Iliamna Lake at Eagle Bay to the mine site. Construction would involve using heavy equipment (for construction, excavation, and pipeline installation) and vehicles to transport personnel, fuel, and supplies during construction activities. Crews would live in camps at work sites. A temporary airstrip would be built at Amakdedori port to facilitate the construction phase, and Amakdedori port would be used for off-loading construction equipment and supplies from air and water deliveries. The magnitude and extent of impacts from these actions would be in the number of vehicles using the roads. Road traffic in Kokhanok would increase during construction as project vehicles travel from the airstrip to the port access road. Similarly, road traffic in Iliamna and Newhalen would increase during construction from project vehicles associated with delivering goods and services from the airstrip to the mine access road and from local employees traveling to construction work sites. This volume of traffic would decrease with the transition from construction to operations but would still be higher than before construction.

Until Iliamna Lake is connected to Cook Inlet via the transportation corridor at the south ferry terminal, the Williamsport-Pile Bay Road (which connects the two waterbodies at the north end of Iliamna Lake over land) would be used to transport supplies to the beachheads on Iliamna Lake during construction (PLP 2018-RFI 037). The magnitude and extent of the impact would be an increase in the volume of vehicles on the Williamsport-Pile Bay Road during construction. The road is currently used infrequently (an average 38 trips per day in the summer only) (see Section 3.12, Transportation and Navigation) to transport commercial fishing vessels and general supplies (Kevin Waring & Associates 2010b). The impact would last throughout construction and would be certain to occur under Alternative 1a.

The intersection of the mine access road with the Newhalen River Road would connect the mine access road to the existing roads in the communities of Iliamna and Newhalen, and seasonally to Nondalton. The Kokhanok spur road would connect the Kokhanok community roads to the port access road, which would run from the south ferry terminal to Amakdedori port. The spur road would be gated to prevent vehicles from using the port access road. Additional access would be coordinated between the State of Alaska, the Lake and Peninsula Borough (LPB), PLP, and landowners. Known trail crossings would be marked, and traffic controls would be implemented for safety (PLP 2018-RFI 027). Use of the mine and port access roads, and the spur road to Kokhanok by the local communities and businesses would be scheduled and coordinated with PLP. The magnitude of impact would decrease after mine closure because mine traffic would decrease (but would not be eliminated) and the road system would be retained as long as required for the transport of bulk supplies needed for post-closure water treatment and monitoring, possibly lasting for years or decades. The adverse effects would be noticed by the nearby community members who travel through the area.

The current public roadway network in the EIS analysis area is limited to the vicinity of existing communities and is used by local residents. Local roads provide important routes for overland travel, because there are no alternative roads. The airports in Iliamna and Kokhanok are outside of each town center. The magnitude of impacts on local roads would be an increase in the number of vehicles on roads connecting the towns of Iliamna and Kokhanok to their respective airports, with fewer additional vehicles in town. The duration of the impact would be long term, and it would be certain to occur if the project is permitted and Alternative 1a is implemented.

If snow cover on land and ice formation on Iliamna Lake are adequate during winter, surface transportation occurs over land and Iliamna Lake for subsistence activities and inter-village travel. The new port and mine access roads could act as obstacles for overland inter-village and subsistence travel, although there would be marked crossing points for known trail crossings (PLP 2018-RFI 027). People using off-road vehicles and snowmachines could potentially create unauthorized trails from the project roads or rights-of-way (ROWs) to access lands and waterbodies. This would be infrequent as access to the project roads would be regulated and therefore limited. These impacts would be long term.

During project operations, daily transportation of materials (concentrate, fuel, reagents, and consumables) would require up to 35 round trips by truck per day on each leg of the road, including three loads of fuel per day. A maximum driving speed of 35 miles per hour would be enforced on the corridor roads using GPS fleet tracking technology (PLP 2018-RFI 122). Personnel would be transported to the mine site from Iliamna, and non-resident workers would remain at the mine site during their 2-week work shifts, which would minimize traffic on the mine and port access roads. Personnel who live locally would be transported daily via shuttle bus. Gates limiting unauthorized traffic would be installed on the spur road. The communities of Iliamna, Newhalen, and Nondalton could see altered traffic patterns and a higher volume of vehicles on the roads as employees are transported from the Iliamna Airport to the mine site. There are no existing roads in the vicinity of the road that would be constructed from Eagle Bay to the mine site; this road would cross the existing Newhalen River Road. Building a spur road to Iliamna would not be necessary under this alternative. The magnitude of impacts from this alternative would be the increased traffic on the Newhalen River Road (maintained by the State) between the crossing and Iliamna. The duration of impacts would be long term lasting for the life of the project and the likelihood of impacts would be certain to occur.

Impacts on surface transportation would last through the life of the mine and post-closure until the roads are no longer deemed necessary for post-closure monitoring activities. These impacts would be certain to occur under Alternative 1a.

## Amakdedori Port

The temporary beachhead and workforce camps for construction, the Amakdedori port facilities (lasting for the life of the project), and post-closure facilities at Amakdedori would be located in the same general area. Currently, no existing/developed surface transportation facilities exist in the vicinity of the port site. The magnitude and extent of impacts from port construction and operation would be the amount of disrupted surface transportation activities associated with the area's subsistence and cultural uses. Figures in Section 3.9 and Appendix K3.9, Subsistence, show some subsistence use in the areas in the vicinity of Amakdedori, but not at the port site. While subsistence use in the area of the port appears to be infrequent, construction and operations activities at the Amakdedori port site could require that some traditional overland routes be altered. The port also could provide a beneficial alternative route for goods to be shipped to Iliamna Lake communities, which could be less expensive than current methods. These impacts would last for the life of the project through closure and would be certain to occur under Alternative 1a.

## Natural Gas Pipeline Corridor

During construction of the pipeline on the Kenai Peninsula and connection to the compressor station near Anchor Point, summer traffic on the Sterling Highway would be affected by vehicles transporting materials to the site. The magnitude and extent of the effect would be the amount of traffic that would be delayed and disrupted due to construction of the project components. These traffic delays are expected to be similar to the usual delays experienced on the Sterling Highway during the summer months when tourist traffic is at its highest and road construction is most active (PLP 2018-RFI 037). Construction of this portion of the pipeline is expected to take 3 months during the summer, and the effects would be cumulative with any other local delays. Disruption of traffic may include lane closures and slow vehicles in the immediate vicinity of the construction site. This disruption would be short-term, only occurring during pipeline construction; however, the likelihood of occurrence is certain under Alternative 1a.

Because construction of the pipeline would be in the main transportation corridor from Amakdedori port to the mine site and would not cross existing roads, there would be no additional disruption of community roads systems associated with pipeline installation on the south side of Iliamna Lake. To the north of Iliamna Lake, the natural gas pipeline would make landfall west of Eagle Bay near Newhalen, causing a new corridor to be constructed from the lake to the mine access road. This leg of the pipeline roughly parallels the Newhalen River Road and two smaller roads, crossing each road once. The construction of the pipeline could cause delays in transport for those using the roads between Newhalen and Iliamna, but those impacts would end after the construction phase. The new pipeline corridor could create potential for use as an all-terrain vehicle (ATV) or snowmachine path with offshoots for resource access; this impact would be long term and last for at least the life of the project.

During operations and closure, inspections and maintenance of the pipeline would not be expected to have adverse effects on over-land traffic.

### 4.12.3.2 Air Transportation

Existing airports in Iliamna and Kokhanok would be used to transport personnel and some supplies to and from the project area for construction and operations activities. Iliamna Airport has the capacity to facilitate the planned aircraft traffic for the project and would not require improvements. Kokhanok Airport has a runway capable of handling the anticipated commuter flights for workers, but would require improvements to lighting and navigation, and potentially air radio service. Improvements would presumably take place on the existing airport footprint and therefore would not affect surface waters, including wetlands and other waters. Additional maintenance of the Kokhanok Airport would be required with an increase in traffic and would not be anticipated to have an effect on surface waters, including wetlands and other waters (PLP 2018-RFI 027b). Transportation infrastructure improvements would remain in place after closure providing a potential beneficial impact for regional travel. Helipads would also be built at Amakdedori port and at the mine site. In the event that emergency evacuation of mine personnel is required, any of these air travel facilities could be used.

During construction, work crews would access sites by helicopter or boat until the mine access road is complete. An airstrip would be built at Amakdedori port to facilitate construction. The magnitude of impacts during construction would be the number of flights required. A Twin Otter or similar aircraft would make 20 to 40 flights per month (average of 5 to 10 flights per week) to Amakdedori port, before Kokhanok could be accessed by road. Once the Kokhanok spur road is established, the magnitude would decrease to up to 10 flights per week by Twin Otters to Kokhanok (PLP 2018-RFI 027a). The airstrip at Amakdedori would remain in place through operations for emergency use.

During operations, an estimated 600 employees would fly to Iliamna Airport from the Anchorage or Kenai airport, approximately 200 employees would fly to Iliamna and Kokhanok from surrounding community airports, and about 50 employees would travel by road to project locations; employee flights would be on a 2-week rotation. The magnitude of impacts would be measured by the number of additional weekly employee flights to Iliamna, including one Twin Otter from King Salmon, one from outlying villages, two from Dillingham, four from Kenai, and two

Q400 flights from Anchorage (10 total). If these airplanes are commercial carriers and not private charters, it could have a beneficial effect of more frequent commercial flights, providing for more flight options for local residents. Kokhanok would receive 5 to 10 employee flights per week during operations (PLP 2018-RFI 027a). Iliamna and Kokhanok airports would also receive an estimated one cargo flight per week, and six unscheduled cargo flights per year, in addition to the above passenger flights (PLP 2018-RFI 027). This would increase air traffic from the current annual operations (see Section 3.12, Transportation and Navigation). Increases of air traffic at these magnitudes have the potential to be observed by visitors to Lake Clark National Park and Preserve, where small aircraft are the primary transportation for park visitors; however, this potential would be reduced because flight paths from Anchorage to Bristol Bay generally go over Iliamna Lake or the project area (FAA 2018) (see Section 3.12 and Appendix K3.12, Transportation and Navigation), rather than the preserve. Additionally, Pebble-related air traffic would not conflict with small planes, which fly at a lower altitude and use narrow passes such as Lake Clark Pass. Helicopter traffic would remain throughout operations to perform ongoing environmental monitoring (frequency would depend on the season) and aerial inspections of the transportation corridor (weekly or monthly) (PLP 2018-RFI 027b). These effects would be long term, occurring throughout the life of the project, and would be certain to occur under Alternative 1a.

In terms of magnitude, during project closure, impacts on air traffic would decline because fewer personnel would travel to and from the project area; aerial environmental monitoring and transportation inspections would continue by helicopter (PLP 2018-RFI 027b). Additionally, project personnel would most likely use commercial airlines and cargo flights instead of private charters (PLP 2018-RFP 027a).

### 4.12.3.3 Water Transportation

**Mine Site**

No new water access would be constructed at the mine site. No water transportation impacts would occur at the mine site from the project.

**Transportation Corridor**

The Alternative 1a transportation corridor would cross waterbodies, including the Newhalen River, Gibraltar River, Iliamna Lake, and Cook Inlet. The lower Newhalen River Bridge would have a minimum of 32 feet of vertical clearance in the navigation channel, with 96 feet between each piling. The Newhalen River is approximately 510 feet wide at the crossing. The Gibraltar River bridge would be built where the river is approximately 100 feet wide, but the bridge would extend to 300 feet, with pilings 100 feet apart. The minimum vertical clearance would be 43 feet above the river (PLP 2018i). Existing structures on the Newhalen River include one small-boat launch and a beach landing, indicating that traffic on this river does not include larger vessels. The Gibraltar River bridge would be much smaller than the Newhalen River bridge, and the river supports smaller vessels. The magnitude of impacts due to the structures would be the increased likelihood of a vessel being impeded by either bridge, as the instream pilings would represent a risk of allision[1] to vessels.

Water transportation at the crossings on these two rivers would be directly affected during construction of the crossings and the associated increase in traffic crossing the river. Direct effects of the river crossings after construction would consist of the presence of obstacles from the bridge pilings and the height of the bridges. The risk of impacts would be reduced over the long term

[1] Allision is a nautical term for when a vessel strikes a fixed object.

(during operations and after mine closure), as compared to over the short term (during construction). These impacts to navigation would be certain to occur under Alternative 1a.

To support construction of the north and south ferry terminals and the ferry itself, small temporary barges would cross Iliamna Lake until completion of the ferry terminals. Barges may also move freight and equipment transported during construction on the Williamsport-Pile Bay Road, increasing Iliamna Lake traffic. Construction of the Eagle Bay ferry terminal may use facilities in Iliamna and Newhalen, possibly increasing road traffic and barge traffic to Iliamna creating an additional impact on lake traffic. Employees may be transported to work via boat during this phase. The magnitude of these impacts would be the amount of inter-village and subsistence travel temporarily impeded by construction traffic along the shorelines and across the lake via watercraft, and commercial traffic in Iliamna, Newhalen, and Kokhanok. Structures added to the lake would include ramps at the south ferry terminal and the Eagle Bay ferry terminal (a maximum of 115 feet wide by 155 feet long). A 200-foot by 160-foot ferry construction ramp at the south ferry terminal would extend 36 feet out into the lake. Two mooring buoys would be installed at each ferry terminal, attached to the lake substrate or to anchors 2 feet in diameter. During construction of these project components, there would be direct adverse impacts on water transportation on Iliamna Lake. These adverse impacts would be reduced during operations. The structures would be visible and lighted, but the lake is large enough to provide routes around the structures.

During mine operations, the ferry would cross Iliamna Lake year-round along an 18-mile route that would take an estimated 1.5 hours in open water, or 3 hours in ice conditions. The magnitude of impacts to other lake traffic and navigation would be one round-trip per day in open water by the ferry; this trip would not disrupt lake traffic because it would be infrequent and alternate routes across the lake would be available. The effects would last through operations and post-closure and would be expected to occur under Alternative 1a.

Scoping comments noted hurricane-force winds on Iliamna Lake, which could be hazardous for the ferry crossing in open water. Eagle Bluff, west of Kokhanok, would be downwind of the ferry route and could pose a hazard to the ferry in high winds if it lost power or steering. In addition, there are small islands in the lake within approximately 5 miles of the ferry route that could potentially be hazardous in a high wind situation. The ferry would be constructed with multiple engines, propellers, and steering to minimize the potential for loss of control and reduce impacts (PLP 2018-RFI 052). Scoping comments also noted that winds can push broken ice onshore in large piles; this onshore ice movement has potential to damage infrastructure such as the ferry terminals (especially the north ferry terminal under Alternative 1 due to prevailing wind direction) and would need to be addressed in the design.

When the lake is frozen, if ice cover is sufficient, it is used as a passageway for snowmachines and occasional passenger vehicles (PLP 2018-RFI 088). The magnitude of project impacts on winter lake transportation would be in the number of residents disrupted by cross-lake snowmachine routes and exposed to potential safety hazards from open water created by the ice-breaking ferry. Residents of Kokhanok and Newhalen traveling across Iliamna Lake between those communities would have longer travel times to avoid hazards from the ice breaking ferry. PLP would work with communities (and supply funding) to provide for the marking and maintenance of snowmachine trails between communities across Iliamna Lake and around the ferry route when lake ice is sufficient enough to support such traffic (PLP 2018-RFI 071a). Travel in darkness or white-out conditions includes inherent risks, and trail markings may not be sufficient under low-visibility conditions. The impacts would be long term and certain to occur, lasting throughout the use of the ferry. After mine closure, ferry facilities would be removed and supplies would be transported across the lake using a summer barging operation; therefore, there would be no impacts from ice-breaking ferries.

## Amakdedori Port

During construction and operations, supply barges would transport materials, supplies, and equipment to Amakdedori port, creating an increase in barge traffic on Cook Inlet. The magnitude would be the increase in barge traffic during operations: approximately 27 concentrate vessels and 33 supply barges per year (an average of one vessel per week). Each concentrate vessel would require 10 lightering barge trips between the port site and lightering location to fill the bulk carrier, which would be anchored for 4 to 5 days. Diesel delivery to the port would be by tank barges with an expected maximum load of 4 million gallons to allow fewer shipments during the winter. The additional vessel traffic on Cook Inlet overall would add approximately 110 transits or port calls (an average of two per week) to the 2010 count of 480 (an average of nine per week); however, there is very little existing vessel traffic in Kamishak Bay/west Cook Inlet. Barge speeds would be between 5 and 7 knots and wake heights would not be expected to exceed natural waves at the shore (PLP 2018-RFI 039). The geographical extent of the impacts would be across Cook Inlet and the impacts would be long term, lasting throughout the life of the project.

Amakdedori port infrastructure in Cook Inlet would include an earthen causeway that would extend to 15 feet of natural water depth (1,900 feet long by up to 500 feet wide), two navigation buoys (anchored by 3-foot concrete blocks or anchors), and two lightering locations (2,300 feet by 1,700 feet, with buoys marking the corners and anchored in 80 feet of water). These structures would pose an allision risk for the infrequent traffic that occurs on the west side of the Cook Inlet and would likely be most noticeable when unfavorable sea conditions force vessels to moor in the safe harbor of Iniskin Bay. The impacts would be realized during construction from increased vessel activity, would decrease slightly during operations, and even more so post-closure, after the dock structures have been removed.

Amakdedori port would be located in Kamishak Bay, which has several identified reefs, as well as strong winds that create a funnel effect off of the surrounding mountains. Winds can be accompanied by short, choppy sea on flood currents and cause heavy swells. From Tignagvik Point to Cape Douglas, vessels are warned to proceed with caution (NOAA 2017). Project vessels may encounter these winds and swells during barging and lightering activities; vessels could drift onto reefs, mud flats, or otherwise run aground at the southern end of Kamishak Bay or near Amakdedori should they lose power or steering. The duration of impact would be long term and would be expected to occur under Alternative 1a. Two lighted navigation buoys (3 feet in diameter) would be located on the reefs framing the entrance to the Amakdedori port. The nearby Augustine volcano has potential to cause a tsunami at the port site as it has in the past (PLP 2018-RFI 039) (see Section 4.15, Geohazards and Seismic Conditions).

## Natural Gas Pipeline Corridor

Construction of the entire pipeline would take place during the second and third years of construction. Impacts on water transportation would be from the construction of the pipeline, with 104 miles crossing the Cook Inlet seabed and 21 miles crossing on the Iliamna Lake bed. This construction phase would involve working in and crossing a high-traffic area of Cook Inlet and would represent collision hazards for vessels transiting Cook Inlet and Iliamna Lake (Eley 2012; Nuka and Pearson 2015). The construction of the Cook Inlet crossing of the pipeline would be expected to take 30 to 40 days and would include approximately 10 construction, support, and survey vessels. These vessels would stay in Cook Inlet for the duration of this effort, some vessels would travel to shore daily to resupply. In Iliamna Lake, pipeline construction would require one barge (PLP 2018-RFI 027b). Impacts on water transportation would be short term and certain to occur.

In terms of magnitude, once the pipeline is fully operational, effects on vessel traffic and anchoring in Cook Inlet or in Iliamna Lake would be reduced. The 12-inch-diameter pipe would be placed in a trench deeper than the height of the installation, or HDD would be used to install pipe segments. If the depth of water is greater than 200 feet, the pipeline would be placed atop the seabed. This pipeline would add to the multiple pipelines and other structures already installed and located in Cook Inlet. In Iliamna Lake and Cook Inlet, vessel operators would be aware of the locations of underwater pipelines as they would be included on nautical charts. The effects of post-operational activities would be short term in duration.

### 4.12.3.4 Navigation

#### Mine Site

No new water access would be constructed at the mine site. No navigation impacts would occur from the project to the Kvichak and Nushagak rivers, which are navigable waters hydrologically connected to the mine site.

#### Transportation Corridor

The transportation corridor would cross the following federal navigable waterbodies:

- Newhalen River (considered navigable by the US Coast Guard [USCG] only)
- Gibraltar River (considered navigable by USCG only)
- Iliamna Lake (considered navigable by USACE and USCG)

Navigation at the Newhalen River and Gibraltar River crossings would be directly affected during construction of the bridge and by the associated increase in traffic crossing the river. Direct effects of the river crossing after construction would consist of the presence of bridge pilings and the height of the bridge as obstacles. The Newhalen River north bridge would have 29 feet of vertical clearance in the navigation channel, with 98 feet of horizontal clearance. The Newhalen River is approximately 510 feet wide at the crossing. The Gibraltar River bridge (which would require a separate permit to build) would be built where the river is approximately 100 feet wide, but the bridge would extend to 300 feet, with pilings 100 feet apart. The minimum vertical clearance would be 43 feet above the river (PLP 2018i). Navigation is not likely to be impeded by these bridges, but the instream pilings would represent an increased risk of allision to vessels. The risk of impacts would be reduced over the long term (during operations and after mine closure), as compared to over the short term (during construction). These impacts to navigation would be certain to occur under Alternative 1a.

Construction of the Eagle Bay ferry terminal may use facilities in Iliamna and Newhalen, possibly increasing road traffic and barge traffic to Iliamna creating an additional impact on lake navigation. During construction of ferry terminal components, there would be direct adverse impacts to navigation on Iliamna Lake. These adverse impacts would be reduced during operations. During operations, the ferry terminal structures would create an allision risk to vessels traveling along the shore. The structures have the potential to impact navigation, but the magnitude of impacts would be reduced because the terminals would be visible and lighted; the lake is large enough to provide routes around the structures.

#### Amakdedori Port

Amakdedori port infrastructure would be constructed in Cook Inlet, which is considered navigable by USACE, USCG, Bureau of Ocean Energy Management (BOEM), and Bureau of Safety and Environmental Enforcement (BSEE). For magnitude and extent, these structures would pose an allision risk for the infrequent traffic that occurs on the west side of the Cook Inlet. These structures would be recorded on navigation charts and would not restrict navigation. The impacts would be realized during construction from increased vessel activity, would decrease slightly during operations, and even more so post-closure after the dock structures have been removed. The duration of impacts would be long term and would be expected to occur under Alternative 1a.

**Natural Gas Pipeline Corridor**

The construction phase would represent collision hazards for vessels transiting Cook Inlet and Iliamna Lake (Eley 2012). Impacts on navigation would be short term and certain to occur; however, these waterbodies are large and non-project related navigation would be maintained.

In terms of magnitude, once the pipeline is fully operational, effects on navigation and anchoring in Cook Inlet or in Iliamna Lake would be reduced. In Iliamna Lake and Cook Inlet, vessel operators would be notified (via a USCG-approved method) of the pipeline location. Effects of post-operational activities would be short term in duration.

## 4.12.4 Alternative 1

Alternative 1 differs from Alternative 1a in the location of the north ferry terminal (west of Newhalen) and the natural gas pipeline, which follows the same route. The mine access road connects the north ferry terminal to the mine site and requires the Iliamna spur road to be constructed to connect to the existing roads of Iliamna, Newhalen, and (seasonally) Nondalton. Impacts to surface transportation, air transportation, water transportation, and navigation at the mine site would be the same as under Alternative 1a.

### 4.12.4.1 Surface Transportation

Impacts on surface transportation at Amakdedori port and the mine site would be the same as under Alternative 1a.

**Transportation Corridor**

The transportation corridor for Alternative 1 would differ from Alternative 1a north of Iliamna Lake. The ferry terminal and pipeline landfall would occur west of Newhalen, creating a need for a mine access road from the terminal to the mine site. Construction impacts would be the same as under Alternative 1a, except the road would not cross the Newhalen River Road. Long term effects would be similar to Alternative 1a because of the connection of the mine road to village road systems.

**Natural Gas Pipeline Corridor**

Impacts of the natural gas pipeline corridor on surface transportation on the Kenai Peninsula would be the same as under Alternative 1a.

The natural gas pipeline corridor for Alternative 1 would differ from Alternative 1a; it makes landfall north of Iliamna Lake west of Newhalen at the north ferry terminal. Because construction of the pipeline would be in the main transportation corridor from Amakdedori port to the mine site and would not cross existing roads, there would be no additional disruption of community roads systems associated with pipeline installation.

During operations and closure, inspections and maintenance of the pipeline would not be expected to have adverse effects on overland traffic.

### 4.12.4.2 Air Transportation

Impacts on air transportation to and from the mine site, Iliamna, and Kokhanok would be the same as under Alternative 1a.

### 4.12.4.3 Water Transportation

Impacts on water transportation at Amakdedori port and the mine site would be the same as under Alternative 1a.

#### Transportation Corridor

The Alternative 1 transportation corridor would cross waterbodies including the Newhalen River (on the spur road), Gibraltar River, Iliamna Lake, and Cook Inlet. Of these crossings, seven would use bridges. Bridge construction and impacts on water transportation would be the same as Alternative 1a.

#### Natural Gas Pipeline Corridor

Impacts on water transportation from the natural gas pipeline would be the same as under Alternative 1a.

### 4.12.4.4 Navigation

Navigation impacts south and east of Iliamna Lake (including the Lake) for Alternative 1 would be the same as under Alternative 1a. North of Iliamna Lake, the Iliamna spur road would cross the Newhalen River at a different location. The lower Newhalen River bridge would have a minimum of 32 feet of vertical clearance in the navigation channel, with 96 feet between each piling. The Newhalen River is approximately 596 feet wide where the crossing would be located. Impacts would be the same as Alternative 1a.

### 4.12.4.5 Alternative 1—Kokhanok East Ferry Terminal Variant

The Kokhanok East Ferry Terminal Variant would have the same magnitude, duration, extent, and likelihood of impacts to air and surface transportation as Alternative 1.

For the Kokhanok East Ferry Terminal Lake Variant, there would be little change to navigation on Iliamna Lake other than relocation of the ferry terminal (in-water structures would be nearly identical). Operation of the ice-breaking ferry on Iliamna Lake at the Kokhanok east ferry terminal would be more sheltered from wind and waves, but the route would contain more navigational hazards, such as shallow water, and would be 33 percent longer, for a total impact magnitude of 27 miles (PLP 2018-RFI 078). Snowmachine access to Iliamna Lake would be provided east of the terminal to enable access to the Sid Larson Bay area without crossing the ferry route (PLP 2018-RFI 078). Alternate marked safe routes would help avoid the ferry path, but would have the potential to add to travel time, distance, and fuel costs. The duration of these impacts would be long term and would be certain to occur under this variant.

The area near the Kokhanok East Ferry Terminal Variant has thicker ice for a longer duration than the south ferry terminal. There is a substantial amount of winter traffic between Kokhanok and Sid Larson Bay (east of the community), and winter travel routes would cross the Kokhanok east ferry route. The creation of an alternate winter travel route along the Kokhanok east spur road with an access point to the lake east of the terminal would mitigate this impact by creating a route that would not cross ferry traffic. However, traffic in the town of Kokhanok would see an increase between the airport and the ferry terminal site. These impacts would also be long term and certain to occur under this variant.

#### 4.12.4.6 Alternative 1—Summer-Only Ferry Operations Variant

The magnitude of impacts due to the Summer-Only Ferry Operations Variant would be a doubling of truck traffic in the summer to 78 round trips per day on each access road, and none in the winter. Surface transportation over ice on Iliamna Lake would not be disrupted during the winter under this variant. This variant would have the same impacts to air transportation as Alternative 1.

Under the Summer-Only Ferry Operations Variant, the number of in-water structures would be the same but there would be two ferry trips per day during open water, and no trips when there is ice cover. The risk of allision with ferry terminal components would be the same as described above, but in terms of magnitude, increased ferry traffic would increase the risk of vessel collisions, especially if two ferry vessels are needed. These impacts would be long term and certain to occur under this variant.

#### 4.12.4.7 Alternative 1—Pile-Supported Dock Variant

The Pile-Supported Dock Variant would construct similar structures in navigable waters and would not change vessel traffic. The magnitude, duration, extent, and likelihood of impacts of a pile-supported dock to navigation and air and surface transportation would not differ from those associated with a solid fill type dock.

### 4.12.5 Alternative 2—North Road and Ferry with Downstream Dams

Alternative 2—North Road and Ferry with Downstream Dams would be very similar to Alternative 1a, except that a different dam design would be used to construct the bulk tailings storage facility north embankment at the mine site. The port site would be at Diamond Point instead of Amakdedori, and the port access road would go from Diamond Point to Pile Bay in Iliamna Lake. Impacts to surface transportation, air transportation, water transportation, and navigation at the mine site would be the same as under Alternative 1a.

#### 4.12.5.1 Surface Transportation

**Transportation Corridor**

Effects on the Kenai Peninsula would be the same as Alternative 1a. The port location at Diamond Point would require a new port access road to be constructed to Pile Bay through Williamsport, in the vicinity of and replacing the current Williamsport-Pile Bay Road. Construction would create an increase of traffic on the road during the busy summer months. Once constructed, project-related haul trucks would share the road with privately operated trucks and vessels being portaged. The magnitude of impacts would be an increase in the volume and density of traffic. The Williamsport-Pile Bay Road is difficult to traverse, especially with wide loads, because it is steep and narrow. An improved road would make the transportation corridor more economically and logistically appealing for portaging vessels and shipping supplies to villages, as the port access road would be built to withstand the full capacity of current and potential future traffic. This would have the potential to further increase private vehicle traffic, if the proposed or existing Williamsport port could accommodate the increase. These impacts would occur every season during construction and operations, and would require coordination between PLP and private users.

There are no existing roads in the vicinity of the road that would be constructed from Eagle Bay to the mine site; potential adverse effects on current surface transportation would be similar to Alternative 1a with regard to Iliamna, Newhalen, and Nondalton. The magnitude of impacts from this alternative would be the amount of increased traffic on the section of the Newhalen River Road (maintained by the State) between the crossing and Iliamna. The duration of impacts would be long term, lasting for the life of the project and impacts would be certain to occur. Under this alternative, Kokhanok would not be connected to the road system and therefore would not experience surface transportation effects.

**Diamond Point Port**

The need for a temporary beachhead during construction may be eliminated at the Diamond Point port site, but a construction camp may be necessary. The magnitude of adverse impacts on surface transportation due to port improvements and operation would be the amount of additional mine traffic to the quarry area, and the creation of a connection of the quarry with Williamsport and the road to Pile Bay. The duration and likelihood of these impacts would be long term and certain to occur under Alternative 2.

**Natural Gas Pipeline Corridor**

Effects of construction of the natural gas pipeline on the Kenai Peninsula would be the same as under Alternative 1a. The crossing from Ursus Cove to Cottonwood Bay over land would not affect surface transportation because there are no existing roads in the area and little to no subsistence travel; the pipeline ROW would be unlikely to be used for transportation. Construction along the road to Pile Bay would occur simultaneously with road construction and improvements, and impacts to surface transportation would be the same as discussed above. Installation of the pipeline from where it would depart from the road near Pile Bay to where it would realign north of Eagle Bay would run through the community of Pedro Bay. The magnitude of impacts would be in the increase of the number of vehicles in the village as construction vehicles work their way through and near town. This impact would be short term, occurring only during the construction phase. During operations, the pipeline ROW between the two ferry terminals may create a route for ATV or snowmachine traffic. The most likely users of this new route along the ROW would be the residents in the communities of Pedro Bay, Nondalton, Iliamna, and Newhalen. The duration of this impact would be long term lasting through the life of the project. In terms of likelihood, all impacts would be certain to occur under Alternative 2. Impacts of the new ROW on access to subsistence resources are discussed in Section 4.9, Subsistence.

### 4.12.5.2 Air Transportation

The frequency of flights to and from Iliamna under this Alternative would be the same as Alternative 1a; therefore, impacts to air transportation at Iliamna would be the same as Alternative 1a. Construction cargo and passenger flight frequencies to the airstrip in Pile Bay would be similar to flight frequencies to Kokhanok under Alternative 1a. The magnitude, duration, extent, and likelihood of impacts to Pedro Bay and Pile Bay would be similar to those discussed for Kokhanok under Alternative 1a, including the use of the airport at Pedro Bay during construction. PLP would not construct a new airstrip at Diamond Point, but would improve the existing airstrip near Pile Bay for limited use during construction. It is assumed that improvements would take place on the existing airport footprint and therefore would not affect wetlands and other waters.

### 4.12.5.3 Water Transportation

The effects of the transportation corridor on water transportation would be similar to Alternative 1a, except for the locations of the ferry terminal (at Pile Bay instead of Eagle Bay), ferry route, ferry traffic, and bridge locations. The Iliamna River, considered navigable by the USCG and the State of Alaska, would be crossed by a bridge along the Williamsport-Pile Bay Road. Water transportation would not be impeded by these bridges, but the instream pilings would create an increased risk of allision to vessels. The Gibraltar River would not be crossed in this alternative. At the crossings, the magnitude of adverse impacts on water transportation would be the amount of construction activities occurring in the river at the crossings and the associated increase in traffic crossing the river. The magnitude of effects on water transportation at river crossings after construction would be at the bridge pilings and the height of the bridges, lasting through operations and into closure. These short- and long-term effects would be certain to occur under Alternative 2.

Under Alternative 2, the ferry terminals would not be expected to restrict traffic. The community of Pedro Bay would be affected by year-round and summer-only ferry operations in the way that Kokhanok would be as described under Alternative 1a. The northeastern portion of Iliamna Lake has a lower median number of days of ice than the southwestern portion, meaning that the ferry route and terminals in this alternative would have less of an adverse effect on winter cross-lake transportation than Alternative 1a and Alternative 1. See Section 4.9, Subsistence, for impacts of access to subsistence resource use areas.

The Diamond Point port under Alternative 2 would be similar in scale to the Amakdedori port and would pose a similar allision risk to vessels. The construction and operation of a deepwater loading facility would impact marine vessel traffic in Iniskin Bay by increasing congestion, especially during bad weather, when vessels take refuge in the bay. Dredging would be required at Diamond Point, regulated by the USACE. The magnitude of impacts from dredging and lightering activities would be in the increase in the number of vessels in the area, especially during inclement weather when vessels take refuge in Iniskin Bay. Project-related vessel activity would be similar to that discussed under Alternative 1a and would be long term, occurring during operations. The likelihood of the impact would be certain if Alternative 2 is selected and the project is permitted and built.

During construction, PLP could use Williamsport to transport supplies until adequate facilities can be constructed at Diamond Point. Navigating into Williamsport can be challenging (see Section 3.12, Transportation and Navigation) and could cause delays and incur additional cost. Given the short amounts of time when it is possible to land barges at Williamsport (high tide only), and the possibility of increment weather, there could be impacts to other users, particularly at the beginning and conclusion of the commercial fishing season.

The magnitude, duration, and likelihood of adverse effects on water transportation from the construction and operation of the natural gas pipeline in Cook Inlet would be the same as under Alternative 1a; however, the extent of the impacts would be different as Alternative 2 would be located in an area farther north. Under Alternative 2, there would be no pipeline in Iliamna Lake.

### 4.12.5.4 Navigation

The effects of the transportation corridor on navigation would be similar to Alternative 1a, except for the location of a ferry terminal, ferry traffic, and bridges. The Iliamna River, considered navigable by the USCG and the State of Alaska, would be crossed by a bridge along the Williamsport-Pile Bay Road. The Iliamna River bridge would be built alongside an existing bridge built by the Alaska Department of Transportation and Public Facilities (ADOT&PF) in 2018 to replace a historic trestle bridge on Williamsport-Pile Bay Road. The new bridge would have a vertical clearance of approximately 21 feet, two sets of pilings set 67 feet apart, and would have potential to replace the ADOT&PF bridge. The upper Newhalen River Bridge would be built with a minimum vertical clearance of 25 feet, and four sets of pilings set at approximately 124 feet apart. Navigation would not be impeded by these bridges, but the instream pilings would represent an increased risk of allision to vessels. As discussed under Alternative 1a, the Newhalen River is bigger than other navigable rivers with crossings. At the crossings, the magnitude of adverse impacts on navigation would be the construction activities occurring in the river at the crossings and the associated increase in traffic crossing the river. The magnitude of effects on navigation at river crossings after construction would consist of bridge pilings and the height of the bridges, lasting through operations and into closure. These short- and long-term effects would be certain to occur under Alternative 2.

Under Alternative 2, a ferry terminal would be constructed at Pile Bay instead of the south ferry terminal; however, it would be similar in design to Alternative 1a and would not be expected to restrict navigation.

The Diamond Point port under Alternative 2 would pose an allision risk to vessels similar to that of Alternative 1a. The construction and operation of a deepwater loading facility would impact marine vessel traffic in Iniskin Bay by increasing congestion, especially during bad weather, when vessels take refuge there. Dredging and lightering activities at Diamond Point would cause an increase in the number of vessels in the area, and would be long term, occurring during operations. The likelihood of the impact would be certain under Alternative 2.

The magnitude, duration, and likelihood of impacts on navigation from the construction and operation of the natural gas pipeline in Cook Inlet would be the same as under Alternative 1a; however, the extent of the impacts would be different as Alternative 2 would be located in an area farther north. Under Alternative 2, there would be no natural gas pipeline in Iliamna Lake.

#### 4.12.5.5 Alternative 2—Summer-Only Ferry Operations Variant

Under the Summer-Only Ferry Operations Variant, the magnitude, duration, and likelihood of adverse effects on surface transportation traffic would be similar to the Alternative 1 variant; however, would affect the area around Pedro Bay in terms of extent. The magnitude of impacts would be the amount of increased activities and traffic along the improved Williamsport-Pile Bay Road and disruption from increased truck traffic in the summer, as the volume of mine traffic would double in intensity. Truck traffic would be absent in the winter. The impacts to the Williamsport-Pile Bay Road would be long term and certain to occur.

Under the Summer-Only Ferry Operations Variant, the in-water ferry terminal structures would be the same as described for Alternative 2, but there would be two ferry trips per day during open water and no trips when there is ice cover. The risk of allision with ferry terminal components would be the same as under Alternative 1a; however, in terms of magnitude, increased ferry traffic would increase the risk of vessel collisions, especially if two ferry vessels are needed.

#### 4.12.5.6 Alternative 2—Pile-Supported Dock Variant

The Pile-Supported Dock Variant would construct similar structures in navigable waters and would not change vessel traffic compared to the Alternative 2 solid fill dock. The magnitude, duration, and extent of impacts of a pile-supported dock to navigation and air and surface transportation would not differ from a solid fill type dock.

#### 4.12.5.7 Alternative 2—Newhalen River North Crossing Variant

The design of the bridge at the Newhalen River would be the same as described above for Alternative 2 and would have the same impacts to water transportation and navigation.

### 4.12.6 Alternative 3—North Road Only

Impacts to surface transportation, air transportation, water transportation, and navigation at the mine site would be the same as under Alternative 1a.

#### 4.12.6.1 Surface Transportation

Effects on the Kenai Peninsula would be the same as under Alternative 1a. The magnitude, duration, and extent of adverse effects of the road from Diamond Point through Williamsport to Pile Bay would be the same as in Alternative 2.

Under this alternative, a road would be built from near Diamond Point and routed around the north side of Iliamna Lake, through Pedro Bay and to the mine site to eliminate the need for the ferry. The route would be the same as the natural gas pipeline corridor from Alternative 2, and have similar surface transportation effects during construction. The magnitude of effects of this road during operations and closure would be an average of 35 heavy truck round trips per day through Pedro Bay; there would also be additional vehicle traffic because the road would connect the communities on the north side of Iliamna Lake over land to each other and to Cook Inlet. Access would be controlled the same as under Alternative 1a, although private traffic would be allowed on the Williamsport-Pile Bay Road portion of the road. The impacts during construction would be short term; impacts during operations and closure would be long term. They would be expected to occur under Alternative 3.

The road would have similar effect on traffic in Iliamna, Newhalen, and Nondalton, as described under Alternative 2.

Effects on surface transportation at the Diamond Point port site would be the same as under Alternative 2.

Installation of the natural gas pipeline along the road from the Pile Bay spur to the mine site would occur simultaneously with road construction and improvements and have similar effects as Alternative 2.

#### 4.12.6.2 Air Transportation

The frequency of flights to and from Iliamna under this Alternative would be the same as Alternative 1a; therefore, impacts to air transportation at Iliamna would be the same as Alternative 1a. Flight frequencies to Pedro Bay would be similar to Alternative 2, but the connecting of Pedro Bay by road to the Cook Inlet would affect frequency of flights after construction, if the road leads to more traffic through Pedro Bay. In terms of magnitude and extent, potential effects on Kokhanok would be limited to resident crew change flights.

#### 4.12.6.3 Water Transportation

The magnitude, duration, and extent of effects of Alternative 3 would be similar as under Alternative 2 for water transportation at the Diamond Point port site, and similar to Alternative 2 waterbody crossings along the transportation corridor. This alternative would eliminate the ferry and all impacts to transportation on Iliamna Lake.

Bridges for Alternative 3 would include Iliamna River (discussed under Alternative 2 and considered navigable by the USCG and the State of Alaska) and Pile River (considered navigable by the State of Alaska). Water transportation is not likely to be impeded by these bridges, but the instream pilings would represent an increased risk of allision to vessels. Impacts from the bridges would be long term and certain to occur under Alternative 3.

As discussed under Alternative 2, water transportation at the crossings on these rivers would be directly affected during construction of the crossings due to the associated increase in vessel traffic crossing the river. Direct effects to navigation from the river crossings after construction would consist of bridge pilings and the height of the bridges. Impacts during construction would be short term and long-term during operations and closure; they would be expected to occur under Alternative 3.

### 4.12.6.4 Navigation

The duration and extent of effects of Alternative 3 would be similar to Alternative 2 navigation at the Diamond Point port site and similar to Alternative 2 waterbody crossings along the transportation corridor. This alternative would eliminate the ferry and all impacts to navigation on Iliamna Lake. There would be a higher magnitude of impacts to vessels travelling to Williamsport, as the dock would occupy more of Iliamna Bay than under Alternative 2, representing an increased risk of allision; however, navigation to Williamsport would not be restricted.

Bridges for Alternative 3 would include Iliamna River (discussed under Alternative 2 and considered navigable by the USCG and the State of Alaska) and Pile River, considered navigable by the State of Alaska. The Pile River Bridge would have a 26-foot minimum vertical clearance and two sets of pilings set approximately 80 feet apart in the center of the channel. Navigation is not likely to be impeded by these bridges, but the instream pilings would represent an increased risk of allision to vessels. Impacts from the bridges would be long term and certain to occur under Alternative 3.

As discussed under Alternative 2, navigation at the crossings on these rivers would be directly affected during construction of the crossings due to the associated increase in vessel traffic crossing the river. Direct effects of the river crossings after construction would consist of bridge pilings and the height of the bridges being a risk to navigation. The impacts during construction would be short term and long-term during operations and closure; impacts would be expected to occur under Alternative 3.

### 4.12.6.5 Alternative 3—Concentrate Pipeline Variant

The Concentrate Pipeline Variant would result in impacts with similar magnitude, duration, and extent as those described above under surface transportation, except that truck traffic would be reduced to 18 round trips per day, reducing the magnitude of effects on overland traffic. This variant would not change the Alternative 3 impacts to navigation or air transportation.

## 4.12.7 Cumulative Effects

Impacts to transportation and navigation would be those actions that increase land, sea, or air facilities and traffic volumes (see Section 4.10, Health and Safety, for a discussion on health and safety impacts). The analysis area used for cumulative effects is the same as used for the analysis of direct and indirect effects, the transportation and navigation resources that could be affected by the mine site, port, transportation corridor, material sites, and natural gas pipeline corridor for each alternative. This includes surface transportation from the mine site to Cook Inlet and a small section of the Sterling Highway, air transportation from airports across the region (including Dillingham and Anchorage), and water transportation on Cook Inlet, Iliamna Lake, and navigable rivers from the mine site to Cook Inlet. Navigation also includes deepwater port construction and usage from local to global users.

Many of the actions identified in Section 4.1, Introduction to Environmental Consequences, are considered to have no potential of contributing to cumulative effects on transportation and navigation in the analysis area. These include potential mineral deposit projects that are not anticipated to occur in the operations timeframe of the project (Humble, AUDN/Iliamna, and Kamishak), activities that may occur in the analysis area but are unlikely to result in any appreciable impact on transportation and navigation (such as tourism, recreation, commercial fishing, recreational fishing, and hunting), scientific surveys and research, clean-up of industrial pollutants and contaminated sites, or actions outside of the cumulative effects analysis area.

### 4.12.7.1 Past and Present Actions

Actions that have affected transportation and navigation in the past or present in the EIS analysis area include mining exploration, non-mining related projects, community development, oil and gas development, and subsistence activity. These actions have resulted in development of transportation infrastructure and have altered traffic patterns and increased traffic over land, in the air, and on waterways. In particular, the construction of the Williamsport-Pile Bay Road allows portage of fishing vessels and some cargo from Cook Inlet to Iliamna Lake during the summer season, generating road, marine and Iliamna Lake vessel traffic. Communities and roads already exist in the EIS analysis area, and activities at the mine site and other nearby mineral deposits currently include exploration drilling, which has resulted in a summer season increase in air traffic in support of exploration activities. Oil and gas activity, docks, ports, and marine vessel traffic have impacted navigation in Cook Inlet although there has been little development in Iliamna Lake and the navigable rivers.

### 4.12.7.2 Reasonably Foreseeable Future Actions

Reasonably foreseeable future activities in the cumulative impact study area have the potential to contribute cumulatively to impacts on transportation and navigation. The potential future actions are similar to the project in how they impact surface, air, and water transportation and navigation during construction, operations, and closure.

The future actions included in this analysis are those that would contribute to the cumulative increase in land, sea, and air traffic in the EIS analysis area. The following Reasonably Foreseeable Future Actions (RFFAs) identified in Section 4.1, Introduction to Environmental Consequences, were carried forward in this analysis based on their potential to impact transportation and navigation in the EIS analysis area: Pebble project expansion scenario; other mineral exploration projects, oil and gas exploration and development, and road improvement and community development projects.

The No Action Alternative would not contribute to cumulative effects on transportation and navigation.

The project alternatives with RFFAs' contribution to cumulative effects on transportation and navigation are summarized in Table 4.12-2.

**Table 4.12-2: Contribution to Cumulative Effects on Transportation and Navigation**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Pebble Project Expansion Scenario | **Mine Site:** The mine site would mine and process more ore over a longer period of time, have a larger open pit, and create new facilities to manage water and store tailings and waste rock. This would increase and extend truck traffic in the mine site.<br>A larger mine site and infrastructure footprint would be more noticeable to those traveling over land for inter-village trips and would continue to impede non-mine-related access through the mine site.<br>**Other Facilities:** A north access road, concentrate pipeline, and diesel pipeline would be constructed along the Alternative 3 road alignment, and extended to a new deepwater port site at Iniskin Bay. The portion of the access road from the Eagle Bay ferry terminal to the existing Iliamna area road system would already be constructed. The north access road would be extended east from the Eagle Bay ferry terminal to the Pile Bay terminus of the Williamsport-Pile Bay Road. Although the concentrate truck traffic along the south access road would be eliminated, and truck traffic would be reduced to 21 round trips per day, the Amakdedori port facility and transportation corridor (including ferry) would continue to be used for general cargo and concentrate shipment and would extend the duration of truck and vessel traffic effects in the port area and transportation corridor, although at a reduced level. The access road to Diamond Point, if open to non-mining traffic, would increase traffic overall through the Williamsport-Pile Bay Road corridor, and could be permanent. The construction and operation of a deepwater loading facility would impact marine vessel traffic in Iniskin Bay by increasing congestion, especially during bad weather, when vessels take refuge there. Expansion would continue operation of the port facilities at a higher production rate over an extended period of time.<br>An additional 58 years of mining and processing would extend the impacts on Cook Inlet marine vessel traffic. | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** Alternative 1 would add a road that would be constructed between the mine site and Iniskin Bay and a new port at Iniskin Bay.<br>**Magnitude:** The magnitude of cumulative impacts to transportation and navigation would be similar to the magnitude of Alternative 1a, with the added impacts of the additional road, concentrate and diesel pipeline, and Iniskin Bay port construction.<br>**Duration/Extent:** The duration of cumulative impacts to transportation and navigation would be similar to as under Alternative 1a. The extent would increase to include the northern side of Iliamna Lake, Pile Bay, and Iniskin Bay.<br>**Contribution:** This contributes to cumulative effects on transportation and navigation through additional surface, air, and vessel traffic. Therefore, this scenario would have a | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** The north access road would be extended east from the Eagle Bay ferry terminal to Iniskin Bay. Concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay.<br>**Magnitude:** Cumulative effects of construction disturbance, traffic, and navigation impacts would be similar to those discussed under Alternative 1a, except the magnitude of impacts would be reduced (Alternative 2 would not develop both Amakdedori and Diamond Point transportation corridors, the corridor for the diesel and concentrate pipelines would have been disturbed for the natural gas pipeline, and the transportation and natural gas pipeline corridors would already have some impacts on transportation and navigation in Iliamna and Iniskin bays). An access road would be constructed | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** Overall, expansion would use the existing north access road; a concentrate pipeline and diesel pipeline would be constructed along the existing road alignment and extended to a new deepwater port site at Iniskin Bay (a service road would also be extended to Iniskin Bay). Concentrate truck traffic would cease along the north access road after 20 years of initial operations. Changes in port vessel traffic would be identical to Alternative 2.<br>**Magnitude:** Expanded mine site development and associated contributions to cumulative impacts would be similar to those under Alternative 2. Under Alternative 3, project expansion would continue to use the existing Diamond Point port facility, would use the same natural gas pipeline, and would use the same north access road for general vehicle traffic and Concentrate Pipeline Variant infrastructure, but would extend the |

**Table 4.12-2: Contribution to Cumulative Effects on Transportation and Navigation**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | Project-generated vessel traffic in Cook Inlet would include deep-draft vessels such as concentrate transport vessels, vessels for fuel, and barges for delivery and transport of materials and supplies. Increased production and transport of concentrate through a pipeline would further increase vessel traffic on Cook Inlet, therefore increasing the magnitude, duration, and extent of impacts. The additional concentrate and diesel pipelines to Iniskin Bay would have impacts to the transportation characteristics of the region similar to those discussed for the natural gas pipeline under Alternative 2 and Alternative 3 above, primarily associated with construction activities and the development of access roads along the pipelines.<br>**Magnitude:** Truck traffic would decrease due to concentrate being transported through a pipeline, but there could be impacts from having two active transportation corridors on navigation, air transportation, and surface transportation.<br>**Duration/Extent:** The duration/extent of cumulative impacts to transportation and navigation would vary; concentrate truck traffic would cease after 20 years of initial operation, and concentrate vessel traffic would shift from Amakdedori to Iniskin Bay in the same time period. Because mill throughput would increase, it is possible that the frequency of vessel traffic would also increase, depending on the size of vessels being loaded. The extended timeframe of mining would have a longer duration of effects on transportation, lasting 78 years.<br>**Contribution:** This contributes to cumulative effects on transportation and navigation through additional surface, air, and vessel traffic. Therefore, this scenario would have a larger contribution to cumulative effects in the area than Alternative 1a alone. The contribution to cumulative effects would be slightly less than Alternative 1, but more than Alternative 2 and Alternative 3. | larger contribution to cumulative effects in the area than Alternative 1a or Alternative 1 alone. | along the concentrate pipeline, and year-round ferry operations would be discontinued. With regard to traffic, truck traffic would be limited to one transportation corridor instead of two, and vessel traffic would be concentrated in the Diamond Point/Iniskin Bay area, rather than being split between Amakdedori and Iniskin facilities.<br>**Duration/Extent:** The duration of cumulative impacts to transportation and navigation would be similar to that under Alternative 1a. The extent would avoid the Amakdedori and Kokhanok areas and Iliamna Lake.<br>**Contribution:** The contribution to cumulative impacts would be similar to that under Alternative 1a, although affecting fewer acres and a smaller geographic area for vehicular and vessel traffic. | concentrate pipeline to Iniskin Bay. The port site and associated facilities would be constructed at Iniskin Bay as discussed under Alternative 1a. A diesel pipeline from the mine site to Iniskin Bay would be constructed as discussed under cumulative effects for Alternative 1a.<br>**Duration/Extent:** The duration/extent of cumulative impacts to transportation and navigation would be similar to those under Alternative 2, except that the north access road would be constructed at the outset of the project and would not involve construction and operation of a ferry.<br>**Contribution:** The contribution to cumulative impacts would be similar to that under Alternative 1a, although affecting fewer acres. |

**Table 4.12-2: Contribution to Cumulative Effects on Transportation and Navigation**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Other Mineral Exploration Projects | **Magnitude:** Mining exploration activities, including additional borehole drilling, road and pad construction, and development of temporary camp facilities, would result in additional helicopter traffic in the vicinity of exploration activities, possibly based out of the Iliamna airport.<br>**Duration/Extent:** Exploration activities typically occur at a discrete location for one season, although a multi-year program could expand the geographic area affected within a specific mineral prospect. Section 4.1, Introduction to Environmental Consequences, identifies seven mineral prospects in the EIS analysis area where exploratory drilling is anticipated (four of which are in relatively close proximity to the Pebble Project and infrastructure).<br>**Contribution:** There would be an accumulating demand for regional and helicopter air transportation and logistical support, particularly if mining exploration activities or construction schedules of the proposed alternative and RFFAs overlap. It is likely that any increased demand for air transport could be met by adding supply, because the RFFA sites are distributed with different airstrips and staging sites, rather than clustered. | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |
| Oil and Gas Exploration and Development | **Magnitude:** Onshore oil and gas exploration activities could involve seismic and other forms of geophysical exploration, and in limited cases exploratory drilling. Similar to mining exploration activities, helicopter support would be required, although the location of previous exploration activities indicate that support would likely be based out of King Salmon. Helicopter support could contribute to cumulative air traffic congestion, depending on the location(s) of drilling. Offshore oil and gas projects in Cook Inlet could contribute cumulatively to adverse impacts to boat traffic and navigation on the inlet if construction periods overlapped. | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |

**Table 4.12-2: Contribution to Cumulative Effects on Transportation and Navigation**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | From June to October, vessel traffic in the Cook Inlet typically includes large deep-draft vessels, tugs, barges, and small commercial vessels. The alternative vessel and barge delivery traffic would contribute to the disturbance of transportation access and traffic levels in Cook Inlet. Construction of the Alaska LNG project or the ASAP project would increase vessel traffic in the vicinity of Cook Inlet during the period of construction. Operation of the Alaska LNG project would generate monthly LNG carrier traffic for the duration of operations.<br>Magnitude would increase. This project could add to the cumulative vessel traffic of Cook Inlet with Alaska LNG or ASAP.<br>**Duration/Extent:** Seismic exploration and exploratory drilling are typically single-season, temporary activities. The 2013 Bristol Bay Area Plan shows 13 oil and gas wells drilled on the western Alaska Peninsula and a cluster of three wells near Iniskin Bay. Offshore exploration would occur on leases in southern Cook Inlet, to the east of Iniskin Bay.<br>**Contribution:** The alternative vessel and barge delivery traffic would contribute to the disturbance of transportation access and traffic levels in Cook Inlet. The magnitude and geographic extent of effects would increase, but the duration would remain the same. | | | |
| Road Improvement and Community Development Projects | **Magnitude:** Anticipated road improvement projects in the region include new transportation corridors currently being studied in the LPB, such as the Williamsport-Pile Bay Road upgrade and the Nondalton-Iliamna River Road Corridor and Bridge, which would improve overland routes in the region (access to Nondalton) and inter-regionally from Cook Inlet to Iliamna Lake. These improvements could have positive cumulative effects on transportation with Alternative 1a. The timing of the improvements to the Williamsport-Pile Bay Road would be critical in determining whether the improvements would be positive or adverse to traffic on the road. If | Similar to Alternative 1a. | The Williamsport-Pile Bay Road upgrade and the Nondalton-Iliamna River Road Corridor and Bridge construction would have cumulative effects similar to those under Alternative 1a. The magnitude, geographic extent, and duration of cumulative impacts in Alternative 2 would be greater than under | The Williamsport-Pile Bay Road upgrade and the Nondalton-Iliamna River Road Corridor and Bridge construction would have cumulative effects similar to those under Alternative 1a.<br>The magnitude of effects would be similar to Alternative 2 and less than Alternative 1. The |

**Table 4.12-2: Contribution to Cumulative Effects on Transportation and Navigation**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | implemented during the construction phase of Alternative 1a, the adverse effects would be temporary and would affect the progress of road improvement, portaging ships, and PLP's construction schedule, and could increase duration of all three elements. If the improvements occurred before or after the construction phase of Alternative 1a, the magnitude would be far less.<br>Surface transportation could cause additional traffic and some disruption along roads leading to the communities of Iliamna, Newhalen, and Nondalton via the project roads; Kokhanok community roads would be connected to the south access road, which would run from the south ferry terminal to Amakdedori port.<br>Subsistence activities have the potential to affect transportation and navigation in the region, because they can increase the number of people using overland routes and boat traffic in certain areas.<br>The further development of the Diamond Point Rock Quarry could have some effects on transportation if it is developed or operational during the construction phase of Alternative 1a, while the Williamsport-Pile Bay Road is used for transport. If issued, the quarry's permit to dredge could either be beneficial to transportation in the area, creating easier navigation in Iliamna Bay; or it could hinder transportation, depending on the timing and location of the dredging. Overall, the magnitude of effects and geographic extent of cumulative effects would increase, but the duration would remain the same.<br>**Duration/Extent:** Disturbance from road construction would typically occur over a single construction season. Increased project vehicle traffic and effects on local roads would occur over the expanded mine operating period, and to a lesser degree during initial closure activities. The geographic extent would be limited to the vicinity of communities and Diamond Point. | | Alternative 1a and Alternative 1 because the project infrastructure and logistical operations would be more concentrated in this area through all phases, having a larger compounded impact over the life of the project and beyond.<br>The footprint of the Diamond Point rock quarry in Alternative 1a and Alternative 1 coincides with the Diamond Point port footprint in Alternative 2 and Alternative 3. The development of the Diamond Point Rock Quarry would have impacts on transportation and navigation similar to those during the construction phase of Alternative 1a, because the Williamsport-Pile Bay Road and Iliamna Bay would be used for transport. The magnitude of effects, geographic extent, and duration of cumulative effects would be the same as discussed for Alternative 1a. | development of the Diamond Point Rock Quarry would have impacts on transportation and navigation similar to those under Alternative 2. The development and operation of the Diamond Point Rock Quarry was considered above; the magnitude of effects, geographic extent, and duration of cumulative effects would remain the same as Alternative 1a. |

**Table 4.12-2: Contribution to Cumulative Effects on Transportation and Navigation**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | **Contribution:** Cumulative impacts would occur associated with surface transportation between the communities for subsistence and recreational uses, in addition to the ongoing LPB, rural Alaska Village Grant Program, and other village projects. | | | |
| Summary of Project contribution to Cumulative Effects | Overall, the contribution of Alternative 1a to cumulative effects to transportation and navigation, when taking other past, present, and reasonably foreseeable future actions into account, would be minor to moderate in terms of magnitude, duration, and extent. | Similar to Alternative 1a. | Similar to Alternative 1a, although affecting a smaller amount of acreage and a smaller geographic area for vehicular and vessel traffic. | Similar to Alternative 2, except that the north access road would be constructed at the outset of the project and not involve construction and operation of a ferry. |

Notes:
ASAP = Alaska Stand Alone Pipeline
EIS – Environmental Impact Statement
LNG = Liquefied Natural Gas
LPB = Lake and Peninsula Borough
PLP = Pebble Limited Partnership
RFFA = reasonably foreseeable future action

# 4.13 GEOLOGY

This section describes project-related impacts on the geologic resources and materials discussed in Section 3.13, Geology, for all project alternatives and variants. Geologic resources addressed herein are defined as bedrock (including ore), overburden (e.g., glacially derived gravels and sands, alluvium along the transportation corridors), and material site resources (e.g., rock, gravel). The impacts to geologic resources described in this section include removal and relocation of these materials for onshore areas.

Impacts to offshore lake and marine sediments, including dredged sediments and the Iliamna Lake pipeline berm, are described in detail in Section 4.18, Water and Sediment Quality; and Section 4.22, Wetlands and Other Waters/Special Aquatic Sites. Impacts to lake and marine sediments are briefly addressed in this section as pertains to the footprint disturbance from pipeline construction.

Appendix K4.13 presents an analysis of potential impacts on paleontological resources. The impacts of the project on other aspects of the geologic environment are described in the following sections: Section 4.14, Soils; Section 4.15, Geohazards and Seismic Conditions; Section 4.17, Groundwater Hydrogeology; Section 4.18, Water and Sediment Quality; and Section 4.22, Wetlands and Other Waters/Special Aquatic Sites, which also describes the affected footprint of project features, and facilities of the components, for all phases of the project.

The Environmental Impact Statement (EIS) analysis area for geology includes the mine (including quarry material sites), port and ferry terminals, and transportation and pipeline corridors.

The impact analysis considered the following factors: magnitude, duration, geographic extent, and potential:

- Magnitude—impacts are assessed based on the magnitude of the impact as indicated by the quantified amount of geologic resources or area expected to be affected.
- Duration—impacts are assessed based on the duration of effects on geologic resources (e.g., short-term, long-term, or permanent). Short-term effects are considered to be those impacts occurring only during the construction and operations phases; long-term effects are considered to be those impacts extending into closure; and permanent effects are considered to be those impacts extending indefinitely into post-closure, with no restorative actions planned.
- Geographic extent—impacts are assessed on the location and distribution of occurrence of the expected effects on geologic resources (e.g., mine site footprint).
- Potential—impacts are assessed based on the potential likelihood of an effect to geologic resources occurring as a result of actions.

Geotechnical investigations and studies have been completed to support engineering design (see Appendix K4.15, Geohazards and Seismic Conditions). Additional investigations and studies are ongoing and would continue as needed to support detailed design and project compliance with all relevant regulations that are protective of the environment. Mitigation measures that could reduce project impacts to geologic resources are discussed in Chapter 5, Mitigation, and Appendix M1.0, Mitigation Assessment.

## 4.13.1 Summary of Key Issues

All action alternatives would result in a similar magnitude and potential for impacts related to geology. The primary difference between the alternatives would be the areas and volumes of geologic resources that would be affected. Appendix K2 includes detailed tables with the permanent and temporary construction footprints for each alternative and their respective variants, summarized by project component (mine site, transportation corridor, port, and natural gas pipeline). Table 4.13-1 summarizes the key issues, primarily by permanent direct footprints for geologic resources (bedrock, overburden, and material site resources) across all alternatives, components, and variants.

**Table 4.13-1: Summary of Key Issues for Geology**

| Impact-Causing Project Component | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | | **Mine Site** | | |
| **Mine Site Construction and Operations** | Construction and operation of the mine site would result in removal and/or placement of geologic resources in conjunction with all facilities.<br>Impacts would also occur from blasting of bedrock in construction areas. | Impacts would be the same as those for Alternative 1a.<br>***Summer Only Ferry Operations Variant Project Footprint:***<br>Increases the mine site footprint by 33 acres, and resulting permanent direct impacts on geologic resources. | Impacts would be similar to those of Alternative 1a, except the bulk TSF main embankment would be a downstream design, which would result in a small (about 1.5 percent) increase in the total mine site footprint, and resulting direct impacts on geologic resources.<br>***Summer Only Ferry Operations Variant Project Footprint:***<br>Increases the mine site footprint by 33 acres, and resulting permanent direct impacts on geologic resources. | Impacts would be similar to those for Alternative 1a.<br>***Concentrate Pipeline Variant***: Increases the mine site footprint by less than 1 acre, and resulting permanent direct impacts on geologic resources. |
| **Mine Site Closure** | All embankments other than those at the bulk TSF would be removed, and the areas reclaimed at closure, resulting in direct long-term impacts.<br>Pyritic TSF: Material would be placed in the open pit. The pyritic TSF would be closed and reclaimed in place, resulting in direct long-term impacts.<br>Open Pit: Would be partially backfilled, resulting in direct permanent impacts.<br>Bulk TSF: Would be closed and reclaimed in place, resulting in permanent direct impacts. | Impacts would be the same as those for Alternative 1a.<br>No change in impacts for variants. | Impacts would be the same as those for Alternative 1a, except with a larger bulk TSF footprint.<br>No change in impacts for variants. | Impacts would be the same as those for Alternative 1a.<br>No change in impacts for variants. |

**Table 4.13-1: Summary of Key Issues for Geology**

| Impact-Causing Project Component | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| **Transportation Corridor** | | | | |
| **Transportation Corridor Construction and Operations** | Access Roads: Total 74 miles.<br>Mine Access Road: 35 miles from the mine site to Eagle Bay, mostly surficial glacial deposits. Bedrock ~2 miles, blasting impacts likely.<br>Port Access Road: 37 miles, mostly bedrock; blasting impacts likely.<br>Geologic MSs: 19 total; 380 acres.<br>Mine Access Road MSs: 11 total; 2 would require blasting.<br>Port Access Road MSs: 8 total; all would require blasting.<br>Ferry Terminals: 30 acres of permanent direct impacts for the north and south ferry terminals combined; requiring excavation of surficial glacial deposits and possibly bedrock. | Access Roads: Total 77 miles.<br>Mine Access Road: 28 miles from the mine site to the north ferry terminal, mostly surficial glacial deposits. Bedrock ~2 miles; blasting impacts likely.<br>Iliamna Spur Road: 9 miles, mostly surficial glacial deposits.<br>Port Access Road: same as Alternative 1a.<br>Geologic MSs: 19 total; 251 acres.<br>Mine Access Road MSs: 8 total; 2 would require blasting.<br>Iliamna Spur Road MSs: 3 total; no blasting required.<br>Port Access Road MSs: same as Alternative 1a.<br>Ferry Terminals: 27 acres of permanent direct impacts for the Eagle Bay and south ferry terminals combined; requiring excavation of surficial glacial deposits and possibly bedrock.<br>***Kokhanok East Ferry Terminal Variant:*** 19 acres of permanent direct impacts Kokhanok East and north ferry terminals combined; requiring excavation of surficial glacial deposits and possibly bedrock.<br>Geologic MSs: 19 total, 358 acres.<br>***Summer-Only Ferry Variant*:** No changes to geological impacts. | Access Roads: Total 54 miles<br>Mine Access Road: same as Alternative 1a.<br>Port Access Road: 18 miles (~5 miles using existing road). Blasting would likely be required.<br>Geologic MSs: 17 total; 321 acres.<br>Mine Access Road MSs: 11 total; 2 would require blasting.<br>Port Access Road MSs: 6 total; 3 would require blasting.<br>Ferry Terminals: 25 acres of permanent direct impacts for the Eagle Bay and Pile Bay terminals combined; requiring excavation of surficial glacial deposits and possibly bedrock<br>***Newhalen River North Crossing Variant:*** Impacts would be the same at either crossing location. Slight increase (0.3 mile) in mine access road length than Alternative 2.<br>Geologic MSs: 17, 338 acres.<br>***Summer-Only Ferry Variant***: Same road length, but increased footprint from Alternative 2 by 22 acres, and resulting impacts on geologic resources, due to the container yard. | Access Roads: Total 82 miles.<br>Mine Access to Port Road: Mostly surficial glacial deposits from mine site to Knutson Bay, then a combination of glacial deposits and bedrock to the port. Blasting likely for northwestern Knutson Bay, Pedro Bay to Williamsport-Pile Bay Road intersection, and Williamsport to the port.<br>Geologic MSs: 27 total; 604 acres.<br>Mine Access Road to Port MSs: 27 total; 6 would require blasting.<br>Port Access Road MSs: none.<br>Ferry Terminals: none.<br>***Concentrate Pipeline Variant*:** Same impacts as those for Alternative 2 for the gas pipeline corridor. |

**Table 4.13-1: Summary of Key Issues for Geology**

| Impact-Causing Project Component | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| **Transportation Corridor Closure** | Geologic MSs: Progressively reclaimed but not backfilled; permanent impacts.<br>Ferry Terminals: Decommission and reclamation at mine closure; long-term impacts. | Same as Alternative 1a. | Same as Alternative 1a. | Same as Alternative 1a.<br>***Concentrate Pipeline Variant:*** Same impacts as those for the Alternative 2 natural gas pipeline. |
| **Ports** | | | | |
| **Port Construction and Operation** | Amakdedori Port: Construction of the onshore port terminal and airport (22 acres total) would impact surficial glacial deposits and possibly alluvium. | Amakdedori Port: Construction of the onshore port terminal and airport (22 acres total) would impact the same types of materials as Alternative 1a.<br>***Pile-Supported Dock Variant:*** Onshore impact same as Alternative 1.<br>***Summer-Only Ferry Variant:*** Increases the onshore port footprint by 27 acres, and resulting permanent direct impacts on geologic resources, due to the container yard. | Diamond Point Port: Construction of the onshore port terminal (25 acres) would impact the same types of surficial materials as Alternative 1a with possibly some impacts to bedrock in addition.<br>***Pile-Supported Dock Variant:*** Onshore impacts same as Alternative 2. | Diamond Point Port:<br>Construction of the onshore port terminal (16 acres) would predominantly affect bedrock.<br>**Concentrate Pipeline Variant:** Same as Alternative 3. |
| **Port Closure** | Amakdedori Port: Structures and caissons removed after mine closure; impacts would be long-term. | Amakdedori Port: Same as Alternative 1a.<br>***Pile-Supported Dock Variant***: Similar to the above, but the impact would be less because of smaller piling footprint and no causeway and wharf earthfill. Long-term impacts.<br>***Summer-Only Ferry Variant:*** Same as for Alternative 1a, but larger area due to container yard; long-term impacts. | Diamond Point Port:<br>Same as Alternative 1.<br>***Pile-Supported Dock Variant***: Less area of impact than Alternative 2; long-term impacts. | Impacts would be similar to those for Alternative 2.<br>***Concentrate Pipeline Variant***:<br>Minimal impact difference; long-term impacts. |

**Table 4.13-1: Summary of Key Issues for Geology**

| Impact-Causing Project Component | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| **Natural Gas Pipeline Corridor** | | | | |
| **Gas Pipeline Construction and Operations** | Impacts from onshore segments of the pipeline that are co-located with a road are addressed under the Transportation Corridor (for all action alternatives and variants).<br>Onshore pipeline-only segments (about 15 miles) would directly affect geologic resources during construction; primarily surficial deposits.<br>Geologic MSs: none.<br>The Cook Inlet crossing (buried for most of the route, except for 11.2 miles which would be on the seafloor) and the Iliamna Lake crossing would have temporary impacts on lake and marine sediments (addressed in Section 4.18, Water and Sediment Quality). | Impacts would be the same as Alternative 1a, except the onshore pipeline-only segments (about 5 miles) are shorter and would affect fewer geologic resources.<br>Kenai Peninsula: Same as Alternative 1a.<br>Geologic MSs: none. | Onshore pipeline-only segments (about 45 miles) would directly affect geologic resources during construction; primarily surficial deposits and some bedrock which would likely require blasting.<br>All of the pipeline segments across Cook Inlet would be buried in the seafloor. Impacts to marine sediments are addressed in Section 4.18, Water and Sediment Quality. There would be no pipeline crossing of Iliamna Lake.<br>Geologic MSs: 13 total, 298 acres; 3 require blasting. | Because the pipeline would follow the north access road from the Diamond Point port to the mine site, impacts are addressed under the Transportation Corridor.<br>Onshore pipeline-only segments are limited (less than 10 miles) and would primarily affect surficial deposits and bedrock.<br>Geologic MSs: 3 total, 11 acres; 2 require blasting. |
| **Gas Pipeline Closure** | Required through post-closure, resulting in permanent impacts. | Same as for Alternative 1a. | Same as for Alternative 1a. | Same as for Alternative 1a. |

Notes:

~ = approximately
HDD = horizontal directional drilling
MS(s) = material site(s)
N/A = Not Applicable
ROW = right-of-way
TSF = tailings storage facility

## 4.13.2 No Action Alternative

Under the No Action Alternative, federal agencies with decision-making authorities on the project would not issue permits under their respective authorities. The Applicant's Preferred Alternative would not be undertaken, and no construction, operations, or closure activities specific to the Applicant’s Preferred Alternative would occur. Although no resource development would occur under the Applicant's Preferred Alternative, Pebble Limited Partnership (PLP) would retain the ability to apply for continued mineral exploration activities under the State's authorization process (ADNR 2018-RFI 073) or for any activity not requiring federal authorization. In addition, there are many valid mining claims in the area, and these lands would remain open to mineral entry and exploration by other individuals or companies.

It would be expected that current State-authorized activities associated with mineral exploration and reclamation, as well as scientific studies, would continue at levels similar to recent post-exploration activity. The State requires that sites be reclaimed at the conclusion of their State-authorized exploration program. If reclamation approval is not granted immediately after the cessation of activities, the State may require continued authorization for ongoing monitoring and reclamation work as it deems necessary.

Geology along the transportation corridor, natural gas pipeline corridor, and at the port sites would remain in its current state. There would be no direct or indirect impacts on baseline geology conditions in the EIS analysis area from implementation of the No Action Alternative.

### 4.13.3 Alternative 1a

This section addresses the analysis of impacts from Alternative 1a on geologic resources and materials. Scoping comments related to geology requested that impacts to bedrock, surface geology, material resources, and paleontology be analyzed. Paleontological impacts analysis is described in Appendix K4.13.

#### 4.13.3.1 Mine Site

Potential impacts to geology at the mine site include removal and relocation of geologic materials due to construction of the open pit, tailings storage facilities, quarries, and other mine site facilities. These impacts are discussed in the following subsections.

Under Alternative 1a, the magnitude and extent of impacts on geologic resources from construction and operations at the mine site would be the removal and relocation of rock and overburden within 8,390 acres of land (see Figure 2-4, and Section 4.14, Soils) (PLP 2020d). These impacts would be permanent and would be certain to occur if the project is permitted and constructed. Closure of some facilities and regrading of facility footprints during site closure would minimize some of these impacts (see Figure 4.16-3 through Figure 4.16-7).

#### *Open Pit*

Removing and relocating overburden and rock from the open pit area would result in direct impacts on geologic resources, which would be permanent, unavoidable consequences of the project.

The magnitude and extent of impacts from excavating the open pit during construction and operation would be the removal and relocation of approximately 1.44 billion tons (approximately 2.9 trillion pounds) of material including overburden, mineralized process material, and waste rock. The open pit would be approximately 8 percent of the total mine site surface area (see Chapter 2, Alternatives).

The majority of rock removed from the open pit would remain at the mine site in the form of tailings. Bulk tailings would remain in the bulk tailings storage facility (TSF). Pyritic tailings (including potentially acid generating [PAG] rock and finer pyritic tailings) would be stored in the pyritic TSF during operations and relocated to the open pit during closure.

A relatively small fraction of the excavated rock from the open pit would make up the economic minerals that would be processed (concentrated) at the mine site then exported off site. This economic mineral portion would include 7.4 billion pounds of copper, 12.1 million ounces of gold, and 398 million pounds of molybdenum (PLP 2020d).

Approximately 89.5 million tons of overburden would be removed from the open pit. Suitable rocky overburden materials would be used for embankment fill, regrading purposes, and other rockfill for the project. Appendix K4.15, Geohazards and Seismic Conditions, addresses the volumes and geotechnical characteristics of the rockfill generated from the open pit and the quarries. Topsoil would be used as a growth medium during reclamation, some overburden material would be used for regrading purposes, and the remainder would be placed in the overburden stockpile.

At the close of mining, the open pit would be partially backfilled with pyritic tailings and PAG waste rock. The partial backfilling would reduce the volume of the open pit, but a permanent void in the landscape would remain. The extent of impacts would be limited to the footprint of the excavated pit and the locations where the materials would be relocated in the mine site. These impacts would be certain to occur if the mine were permitted and built.

### *Tailings Storage Facilities*

A bulk TSF and pyritic TSF would store tailings and waste rock generated from the mined and processed open pit rock (see Figure 2-4). Approximately 88 percent would be bulk tailings, and approximately 12 percent would be pyritic tailings (PLP 2020d).

The bulk TSF would have the largest footprint of the mine site facilities: about 30 percent of the mine site area. The pyritic TSF would compose about 5 percent of the mine site area.

The magnitude and extent of direct impacts on geologic material resources would be from the removal and relocation of rock and overburden required for construction of the two TSFs. The impacts would be limited to the footprints of the facilities. During closure, the pyritic tailings (including PAG waste rock) would be backfilled into the open pit, and the footprint of the pyritic TSF would be regraded to near preexisting topography, so that its impact would be long-term. The bulk TSF would be closed, recontoured, and vegetated at closure, and would remain as a new landform. The impact of the bulk TSF on the landscape would be permanent and would be certain to occur if the mine is permitted and the bulk TSF is constructed.

### *Quarries*

Surficial overburden and bedrock would be removed from three quarries in the western portion of the mine site to provide rockfill for the construction of embankments, roads, and other mining-related facilities (see Figure 2-4). The quarries would be developed primarily in granodiorite bedrock (competent igneous rock), and blasting would be required to remove the rock. The combined areas of the three rock quarries would be an estimated 16 percent of the total mine site area. The magnitude and area of impacts from quarry excavation would be the removal of the following estimated volumes of material and respective dimensions (PLP 2020d; PLP 2018-RFI 015):

- 1.7 billion cubic feet ($ft^3$) from Quarry A (approximately 5,000 feet by 2,900 feet)
- 3.2 billion $ft^3$ from Quarry B (approximately 5,800 feet by 7,000 feet)
- 1.4 billion $ft^3$ from Quarry C (approximately 5,200 feet by 3,300 feet)

The area of Quarry A would be covered during construction of the bulk TSF; Quarries B and C (west and east of the bulk TSF, respectively) would be backfilled and reclaimed during mine closure (see Section 4.16, Surface Water Hydrology, Figure 4.16-4). Excavation of the quarries would result in direct, long-term to permanent impacts on geologic resources. These impacts would be certain to occur if the mine were permitted and built.

### *Other Mine Site Facilities*

Geologic materials would be removed from and/or relocated to various other facility footprints in the mine site, including water management facilities; milling and processing facilities; the power plant; water treatment plants; camp facilities; storage facilities, including laydown areas; and access roads (see Figure 2-4).

The magnitude and extent of the direct impacts on geologic resources at the mine site would be the removal and relocation of geologic materials at these sites, limited to the footprints of the respective facilities. Regrading of some of these facilities at mine closure would minimize impacts on geologic materials (see Section 4.16, Surface Water Hydrology, Figure 4.16-4 through Figure 4.16-7).

Power generation facilities, some camp and storage facilities, access roads, and the open pit water treatment plant would remain to support post-closure water treatment and site monitoring, which would likely continue beyond post-closure. Therefore, the duration of impacts of these facilities on geologic resources would be permanent. The impacts would be certain to occur if the project is permitted and built.

## 4.13.3.2 Transportation Corridor

The transportation corridor for Alternative 1a includes access roads, material sites, and two ferry terminals on Iliamna Lake. The impacts due to the removal and relocation of geologic materials at these sites are discussed in the following subsections.

### Access Roads

Alternative 1a includes the mine access road between the mine site and Eagle Bay ferry terminal; the port access road between the south ferry terminal to Amakdedori port; and the Kokhanok spur road (see Figure 2-18 and Figure 2-19).

The mine access road to the Eagle Bay ferry terminal would be approximately 35 miles long and underlain by surficial glacial deposits, with the potential for bedrock along approximately 2 miles of the corridor, which may require blasting. The port access road from the south ferry terminal to Amakdedori port would be approximately 37 miles long and underlain mostly by bedrock (see Figure 3.13-4).

The construction of access roads would require removing and relocating surficial glacial deposits and bedrock (PLP 2018-RFI 032a). The width of the construction right-of-way (ROW) would vary based on the terrain and underlying geology. The estimated range of disturbed geologic resources to construct the road prism may be roughly 60 to 80 feet (PLP 2020d) (see Figure 2-20). This would include the 30-foot-wide road, embankment slopes, drainage ditches, natural gas pipeline, and cut slopes in surficial glacial deposits and bedrock. Portions of the roadbed underlain by bedrock would likely require blasting (see Figure 3.13-4).

The exact number and design of waterbody crossings would be determined during final design and permitting. Under Alternative 1a, the roads would cross 233 waterbodies, which would require 10 bridges, including crossings of the Newhalen and Gibraltar rivers and Sid Larsen Creek. The remaining crossing structures would consist of various sizes and designs of culverts, depending on fish passage requirements. Impacts at crossings designated as fish passage culverts are addressed in Section 4.24, Fish Values. Bridges and culverts would require rock and riprap consisting of blasted bedrock from the geologic material sites discussed below (PLP 2020d).

The magnitude and extent of direct impacts on geologic resources would be the disturbance of these resources in the access road ROW, at stream crossings footprints, and at the material sites discussed in the next subsection. The mine access road to Eagle Bay and port access road would be required for site maintenance and monitoring through post-closure. Therefore, impacts on geologic resources would be permanent, and would be expected to occur if the mine access road is permitted and constructed.

### Material Sites

The access roads would require rockfill and aggregate for embankments and road surfacing during mine construction, operation, and closure. The rockfill and aggregate would be provided by 19 material sites adjacent to the transportation corridor (Appendix K2, Figure K2-1 and Figure K2-2). There would be 11 material sites along the mine access road and eight along the port access road.

Footprints of the material sites under Alternative 1a would vary from 8 to 45 acres, for a total of approximately 380 acres (see Appendix K2, Alternatives, Table K2-6). The total volume is estimated to be 7.6 million cubic yards ($yd^3$).

Of the 11 material sites along the mine access road to Eagle Bay, two would be situated in bedrock and would likely require blasting (see Figure 3.13-4 and Table K2-6). The other material sites along the mine access road would be in surficial glacial deposits generally consisting of silt- to gravel-sized materials that would not require blasting.

The eight material sites along the port access road would be situated in bedrock and would likely require blasting.

The magnitude of direct impacts of the project at materials sites would be the removal of rock and gravel from these sites. The impact would be permanent in terms of geologic resources, but the extent would be limited to the material site footprints. The material sites would eventually be stabilized and progressively reclaimed, but generally would not be backfilled during mine closure and post-closure. These impacts to material sites would occur if the project is permitted and built.

### Ferry Terminals

Under Alternative 1a, ferry terminals would be constructed on Iliamna Lake at Eagle Bay and the south ferry terminal site west of Kokhanok. Constructing the south ferry and Eagle Bay terminals would require excavation of surficial glacial deposits and possibly bedrock on the combined 30 acres of the terminal footprints (see Figure 2-27 and Figure 2-29).

The magnitude of impacts due to ferry terminal construction on geologic features would be the removal and relocation of geologic materials. The extent of direct impacts would be limited to the footprints of the facilities. The ferry terminals would be closed and the sites would be reclaimed during closure. Impacts related to geology would be permanent, and certain to occur if the project is permitted and the terminals are constructed.

## 4.13.3.3 Amakdedori Port

Under Alternative 1a, the port would be at Amakdedori on the western shore of Cook Inlet (see Figure 2-32).

Construction of the Amakdedori port would affect an onshore footprint of approximately 22 acres, which includes the port terminal and the airstrip north of the port (see Figure 2-32 and Figure 2-33), directly affecting surficial glacial deposits and possibly alluvium (mostly sand and gravel).

The magnitude of impacts on geologic features due to Amakdedori port construction would be the removal and relocation of surficial geologic deposits. The extent of direct impacts to the geology would be limited to the onshore footprints of the port. Impacts to marine sediments at the port are described in Section 4.16, Surface Water Hydrology; Section 4.18, Water and Sediment Quality; and Section 4.22 Wetlands and Other Waters/Special Aquatic Sites. The port would be closed and undergo reclamation after completion of the off-site transport of concentrate. Therefore, the duration of impacts would be long-term, and certain to occur if the project is permitted and the Amakdedori port is constructed.

#### 4.13.3.4 Natural Gas Pipeline Corridor

Construction of the shoreline component of the pipeline west of the compressor station at Anchor Point would use horizontal directional drilling (see Section 4.15, Geohazards and Seismic Conditions). From the eastern shore, trenching would be used to install the pipeline beneath the seafloor for pipeline stability, to mitigate geohazards, to address pipeline free spinning and to provide protection against third-party risks. Approximately 11.2 miles of the natural gas pipeline at an average water depth of 197 feet (60 meters) would not require trenching, and the pipe would be laid on the seafloor (NanaWP and Intecsea 2019b). The construction of the pipeline across Cook Inlet would not affect the geologic resources addressed in this section. Impacts to marine sediments from buried pipeline segments in Cook Inlet are described in Section 4.16, Surface Water Hydrology; Section 4.18, Water and Sediment Quality; and Section 4.22 Wetlands and Other Waters/Special Aquatic Sites.

From the western landfall near Amakdedori port, the magnitude of impacts from pipeline construction on upland geologic features would be the removal of both surficial glacial deposits and bedrock (depending on the location along the corridor) to bury the pipeline. Much of this material would be used to backfill the excavation. Upland pipeline construction would be integrated with access road construction in the ROW where practicable, and the extent of impacts would generally be limited to the immediate vicinity of the construction ROW and in established areas used for material laydown and staging of equipment.

Installing the pipeline would likely require drilling and blasting for those segments mapped as underlain by bedrock (see Figure 3.13-4). Where the pipeline installation is coincident with access road construction, the extent of pipeline-related impacts on geologic resources would be considered part of the impact of the access road ROW.

Impacts associated with sections of the natural gas pipeline that are co-located with the transportation corridor are included under the transportation corridor component. Where the overland pipeline installation is not coincident with access road construction (i.e., pipeline-only segments), the magnitude and extent of impacts from pipeline installation on geologic resources in the 150-foot ROW would primarily be limited to the pipeline trench (see Figure 2-48). Alternative 1a includes approximately 15 miles of onshore pipeline-only construction (see Table 2-2). Geologic resources primarily affected would include glacial overburden and potentially bedrock. The disturbed area would be reclaimed after installation of the pipeline, but the impacts of the excavation on geologic resources would be permanent. These impacts would be certain to occur if the project is permitted, and the pipeline is constructed.

For the crossing of Iliamna Lake to the landfall just east of Newhalen, the pipeline would be buried nearshore in sediments to prevent damage but would then be placed on the floor of the lake for most of the crossing (PLP 2020d). The pipeline segment placed on the lake floor (including the span remediation berm approximately 0.6 mile long in Iliamna Lake) (see Chapter 2, Alternatives and PLP 2020-RFI 164) would not affect the geologic resources addressed herein. Impacts to Iliamna Lake sediments are addressed in Section 4.16, Surface Water Hydrology; Section 4.18, Water and Sediment Quality; and Section 4.22 Wetlands and Other Waters/Special Aquatic Sites.

The natural gas pipeline would be required to support mine site maintenance and monitoring through post-closure. The impact on geologic resources would be permanent, because of the displacement of materials required to accommodate the pipeline.

## 4.13.4 Alternative 1

This section addresses the analysis of impacts on geologic resources and materials from Alternative 1 and variants.

### 4.13.4.1 Mine Site

The magnitude, duration, extent, and likelihood of impacts to geology in the mine site would be the same as those described for Alternative 1a.

### 4.13.4.2 Transportation Corridor

The Alternative 1 access roads include the mine access road from the mine site to the north ferry terminal; Iliamna spur road; and the same port access road and Kokhanok spur road as described for Alternative 1a (see Figure 2-51 and Figure 2-52). Impacts would be similar to those described for Alternative 1a, with the exception of the mine access road and Iliamna spur road.

#### *Access Roads*

The 28-mile-long mine access road from the mine site to the north ferry terminal on Iliamna Lake would be constructed in mostly surficial glacial deposits, with the potential for bedrock along approximately 2 miles of the corridor. The Iliamna spur road would be approximately 9 miles long and underlain by mostly surficial glacial deposits. The associated disturbance to geologic resources would be similar to that of the mine access road. Geology along the port access road from the south ferry terminal to the Amakdedori port and Kokhanok spur road would be the same as that described for Alternative 1a.

The exact number and design of waterbody crossings would be determined during final design and permitting. Under Alternative 1, roads would cross 224 waterbodies. These crossing structures would consist of 10 bridges, and the remainder would be culverts. The use of culverts to allow fish passage at stream crossings is addressed in Section 4.24, Fish Values. Crossing structures would require rock and riprap consisting of blasted bedrock from the geologic material sites discussed below (PLP 2020d).

The magnitude and extent of direct impacts on geologic resources would be the disturbance of these resources in the mine site access road and port access road ROW, at stream crossings footprints, and at the material sites discussed in the next subsection. The mine access road and port access road would be required for site maintenance and monitoring through post-closure. Therefore, impacts on geologic resources would be permanent, and would be expected to occur if the access roads are permitted and constructed as described for Alternative 1a. Aside from the Iliamna spur road and a different route for the mine access road, impacts would be similar to those described for Alternative 1a.

#### *Material Sites*

The access roads would require rockfill and aggregate for embankments and road surfacing during mine construction, operation, and closure. The rockfill and aggregate would be provided by 19 material sites adjacent to the transportation corridor (Appendix K2, Figure K2-3 and Figure K2-4). There would be eight material sites along the port access road; eight along the mine access road; and three along the Iliamna spur road.

Footprints of the material sites would vary from 8 to 22 acres, for a total of approximately 251 acres (Appendix K2, Alternatives, Table K2-13). The total volume is estimated to be 7.5 million $yd^3$.

The eight material sites along the port access road would be situated in bedrock, and may require blasting (see Figure 3.13-4 and Table K2-13).Two of the eight material sites along the mine access road would likely require blasting, while the remaining six material sites would be in surficial glacial deposits generally consisting of silt- to gravel-sized materials that would not require blasting. All three of the sites along the Iliamna spur road would be in surficial glacial deposits that would not require blasting (PLP 2018-RFI 035) (see Table K2-13).

The magnitude of direct impacts of the project at materials sites would be the removal of rock and gravel from these sites. The impact would be permanent in terms of geologic resources, but the extent would be limited to the material site footprints. The material sites would eventually be stabilized and progressively reclaimed, but generally would not be backfilled during mine closure and post-closure. These impacts to material sites would occur if the project is permitted and built.

### *Ferry Terminals*

Constructing the north and south ferry terminals on Iliamna Lake would require excavation of surficial glacial deposits, and possibly bedrock, on the combined 27 acres of the terminal footprints (see Figure 2-29 and Figure 2-53).

The magnitude of impacts due to ferry terminal construction on geologic features would be the removal and relocation of geologic materials. The extent of direct impacts would be limited to the footprints of the facilities. The ferry terminals would be closed and the sites would be reclaimed during closure. Impacts related to geology would be permanent, and certain to occur if the project is permitted and the terminals are constructed.

## 4.13.4.3 Amakdedori Port

The onshore facilities at Amakdedori port would be the same as those of Alternative 1a; affecting approximately 22 acres of surficial deposits and possible alluvium (mostly sand and gravel) (see Figure 2-56 and Figure 2-57).

The marine port facilities include a truck route and causeway constructed of an earthfill embankment and a barge berth constructed using an enclosed steel sheet-pile wall wharf structure filled with earthfill (see Figure 2-56). The source of the earthfill would likely be the nearest geologic materials site, MS-A08, and possibly the footprint of the port terminal.

The rockfill access causeway would be constructed in nearshore sediment deposits on the bottom of the bay. Dredging would not be required. Impacts to marine sediments are described in Section 4.16, Surface Water Hydrology; Section 4.18, Water and Sediment Quality; and Section 4.22 Wetlands and Other Waters/Special Aquatic Sites.

The magnitude of impacts on geologic resources due to Amakdedori port construction would be the removal and relocation of geologic materials. The extent of direct impacts to onshore geologic resources would be limited to the onshore footprints of the port. The port would be closed and undergo reclamation after completion of the off-site transport of concentrate. Therefore, the duration of impacts would be long-term, and certain to occur if the project is permitted and the Amakdedori port is constructed.

#### 4.13.4.4 Natural Gas Pipeline Corridor

The segment of natural gas pipeline corridor from the compressor station near Anchor Point on the Kenai Peninsula to the south ferry terminal on Iliamna Lake would be the same as that described for Alternative 1a; the types of impacts along these segments would be the same as described for the Alternative 1a.

From the south ferry terminal, the pipeline would cross Iliamna Lake to the north ferry terminal and then continue along the mine access road to the mine site. Impacts associated with sections of the natural gas pipeline that are co-located with the transportation corridor are included under the transportation corridor component.

Alternative 1 includes approximately 5 miles of onshore pipeline-only construction (see Table 2-2). Installing the pipeline would likely require drilling and blasting for those segments mapped as underlain by bedrock (see Figure 3.13-4). Geologic resources primarily affected would include glacial overburden and potentially bedrock. The magnitude and extent of impacts from pipeline installation on geologic resources would primarily be limited to the pipeline trench within the 150-foot ROW (see Figure 2-48). The disturbed area would be reclaimed after installation of the pipeline, but the impacts of the excavation on geologic resources would be permanent. These impacts would be certain to occur if the project is permitted, and the pipeline is constructed.

For the crossing of Iliamna Lake under Alternative 1, the pipeline would be buried nearshore in sediments to prevent damage, but would then be placed on the floor of the lake for most of the crossing, as described for Alternative 1a. The pipeline segment placed on the lake floor (including the permanent berm on the lakebed along two sections of the Iliamna Lake segment to place the pipeline on; approximately 2 miles combined) (see Chapter 2, Alternatives) would not affect the geologic resources addressed herein. Impacts to Iliamna Lake sediments are addressed in Section 4.16, Surface Water Hydrology; Section 4.18, Water and Sediment Quality; and Section 4.22 Wetlands and Other Waters/Special Aquatic Sites.

The natural gas pipeline would be required to support mine site maintenance and monitoring through post-closure. The impact on geologic resources would be permanent, because of the displacement of materials required to accommodate the pipeline.

#### 4.13.4.5 Alternative 1—Summer-Only Ferry Operations Variant

**Mine Site Concentrate Storage**

During the winter, concentrate would be stored in a shipping storage container laydown area constructed of rock and gravel fill northeast of the pyritic TSF (see Figure 2-59). Changes at the mine site related to the additional concentrate storage would result in a 33 acre increase in footprint at the mine site. The magnitude and extent of impacts due to construction of the concentrate storage site on geologic features would be the removal and relocation of geologic materials from these 33 acres. The facility would be removed, and the sites would be reclaimed during closure. Therefore, impacts related to geology would be long-term, and certain to occur if the Summer-Only Ferry Operations Variant is chosen, the project is permitted, and the storage area is constructed.

**Amakdedori Port**

The Summer-Only Ferry Operations Variant would require the Amakdedori port to include an expanded storage yard (27 acres) (see Figure 2-60). The extent of impacts on geologic resources would be limited to the construction footprint. The port would be closed and undergo reclamation after completion of the off-site transport of concentrate for the project. Impacts would therefore be long-term, and certain to occur if the Summer-Only Ferry Operations Variant is chosen, and the project is permitted and built.

### 4.13.4.6 Alternative 1—Kokhanok East Ferry Terminal Variant

The mine access road and Iliamna spur road would be the same as described for the Alternative 1 base case, constructed in mostly surficial glacial deposits, with the potential for bedrock along approximately 2 miles of the corridor. The port access road extends approximately 27 miles from the Amakdedori port to a ferry terminal on the southern shore of Iliamna Lake east of the village of Kokhanok (Kokhanok east ferry terminal) and the Kokhanok spur road extends 5 miles from the port access road to the community of Kokhanok (see Figure 2-61 and Figure K2-4). The port access road to the Kokhanok east ferry terminal site would not require a crossing of the Gibraltar River, and would also have fewer overall stream crossings. Although the port access road alignment differs from the Alternative 1 base case, the geology along the port access road from the south ferry terminal to the Amakdedori port and Kokhanok spur road would be similar to that described for the Alternative 1 base case.

The Kokhanok East Ferry Terminal Variant would be constructed east of Kokhanok (see Figure 2-61 and Figure 2-62). Construction of the ferry terminal under this variant would encounter similar geology as construction of the Kokhanok (south) ferry terminal described for Alternative 1a and Alternative 1. The combined footprint for the north ferry terminal and Kokhanok east ferry terminal would be 19 acres.

The Kokhanok East Ferry Terminal Variant would require approximately 64 percent more rockfill material than the Kokhanok ferry terminal under the Alternative 1 base case (PLP 2020d). A total of 19 material sites (up to 358 acres) have been identified for this variant (Appendix K2, Alternatives, Table K2-14). Three of the material sites for the Kokhanok East Ferry Terminal Variant would change from MS-A01 through MS-A03 (totaling approximately 39 acres) to MS-K01 through MS-K03 (totaling approximately 146 acres). This would result in an approximately 70 percent increase in the area of material sites needed to construct the Kokhanok East Ferry Terminal Variant. The total volume is estimated to be 7.6 million $yd^3$.

The natural gas pipeline alignment from the Amakdedori port would follow the port access road towards the Kokhanok east ferry terminal and the spur road into Kokhanok. From Kokhanok, it would follow an existing road alignment to the point where it departs the shoreline to tie into the proposed route from the Kokhanok west ferry terminal site (Figure 2-61). All other segments of the pipeline would be the same as described for the Alternative 1 base case. Impacts associated with sections of the natural gas pipeline that are co-located with the transportation corridor are included under the transportation corridor component.

The magnitude of impacts on geological features due to construction of the Kokhanok East Ferry Terminal Variant site would be the removal and relocation of geologic materials in the construction footprints of the ferry terminal site, the natural gas pipeline alignment, and the access road to the ferry terminal. The extent of impacts due to the removal of geologic material would be greater than those estimated for the Kokhanok ferry terminal (Alternative 1 base case) because more fill would be required to construct the terminal at the east location.

The closure-related impacts of the Kokhanok East Ferry Terminal Variant would be similar to those for the Kokhanok (south) ferry terminal site. Both ferry terminal sites would be closed and reclaimed in closure, so that the duration of impacts would be long-term. These impacts on geologic resources would be certain to occur if the Kokhanok East Ferry Terminal Variant were chosen, permitted, and built.

#### 4.13.4.7 Alternative 1—Pile-Supported Dock Variant

The onshore facilities and associated impacts to geologic resources at Amakdedori port with incorporation of this variant would be the same as Alternative 1. The pile-supported dock design would reduce impacts to marine sediments compared to the earthen fill dock described for Alternative 1 above. Impacts to marine sediments are described in detail in Section 4.16, Surface Water Hydrology; Section 4.18, Water and Sediment Quality; and Section 4.22 Wetlands and Other Waters/Special Aquatic Sites.

### 4.13.5 Alternative 2—North Road and Ferry with Downstream Dams

The analysis of impacts from Alternative 2—North Road and Ferry with Downstream Dams on geologic resources is presented below.

#### 4.13.5.1 Mine Site

The magnitude, duration, extent, and likelihood of impacts to geology in the mine site would be essentially the same as those previously described for Alternative 1a, with the exception of an increased bulk TSF footprint.

The Alternative 2 bulk TSF main embankment would be constructed using the downstream method compared to centerline construction with downstream buttresses under Alternative 1a (see Figure 2-65 and Figure 2-66). The footprint for the bulk TSF main embankment constructed with the downstream method would increase by approximately 110 acres, requiring additional embankment fill. The magnitude and extent of impacts to geologic resources would increase from about 78 million $yd^3$ for Alternative 1a to about 124 million $yd^3$ for Alternative 2 (PLP 2018-RFI 075a). This would be an increase in direct impacts on geologic resources under Alternative 2 of approximately 5 percent for the bulk TSF main embankment, and approximately 1 percent for the overall mine site (PLP 2018-RFI 075a) as compared to Alternative 1a. The impacts would be permanent because the bulk TSF would be closed and reclaimed in place. The impacts would be expected to occur if Alternative 2 is chosen and the project is permitted and built.

#### 4.13.5.2 Transportation Corridor

<u>**Access Roads**</u>

Alternative 2 would involve constructing and operating mine and port access roads that would total approximately 54 miles (see Figure 2-64). An estimated 5 miles of the Alternative 2 access road would use an existing road; and the remainder would require new road construction or widening of the existing road.

The mine access road to the ferry terminal at Eagle Bay is the same as that described for Alternative 1a, including possible blasting for approximately 2 miles of the corridor (see Figure 3.13-4, Figure 2-51, and Figure 2-64).

The port access road from the Pile Bay ferry terminal to Williamsport would generally follow the existing road (see Figure 2-69). However, the road would need to be expanded and possibly bypassed in places to make it suitable for use by haul trucks. This would have the potential to result in fewer impacts on geologic resources than constructing a new road. However, material sites would still be needed for both construction and maintenance of the road surface (under Material Sites, below). Portions of the port access road corridor are underlain by surficial glacial deposits where there may be less need for blasting. However, if the existing road were to be bypassed or widened to accommodate the requirements for a haul road, it is possible and in places likely, that bedrock would be encountered outside the ROW of the existing road. For example, several material sites are likely in bedrock.

Part of the port access road would require construction of a new, approximately 3-mile-long section of road from Williamsport to Diamond Point. Constructing this section of road would require removing and relocating primarily bedrock (competent igneous intrusive rock), and blasting would likely be required (see Figure 3.13-4 and Figure 2-69).

Under Alternative 2, 220 waterbody crossings would be required including three bridges along the mine access road and four bridges along the port access road. The remaining crossing structures would consist of various sizes and designs of culverts, depending on fish passage requirements. Impacts at crossings designated as fish passage culverts are addressed in Section 4.24, Fish Values.The magnitude of direct impacts on geologic resources from constructing the access road would be the removal of geologic materials. The extent of impacts would be limited to the access road ROW. Because the port access road from Pile Bay to Williamsport would be shorter than the port access road from the south ferry terminal to Amakdedori, the total road distance for Alternative 2 (54 miles) would be approximately 27 percent less than under Alternative 1a (74 miles). If the 5 miles of existing road are considered, the net impact on geologic resources under Alternative 2 would be approximately 34 percent less than the impact under Alternative 1a.

As described for Alternative 1a, the Alternative 2 roads would require site maintenance and monitoring through post-closure. Therefore, the impact on geologic resources would be permanent. The impacts would occur if Alternative 2 is chosen and the transportation system associated with it is permitted and built.

## Material Sites

Road construction and operational maintenance under Alternative 2 would require material sites to provide required aggregate for road surfacing during mine construction, operation, and closure (see Figure 2-67 through Figure 2-69; and Table K2-22).

For Alternative 2, 17 material sites would be required for construction and maintenance of the transportation corridor versus 19 sites under Alternative 1a. The footprints of the Alternative 2 material sites would vary from approximately 6 acres to 45 acres, for a total of approximately 321 acres for the transportation component (see Table K2-22). This would be approximately 16 percent less area than needed under Alternative 1a. The amount of material estimated to be required for construction and maintenance of the transportation corridor is approximately 4.6 million $yd^3$. Material sites used for construction of pipeline-only segments of the natural gas pipeline are discussed below under the natural gas pipeline component.

Blasting would likely be required to remove bedrock from five of the 17 Alternative 2 material sites (see Figure 3.13-4). No blasting is anticipated for the 11 material sites associated with the mine access road to the Eagle Bay ferry terminal. Three of the six material sites between Pile Bay, and the port would likely require blasting. This would result in approximately half of the blasting required under Alternative 1a.

As under Alternative 1a, the magnitude of direct impacts on geologic resources at material sites under Alternative 2 would be the removal and relocation of geologic materials for road surfacing. The extent of direct impacts would be limited to the footprints of the material sites. The material sites would eventually be stabilized and progressively reclaimed, but generally would not be backfilled during mine closure and post-closure. Therefore, impacts would be permanent. They would be certain to occur as described if Alternative 2 was chosen, permitted, and built.

**Ferry Terminals**

The transportation corridor under Alternative 2 would require ferry terminals at Eagle Bay and Pile Bay (combined total of 25 acres). Impacts of the terminal at Eagle Bay are described under Alternative 1a. The terminal at Pile Bay would be approximately the same size as the ferry terminals described for Alternative 1a. The geology at the Pile Bay ferry terminal under Alternative 2 would be similar to the geology at the ferry terminals under Alternative 1a.

The magnitude, duration, extent, and likelihood of impacts of construction of the Alternative 2 ferry terminals on geologic resources would be similar to the impacts of the ferry terminals under Alternative 1a.

### 4.13.5.3 Diamond Point Port

Alternative 2 includes construction of Diamond Point port at Iliamna Bay (see Figure 2-71). The Diamond Point port facility would use a similar design concept as the Amakdedori port under Alternative 1, with an earthen access causeway and sheet-pile wharf structure. The total footprint of the Diamond Point port would be larger than that of the Amakdedori port. The Diamond Point port onshore portions would encompass an estimated 25 acres of permanently affected geologic resources (mostly bedrock) compared to the roughly 22 acres of permanent impact to onshore areas (mostly surficial deposits) at the Amakdedori port under Alternative 1a and Alternative 1.

The magnitude of direct impacts on geologic resources would be the removal and relocation of geologic materials to construct the onshore portion of the Diamond Point port. Because the Diamond Point port site is larger than the Amakdedori port site, the geographic extent of the onshore impacts of Alternative 2 would be greater than that described under Alternative 1a. Due to the presence of bedrock, the Diamond Point port would also require blasting that may not be required at Amakdedori port.

Dredging would be required at the Diamond Point port to deepen the channel adjacent to and near the port wharf structure, and would remove approximately 650,000 $yd^3$ of marine sediments. The dredging area would include an estimated 58 acres offshore. Most dredged material (615,000 $yd^3$) would be used as earthfill behind the sheet pile wall. Remaining material would be placed in the 16 acre dredged materials storage area west of the port terminal. These impacts are described in Section 4.16, Surface Water Hydrology; Section 4.18, Water and Sediment Quality; and Section 4.22 Wetlands and Other Waters/Special Aquatic Sites.

The Diamond Point port would be closed and undergo reclamation after the completion of off-site transport of concentrate, as described for Alternative 1a. Therefore, the duration of impacts would be long-term, and would be certain to occur if this alternative was chosen and the port was permitted and built.

### 4.13.5.4 Natural Gas Pipeline Corridor

Construction of the natural gas pipeline under Alternative 2 would require disturbing both surficial glacial overburden and bedrock for all upland portions of the pipeline (see Figure 2-73). The corridor route, length, and respective geologic resources would differ from those of Alternative 1a. Under Alternative 2, the natural gas pipeline from the Kenai Peninsula to the mine site would have three main segments: 1) Cook Inlet crossing coming ashore at Ursus Cove; 2) northward to Diamond Point port; and 3) overland to the mine site, along the port and mine access roads with a pipeline-only segment between Pile Bay and the mine access road to Eagle Bay. Under Alternative 2, the natural gas pipeline would not cross Iliamna Lake. All Cook Inlet segments of the pipeline would be buried for Alternative 2 (PLP 2020-RFI BSSE 1a). The construction of the pipeline across Cook Inlet would not affect the geologic resources addressed in this section.

Impacts to marine sediments during construction and operation of the buried pipeline segments in Cook Inlet are described in Section 4.16, Surface Water Hydrology; Section 4.18, Water and Sediment Quality; and Section 4.22 Wetlands and Other Waters/Special Aquatic Sites.

Installing the pipeline would likely require drilling and blasting for those segments mapped as underlain by bedrock. Where the pipeline installation is coincident with access road construction, the extent of pipeline-related impacts on geologic resources would be considered part of the impact of the access road ROW.

Pipeline construction materials and methods for Alternative 2 would be similar to those for Alternative 1a. However, the pipeline segment between the Williamsport Pile Bay Road intersection and the mine access road would require an installation corridor independent of the transportation system (i.e., not co-located with an access road). Alternative 2 includes about 45 miles of onshore pipeline-only construction (see Table 2-2). The magnitude and extent of impacts from pipeline installation on geologic resources would primarily be limited to the pipeline trench within the 150-foot ROW (see Figure 2-48). Geologic resources primarily affected would include glacial overburden and bedrock. The disturbed area would be reclaimed after installation of the pipeline, but the impacts of the excavation on geologic resources would be permanent. These impacts would be certain to occur if the project is permitted, and the pipeline is constructed.

For the pipeline segment between the Williamsport-Pile Bay Road intersection and near Pedro Bay, the corridor is underlain by bedrock with relatively steep topography for portions of the alignment. From Pedro Bay to the western portion of Knutson Bay, the geology would consist mostly of surficial glacial deposits, and then bedrock similar to that found near Pedro Bay. From Knutson Bay to the mine site, the geology would generally consist of surficial glacial deposits, similar to the geology of the Alternative 2 transportation corridor to the Eagle Bay ferry terminal.

Thirteen material sites (up to 298 acres) would be required for construction of pipeline-only segments for Alternative 2 (see Appendix K2, Table K2-22). The amount of material estimated to be required from these material sites is approximately 2.8 million $yd^3$.

The magnitude of direct impacts on geologic resources from installation of the natural gas pipeline would be the removal and placement of geologic materials for construction. The extent of impacts would be limited to within the construction ROW for pipeline installation. As described for Alternative 1a, the natural gas pipeline would be required for site maintenance and monitoring through post-closure. The duration of the impact on geologic resources would be permanent, and certain to occur if the pipeline as described for Alternative 2 were permitted and built.

### 4.13.5.5 Alternative 2—Summer-Only Ferry Operations Variant

Impacts would be the same as those described above for Alternative 1 during summer-only ferry operations.

### 4.13.5.6 Alternative 2—Pile-Supported Dock Variant

The onshore facilities and associated impacts to geologic resources at Diamond Point port with incorporation of this variant would be the same as Alternative 2. The pile-supported dock design would reduce impacts to marine sediments compared to the earthen fill dock described for Alternative 2 above, as described in Section 4.18, Water and Sediment Quality; and Section 4.22, Wetlands and Other Waters/Special Aquatic Sites.

#### 4.13.5.7 Alternative 2—North Crossing of the Newhalen River Variant

This variant considers a north crossing location of the Newhalen River as an alternative to the south crossing location that is evaluated in Alternative 1a. The impacts to geological resources would be the same at either crossing location.

### 4.13.6 Alternative 3—North Road Only

The analysis of impacts from Alternative 3—North Road Only on geologic resources is presented below.

#### 4.13.6.1 Mine Site

Impacts of Alternative 3 on geologic resources at the mine site would be the same as those described for Alternative 1a.

#### 4.13.6.2 Transportation Corridor

***Access Road***

The north access road would connect the mine site with the port site north of Diamond Point and would be 82 miles long (see Figure 2-78 and Figure 2-79). The north access road would be about 28 miles longer than the port and mine access roads under Alternative 2.

From the mine site to near Knutson Bay, the geology would consist of surficial glacial deposits, similar to the geology of the Alternative 2 transportation corridor to the Eagle Bay ferry terminal described above, so that blasting may not be required. From the western portion of Knutson Bay to Pedro Bay, the geology would consist mostly of bedrock and surficial glacial deposits, and blasting would be required. From Pedro Bay to the Williamsport-Pile Bay Road intersection, the corridor is mapped as underlain by bedrock and relatively steep topography for portions of the alignment.

The access road from the Williamsport-Pile Bay Road intersection to Williamsport would generally follow the existing road (see Chapter 2, Alternatives), which is underlain by a combination of bedrock requiring blasting and surficial glacial deposits. The last segment of new road from Williamsport to the port site north of Diamond Point would be underlain by bedrock.

Under Alternative 3, 205 waterbody crossings would be required, including 17 bridges. The remaining crossing structures would consist of various sizes and designs of culverts, depending on fish passage requirements. Impacts at crossings designated as fish passage culverts are addressed in Section 4.24, Fish Values.

The magnitude of direct impacts on geologic resources from constructing the access road would be the removal and placement of geologic materials, and the extent of impacts would be limited to the access road ROW. Based on road lengths, Alternative 3 (82 miles) would require removing and relocating approximately 10 percent more geologic material for the access road than under Alternative 1a (74 miles); 6 percent more under Alternative 1 (77 miles); and 34 percent more than under Alternative 2 (54 miles). As with all action alternatives, the road would require maintenance and monitoring through post-closure. Therefore, the duration of the impacts on geologic resources would be permanent. These impacts would be certain to occur if Alternative 3 is chosen and the project is permitted and built.

### *Material Sites*

As with all action alternatives, access road construction and operational maintenance under Alternative 3 would require material sites to provide required aggregate for road surfacing during mine construction, operations, and closure (see Figure K2-7 and Table K2-28).

Twenty-seven material sites would be required for the Alternative 3 north access road, versus 19 material sites under Alternative 1a, 19 sites under Alternative 1, and 17 sites under Alternative 2. The footprints of the Alternative 3 material sites would vary from 6 acres to 45 acres, for a total of an estimated 604 acres (see Table K2-28).

Blasting would likely be required to remove bedrock from six of the Alternative 3 material sites (see Figure 3.13-5 and Table K2-28). All other material sites would be in surficial glacial deposits of sand and gravel and would not require blasting.

The magnitude and extent of direct impacts to material sites under Alternative 3 would be the removal of rock and gravel. The extent of the impact would be limited to the footprints of the material sites; the sites would be eventually stabilized and progressively reclaimed, but not backfilled, during mine closure and post-closure. Therefore, the duration of impacts to the sites would be permanent. These impacts would be expected to occur if Alternative 3 is chosen, permitted, and built.

### *Ferry Terminals*

No ferry terminals would be needed under Alternative 3. Therefore, no associated impacts on geologic resources would occur.

## 4.13.6.3 Diamond Point Port

The port site under Alternative 3 would be north of Diamond Point (see Figure 2-80 and Figure 2-81).

The Diamond Point port onshore footprint would encompass an estimated 16 acres of permanently affected geologic resources, compared to the roughly 22 acres of permanent impact to onshore areas at the Amakdedori port under Alternative 1a and Alternative 1, and 25 acres under Alternative 2. The onshore port location under Alterative 3 is mostly underlain by bedrock. Local topography is steep, dropping to narrow rocky beaches (PLP 2020d, Figure 1-5) and construction would require blasting of bedrock. The magnitude of direct impacts on geologic resources would consist of the removal and relocation of geologic materials to construct the onshore portions of the Diamond Point port.

Under Alternative 3, the port facility would use a similar marine facility design concept as described under Alternative 1a. The caisson dock for Alternative 3 would be constructed in shallower water than the Diamond Point dock under Alternative 2. As a result, additional dredging would be required for dock construction. The Alternative 3 dredge basin would be 76 acres with approximately 1,100,000 $yd^3$ of material anticipated to be initially removed for construction of the channel and turning basin, and an additional 700,000 $yd^3$ of material would be removed during maintenance dredging over the 20-year life of the mine. The dredged material would be placed into two bermed stockpiles (16 acres combined) located in uplands north of the port facility and adjacent to the transportation corridor. Impacts related to dredging of marine sediments are described in Section 4.16, Surface Water Hydrology; Section 4.18, Water and Sediment Quality; and Section 4.22 Wetlands and Other Waters/Special Aquatic Sites.

The Diamond Point port would be closed and would undergo reclamation after the completion of off-site transport of concentrate, as described for the Alternative 1a. Therefore, the duration of impacts would be long-term, and would be certain to occur if this alternative was chosen and the port was permitted and built.

### 4.13.6.4 Natural Gas Pipeline Corridor

As described for Alternative 1a, construction of the natural gas pipeline under Alternative 3 would require removing and relocating geologic resources to bury the pipeline in an excavated trench for all upland portions of the pipeline.

From the port to the mine site, the Alternative 3 pipeline would follow the same route as the north access road previously described. Material sites used for construction of the co-located north access road and pipeline are described under the transportation corridor above. Three additional material sites (approximately 11 acres) would be required for construction of the pipeline-only segment from Ursus Cove to Diamond Point port location. Two of the three material sites along this segment would require blasting (see Table K-28 and Figure K2-7). The amount of material estimated to be required from these material sites is approximately 200,000 $yd^3$.

Alternative 3 includes less than 10 miles of onshore pipeline-only construction (see Table 2-2). Installing the pipeline would likely require drilling and blasting for those segments mapped as underlain by bedrock. The magnitude and extent of impacts from pipeline installation on geologic resources would primarily be limited to the pipeline trench within the 150-foot ROW (see Figure 2-48). Geologic resources primarily affected would include overburden and bedrock. The disturbed area would be reclaimed after installation of the pipeline, but the impacts of the excavation on geologic resources would be permanent. These impacts would be certain to occur if the project is permitted, and the pipeline is constructed.

As described for Alternative 2, all Cook Inlet segments of the pipeline would be buried for Alternative 3 (PLP 2020-RFI BSSE 1a). The construction of the pipeline across Cook Inlet would not affect the geologic resources addressed in this section. Impacts to marine sediments for buried pipeline segments in Cook Inlet are described in Section 4.16, Surface Water Hydrology; Section 4.18, Water and Sediment Quality; and Section 4.22 Wetlands and Other Waters/Special Aquatic Sites.

### 4.13.6.5 Concentrate Pipeline Variant

The Alternative 3 Concentrate Pipeline Variant would involve installing and operating a pipeline to transport concentrate slurry from the mine site to the port location north of Diamond Point. The concentrate pipeline would follow the Alternative 3 north access road route and would be co-located in a single trench with the natural gas pipeline and fiber-optic cable at the toe of the road embankment (see Figure 2-84 and Figure 2-85). Therefore, the impacts to geologic resources would be similar to those under the Alternative 3 transportation corridor.

The Diamond Point port terminal would be modified to accommodate a concentrate pipeline filter plant and bulk storage building (see Figure 2-86). Port operations would change due to the requirements of dewatering the concentrate, storing water and concentrate, and treating and discharging the filtrate water. The overall footprint of the port terminal would not increase; therefore, the impact on geologic materials would be similar to that of the port terminal without concentrate pipeline-related facilities. In addition to the marine facilities described for Alternative 3, the marine facility with the Concentrate Pipeline Variant would include a series of three caissons (60 feet by 60 feet) placed within the dredge basin to provide mooring and loading for concentrate lightering barges; expanding the marine facility footprint by less than 1 acre (approximately 0.2 acre) (see Figure 2-86). Impacts to marine sediments are described in Section 4.16, Surface Water Hydrology; Section 4.18, Water and Sediment Quality; and Section 4.22 Wetlands and Other Waters/Special Aquatic Sites.

The Concentrate Pipeline Variant would also require two electric pump stations; one at the mine site, and one at an intermediate point along the transportation corridor (see Figure 2-83 and

Figure 2-84). The magnitude and extent of impacts on geologic resources at the mine site would be limited to a footprint of about 1 acre. The intermediate pump station would be sited in the footprint of a proposed material site (Figure 2-84) and would not increase the overall footprint. The concentrate pipeline would be decommissioned in place at mine closure; however, to avoid further ground disturbance, the pipeline would not be removed. Therefore, the duration of impact on geologic materials would be permanent. Impacts would be certain to occur at this magnitude if the Alternative 3 Concentrate Pipeline Variant was chosen, and the pipeline is permitted and built.

This variant includes an option to construct an additional 8-inch-diameter return-water pipeline to pump the water extracted from the concentrate back to the mine site. The water return line would be co-located in a single trench with the natural gas pipeline (see Chapter 2, Alternatives). There would be no increase in impacts to geologic resources compared to the main variant.

## 4.13.7 Cumulative Effects

Impacts to onshore geologic resources would include the removal and relocation of bedrock (including ore), overburden, and material site resources. The cumulative effects analysis area for geologic resources encompasses the onshore footprint of the project, including alternatives and variants, the expanded mine footprint (including road, pipeline and port facilities), and any other reasonably foreseeable future actions (RFFAs) in the vicinity of the project that would result in potential synergistic and interactive effects. In this area, a nexus may exist between the project and other past, present, and RFFAs that could contribute to cumulative effects on geologic resources. Section 4.1, Introduction to Environmental Consequences, details the comprehensive set of past, present, and RFFAs considered applicable for evaluation. A number of actions were considered and determined to have no potential for contributing to cumulative effects on geologic resources in the analysis area. These include offshore-based developments; activities that may occur in the analysis area but are unlikely to result in any appreciable impact on geologic resources (such as tourism, recreation, fishing, and hunting); and actions outside of the cumulative effects analysis area.

### 4.13.7.1 Past and Present Actions

Past and present actions that have impacted geologic resources in the analysis area include transportation development where existing roads intersect the project footprint, and mineral exploration in locations where past or current activities have impacted geologic resources (e.g., drill sites). Although these actions affect localized areas, they are additive to other actions that may occur, slightly increasing the total cumulative effect on geologic resources. Past exploration at the Pebble deposit has included drilling of over 1,600 boreholes. Similarly, there have been boreholes drilled associated with exploration at other deposits in the analysis area. However, for approved exploration activities on state lands, there are requirements with regard to stabilizing boreholes and site remediation. Overall, the cumulative effects on geologic resources from past and present actions are minimal in extent and minor in magnitude for all alternatives.

### 4.13.7.2 Reasonably Foreseeable Future

RRFAs that could contribute cumulatively to geology impacts, and are therefore considered in the analysis of cumulative effects to geology include Pebble Project expansion scenario project period; mining exploration activities for Pebble South/PEB, Big Chunk South, Big Chunk North, Fog Lake, and Groundhog mineral prospects; onshore oil and gas development; road improvements and the continued development of the Diamond Point Rock Quarry.

The RFFFA contribution to cumulative effects on geology are summarized by alternative in Table 4.13-2.

The No Action Alternative would not contribute to cumulative effects on geologic resources.

**Table 4.13-2 Contribution to Cumulative Effects on Geology**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Pebble Project Expansion Scenario | **Mine Site:** The mine site footprint would have a larger open pit and new facilities to store tailings and waste rock, which would contribute to cumulative effects on geologic resources through removal of overburden, waste rock, and ore.<br>**Other Facilities:** A north access road, concentrate pipeline, and diesel pipeline would be constructed along the Alternative 3 road alignment, and extended to a new deepwater port site at Iniskin Bay. The mine site access road would be extended east from the Eagle Bay ferry terminal to the Pile Bay terminus of the Williamsport-Pile Bay Road. The existing port access road and ferry system connecting the Amakdedori port would remain in operation. Pipeline construction would have potentially limited impacts on geology from trenching activities<br>**Magnitude:** The Pebble Project expansion scenario project footprint would impact approximately 31,892 acres, compared to 9,612 acres under Alternative 1a.<br>**Duration/Extent:** The duration and extent of cumulative impacts to geology would vary from temporary disturbance during construction to permanent overburden, and ore removal within the footprint of mine and other project facilities over the expanded operations life. The extent of impacts would encompass the expanded mine site, the south access road corridor and the north access road corridor.<br>**Contribution:** This contributes to cumulative effects on geology through removal of overburden, waste rock, and ore. However, the area in the Kvichak and Nushagak River watersheds is relatively undeveloped, and effects would be limited to the project footprint, which is a relatively small area in the watersheds. | **Mine Site:** Same as Alternative 1a.<br>**Other Facilities:** Similar to Alternative 1a.<br>**Magnitude:** Would impact 32,418 acres, similar to Alternative 1a.<br>**Duration/Extent:** The duration and extent of cumulative impacts to geology would be similar to duration and extent of Alternative 1a.<br>**Contribution:** The contribution to cumulative effects from Alternative 1 would be slightly more than from other alternatives. | **Mine Site:** Same as Alternative 1a.<br>**Other Facilities:** The north access road would be extended east from the Eagle Bay ferry terminal to Iniskin Bay. Concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay.<br>**Magnitude:** Overall expansion of Alternative 2 (31,528 acres) would affect slightly less acreage than Alternative 1a (31,892 acres), given that a portion of the north access road and all of the gas pipeline would already be constructed. Impacts to geology from mine expansion would be slightly less than Alternative 1a.<br>**Duration/Extent:** The duration and extent of cumulative impacts to geology would be similar to duration and extent of Alternative 1a, although affecting a slightly smaller amount of acreage.<br>**Contribution:** The contribution to cumulative impacts would be similar to Alternative 1a, although affecting a smaller amount of acreage. | **Mine Site:** Same as Alternative 1a.<br>**Other Facilities:** Overall expansion would use the existing north access road; concentrate and diesel pipelines would be constructed along the existing road alignment and extended to a new deepwater port site at Iniskin Bay.<br>**Magnitude:** Overall expansion of Alternative 3 (31,541 acres) would affect slightly less acreage than Alternative 1a (31,892 acres), given that the north access road and gas pipeline would already be constructed. Impacts to geology from mine expansion would be slightly less than Alternative 1a.<br>**Duration/Extent:** The duration and extent of cumulative impacts to geology would be similar to duration and extent of the other alternatives.<br>**Contribution:** The contribution to cumulative impacts would be similar to the other alternatives. |

**Table 4.13-2 Contribution to Cumulative Effects on Geology**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Other Mineral Exploration Projects | **Magnitude:** Mining exploration activities, including additional borehole drilling, road and pad construction, and development of temporary camp facilities would contribute a small amount of disturbance at discrete locations, depending on landowner permitting and restoration requirements. For example, the 2018 drilling program proposed by PLP consisted of 61 geotechnical boreholes and 19 diamond-drilled core boreholes with diameters ranging from 2 to 8 inches.<br>**Duration/Extent:** Exploration activities typically occur at a discrete location for one season, although a multi-year program could expand the geographic area affected in a specific mineral prospect. Table 4.1-1 in Section 4.1, Introduction to Environmental Consequences, identifies seven mineral prospects in the analysis area where exploratory drilling is anticipated (four of which are in relatively close proximity of the Pebble Project).<br>**Contribution:** This contributes to cumulative effects of geologic resource disturbance, although the areal extent of disturbance is a relatively small portion of the Kvichak/ Nushagak watersheds. Assuming compliance with permit requirements, contributions to geology would be minimal. | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |
| Oil and Gas Exploration and Development | **Magnitude:** Onshore oil and gas exploration activities could involve seismic and other forms of geophysical exploration, and in limited cases, exploratory drilling. Seismic exploration would involve temporary overland activities, with permit conditions that avoid or minimize surface disturbance, | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |

**Table 4.13-2 Contribution to Cumulative Effects on Geology**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | and therefore impacts to geology. Should it occur, exploratory drilling would involve the construction of temporary pads and support facilities, with permit conditions to minimize surface disturbance and restore drill sites after exploration activities have ceased.<br>**Duration/Extent:** Seismic exploration and exploratory drilling are typically single-season temporary activities. The 2013 Bristol Bay Area Plan Amendment shows 13 oil and gas wells drilled on the western Alaska Peninsula, and a cluster of three wells near Iniskin Bay. It is possible that additional seismic testing and exploratory drilling could occur in the analysis area, but based on historic activity, is not expected to be intensive.<br>**Contribution:** Onshore oil and gas exploration activities would be required to minimize surface disturbance, and would occur in the analysis area, but removed from the project. The project would have minimal contribution to cumulative effects. | | | |
| Road Improvement and Community Development Projects | **Magnitude:** Road improvements projects would take place in the vicinity of communities, and have impacts through grading, filling, and potential increased erosion.<br>Only Iliamna and Newhalen are being considered in the analysis area for geologic resource cumulative effects. Some limited road upgrades could also occur in the vicinity of the natural gas pipeline eastern terminus near Stariski Creek. None of the anticipated transportation development in the geologic resources analysis area would | Similar to Alternative 1a and Alternative 2; greater than Alternative 3. | The footprint of the Diamond Point Rock Quarry under Alternative 1a coincides with the Diamond Point port footprint in Alternative 2 and Alternative 3. Cumulative impacts would likely be less under Alternative 2 due to commonly shared project footprints with the quarry site. | Similar to Alternative 2; less than Alternative 1a. |

**Table 4.13-2 Contribution to Cumulative Effects on Geology**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | contribute greatly to cumulative effects on those resources.<br>The Diamond Point Rock Quarry would include the excavation of geologic resources, which would represent a direct and cumulative effect. The estimated total rock reserve of the quarry source is approximately 10 to 15 million cubic yards (USFWS 2012g).<br>**Duration/Extent:** Disturbance from road construction would typically occur over a single construction season. Activity at Diamond Point would likely be seasonal, but continue to occur over multiple years. Geographic extent would be limited to the vicinity of communities and Diamond Point.<br>**Contribution:** Road construction would be required to minimize surface disturbance, and would occur in the analysis area, but removed from the project. The project would have minimal contribution to cumulative effects. | | | |
| Summary of Project contribution to Cumulative Effects | Overall, the contribution of Alternative 1a on cumulative effects to geologic resources, when taking other past, present, and reasonably foreseeable future actions into account, would be minor in terms of magnitude and extent, given the limited acreage affected and permit requirements. Duration would be permanent. | Similar to Alternative 1a, although slightly more acreage would be affected by expansion. | Similar to Alternative 1a, although slightly less acreage would be affected by expansion. | Similar to Alternative 1a, although slightly less acreage would be affected by expansion. |

Note:

PLP = Pebble Limited Partnership

# 4.14 SOILS

This section describes potential impacts on soils resulting from each project component for all alternatives and variants. Mitigation and control measures would incorporate structural and non-structural best management practices (BMPs) to address erosion and stormwater runoff. The evaluation also assumes that activities would be performed in accordance with prepared water management and sediment control plans, and necessary Alaska Department of Environmental Conservation (ADEC) permits (if issued) and stormwater pollution prevention plans (SWPPPs). This includes typical or standard practice activities and BMPs when none are specified in project documents (see Chapter 5, Mitigation). This section also addresses impacts to soil quality from fugitive dust. The impacts of the project on resources related to soils, including impacts to marine and lake sediments, are addressed in Section 4.16, Surface Water Hydrology; Section 4.18, Water and Sediment Quality; and Section 4.22, Wetlands and Other Waters/Special Aquatic Sites.

The Environmental Impact Statement (EIS) analysis area for soils includes all areas that would be disturbed as a result of the project and addresses all alternatives, components, and variants. Disturbed areas would include locations of removal or subsequent placement of soil. Because impact analyses are specific to upland soils, total soil disturbance acreages provided for alternatives and associated variants may be somewhat different from those provided in Appendix K2, Alternatives.

The impact analysis considered the following factors: magnitude, duration, geographic extent, and potential:

- Magnitude—impacts are assessed based on the quantified amount of soil resources expected to be affected (e.g., cubic feet, tons affected).
- Duration—impact duration on soil resources may be short-term, long-term, or permanent. Short-term effects are those impacts occurring only during construction and operations phases; long-term effects are considered to be those impacts extending into closure; and permanent effects are considered to be those impacts extending indefinitely into post-closure, with no restorative actions planned.
- Extent—impacts are assessed on the location and distribution of occurrence of the expected effects on soil resources (e.g., mine site footprint).
- Potential—impacts are assessed based on the potential likelihood of an effect to soil resources.

There were no scoping comments that identified specific concerns regarding the impact of the project on soils.

## 4.14.1 Summary of Key Issues

All alternatives would result in a similar magnitude, duration, and potential for impacts related to soils. The primary difference between the alternatives would be the amount of soils that would be affected. Table 4.14-1 presents a summary of key issues for soil resources.

**Table 4.14-1: Summary of Key Issues for Soil Resources**

| Impact Causing Project Component | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| **Mine Site[1]** | | | | |
| Soil disturbance | ~8,390 acres (total) | ~8,390 acres (total)<br>***Summer-Only Ferry Operations Variant:***<br>~33 additional acres for concentrate laydown area, 8,423 acres (total). | ~107 additional acres (downstream TSF construction).<br>***Summer-Only Ferry Operations Variant:***<br>Same as Alternative 2. | Same as Alternative 1a.<br>***Concentrate Pipeline Variant:***<br>~1 additional acres for pump house and booster station (total). |
| Soil quality | Magnitude and Potential: With the exception of antimony (+3.04%), the percent increase in baseline concentrations for all HAP metals from dust deposition in surface soils would be less than 1 percent; therefore, no adverse change to surface soil chemistry is expected to occur from fugitive dust deposition.<br>Extent: Mine site safety boundary.<br>Duration: Throughout post-closure. | Same as Alternative 1a.<br>***Summer-Only Ferry Operations Variant:***<br>Same as Alternative 1; however, a greater (perceived) potential for soil quality impacts due to additional concentrate handling, transport, and storage. | Same as Alternative 1a.<br>***Summer-Only Ferry Operations Variant:***<br>Same as Alternative 2. | Same as Alternative 1a.<br>***Concentrate Pipeline Variant:***<br>Same as Alternative 3; however, a reduced potential for concentrate release (to soils) because of reduced concentrate transport, handling, and storage. |
| Erosion | Magnitude: Impacts would vary and would be mitigated by implementing the Erosion and Sediment Control Plan and following industry standard BMPs for sediment and erosion control (see Chapter 5, Mitigation).<br>Duration: Pre-activity levels within 100 years.<br>Extent: Project boundaries.<br>Potential: Inherent. | Same as Alternative 1a.<br>***Summer-Only Ferry Operations Variant:***<br>Slight increase in erosion potential attributed to additional concentrate laydown area build-out (33 acres). | Potential erosion increases from TSF build-out.<br>***Summer-Only Ferry Operations Variant:***<br>Same as Alternative 2. | Same as Alternative 1a.<br>***Concentrate Pipeline Variant:***<br>Same as Alternative 3. |

**Table 4.14-1: Summary of Key Issues for Soil Resources**

| Impact Causing Project Component | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| **Transportation Corridor[1]** | | | | |
| Soil disturbance | ~1,793 acres (includes port and mine access roads, ferry terminals, material sites, spur road, and shared pipeline corridor). | ~1,778 acres (includes port and mine access roads, ferry terminals, material sites, spur roads and shared pipeline corridor).<br>***Summer-Only Ferry Operations Variant:***<br>Same as Alternative 1.<br>***Kokhanok East Ferry Terminal Variant:***<br>~Comparable to Alternative 1; however, 13 more acres would be affected primarily due to material site acreage. | ~1,349 acres (includes port and mine access roads, ferry terminals, material sites, spur roads, and shared pipeline corridor). Fewer acres disturbed compared to Alternative 1a and Alternative 1, with ~20 fewer miles of roadway. More material sites under Alternative 2.<br>***Summer-Only Ferry Operations Variant:***<br>~23 additional acres for concentrate storage than Alternative 2.<br>***Newhalen River North Crossing Variant:***<br>Approximately 19 more acres than Alternative 2; primarily due to material site acreage. | ~2,347 acres (includes the north access road, material sites, spur roads, and shared pipeline corridor)<br>25% greater than Alternative 1a.<br>***Concentrate Pipeline Variant:***<br>Increased width of road corridor to accommodate pipeline, but likely less than or equal to 10 percent. |
| Soil quality | Magnitude and Potential:<br>No adverse change to surface soil chemistry from fugitive dust deposition. No potentially acid-generating material from locally sourced material sites, seasonal emission mitigation/ suppression through watering, and concentrate transport in sealed containers.<br>Duration: Indefinite, based on continued post-closure transportation corridor access.<br>Potential: Low | Same as Alternative 1a.<br>***Summer-Only Ferry Operations Variant:***<br>Same as Alternative 1.<br>Kokhanok East Ferry Terminal Variant:<br>Same as Alternative 1. | Same as Alternative 1a.<br>***Summer-Only Ferry Operations Variant:***<br>Same as Alternative 2; however, a greater (perceived) potential for soil quality impacts due to additional acreage for concentrate storage on transportation corridor, handling, and transport steps.<br>***Newhalen River North Crossing Variant:***<br>Same as Alternative 2. | Same as Alternative 1a.<br>***Concentrate Pipeline Variant:***<br>Same as Alternative 3; however, less potential for concentrate release (to soils) because of reduced concentrate transport, handling, and storage. |

**Table 4.14-1: Summary of Key Issues for Soil Resources**

| Impact Causing Project Component | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Erosion | Magnitude: Approximately 27 miles of road corridor in moderate to rough terrain. May require some enhanced design and mitigation measures.<br>Duration: Temporary to indefinite.<br>Extent: Project footprint.<br>Potential: Inherent. Greatest potential for erosion would be along port access road; lower potential for other transportation components. | Magnitude, Extent, and Duration: Comparable to Alternative 1a.<br>Potential: Appreciably greater due to terrain and greater length (~3 additional miles). Approximately 30 miles of road corridor in moderate to rough terrain.<br>***Summer-Only Ferry Operations Variant:***<br>Potential erosion increases due to greater road usage during ice-free months.<br>Kokhanok East Ferry Terminal Variant:<br>Comparable, but potentially less erosion based on shorter road length. | Magnitude and Extent: Reduced, based on smaller acreage of ground disturbance and increased presence of coarser soil types and gentler terrain.<br>Duration: Similar to Alternative 1a.<br>Potential: Increased along 2.5-mile coastline segment of port access road, where unique road design and mitigation measures would prevent or minimize erosion potential; however, erosion potential would likely persist (e.g., topography and maritime conditions).<br>***Summer-Only Ferry Operations Variant:***<br>Potential erosion increases due to greater road usage during ice-free months, but less than the Alternative 1 Summer-Only Ferry Operations Variant, based on shorter road length.<br>***Newhalen River North Crossing Variant:***<br>Minimal potential erosion increases corresponding with slightly increased total acreage of disturbance. | Magnitude, Extent, and Potential: Greater than Alternative 1a, Alternative 1, and Alternative 2, based on greatest footprint acreage and waterbody crossing frequency. However, magnitude and potential may be comparable to Alternative 1 (at a minimum), based on less moderate to rough terrain that coincides with shallow fine-grained soil types.<br>Duration: Similar to Alternative 1a.<br>***Concentrate Pipeline Variant:***<br>Magnitude and Potential: Greatest among all alternatives and variants due to increase (~10 percent) in transportation corridor width.<br>Duration: Similar to Alternative 1a.<br>Extent: Similar to Alternative 3. |

**Table 4.14-1: Summary of Key Issues for Soil Resources**

| Impact Causing Project Component | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| **Port Site[1, 2]** | | | | |
| Soil disturbance | ~29 acres disturbed (includes the port terminal, airstrip, and water extraction site). | Same onshore port footprint as Alternative 1a).<br>***Summer-Only Ferry Operations Variant:***<br>28 additional acres required at Amakdedori port.<br>***Pile-Supported Dock Variant:***<br>Same onshore port footprint as Alternative 1a and Alternative 1. | ~50 acres (includes the port terminal, and dredge material storage areas).<br>***Summer-Only Ferry Operations Variant:***<br>Same as Alternative 2 (the additional acres for seasonal storage of concentrate containers would be along transportation corridor).<br>***Pile-Supported Dock Variant:***<br>Same onshore port footprint as Alternative 2. | ~36 acres (includes the port terminal, and dredge material storage areas).<br>***Concentrate Pipeline Variant:***<br>Same onshore port footprint as Alternative 3. |
| Soil quality | Magnitude:<br>No adverse change to surface soil chemistry from fugitive dust deposition. No PAG material from locally sourced material sites; seasonal emission mitigation/suppression through watering. Concentrate transfer from sealed bins to bulk carriers conducted offshore below deck. Calculated concentrate emissions total approximately 4 pounds per year.<br>Duration: Indefinite, based on continued post-closure port needs.<br>Potential: Low; however, greatest during the operational period during concentrate storage and handling. | Same as Alternative 1a.<br>***Summer-Only Ferry Operations Variant:***<br>Same as Alternative 1; however, a greater (perceived) potential for soil quality impacts due to additional concentrate handling and transport steps.<br>***Pile-Supported Dock Variant:***<br>Same as Alternative 1. | Same as Alternative 1a.<br>***Summer-Only Ferry Operations Variant:***<br>Same as Alternative 2.<br>***Pile-Supported Dock Variant:***<br>Same as Alternative 2. | Same as Alternative 1a. Some additional potential for impacts to soil quality as a result of upland storage of dredged material.<br>***Concentrate Pipeline Variant:***<br>Same as Alternative 3; however, a reduced potential for concentrate release (to soils) because of reduced concentrate transport, handling, and storage. |

**Table 4.14-1: Summary of Key Issues for Soil Resources**

| Impact Causing Project Component | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Erosion | Magnitude: Low.<br>Duration: Indefinite; and up to several years into post-closure.<br>Extent: Project footprint.<br>Potential: Low. | Magnitude: Similar to Alternative 1a.<br>Duration, extent, and Potential: same as Alternative 1a.<br>***Summer-Only Ferry Operations Variant:***<br>Increased erosion due to additional storage area (29 acres) at Amakdedori port.<br>***Pile-Supported Dock Variant:***<br>Lower erosion potential – similar to caisson dock under Alternative 1a. | Magnitude and Extent: Increased, compared to Alternative 1a, based on larger acreage of ground disturbance/ infrastructure, terrain, and dredge material stockpile.<br>Duration: Same as Alternative 1a.<br>Potential: Increases compared to Alternative 1a, based on larger acreage of ground disturbance, terrain, and dredge material stockpile.<br>***Summer-Only Ferry Operations Variant:***<br>Increased erosion magnitude and potential along transportation corridor due to storage sites. No additional effect at the port.<br>***Pile-Supported Dock Variant:***<br>Reduced erosion potential similar to caisson dock under Alternative 1a. | Similar to Alternative 1a. Some additional erosional potential as a result of increased storage of dredged material.<br>***Concentrate Pipeline Variant:***<br>Same as Alternative 3. Additional acreage (0.3) is considered negligible for increased erosion potential. |
| **Natural Gas Pipeline Corridor[1,3]** | | | | |
| Soil disturbance | ~222 acres (includes onshore pipeline-only segments, compressor station, and HDD pullback work area) | ~63 acres (includes onshore pipeline-only segments, compressor station, and HDD pullback work area).<br>***Summer-Only Ferry Operations Variant:***<br>Same as Alternative 1.<br>***Kokhanok East Ferry Variant:***<br>~88 acres. | ~ 1,106 acres (includes onshore pipeline-only segments, compressor station, HDD pullback work area, material sites, and construction access roads).<br>***Summer-Only Ferry Operations Variant:***<br>Same as Alternative 2.<br>***Newhalen River North Crossing Variant:***<br>Same as Alternative 2. | ~138 acres (includes onshore pipeline-only segments, compressor station, HDD pullback work area, and material sites).<br>***Concentrate Pipeline Variant:***<br>Proportional increase of disturbance along pipeline-only segments to accommodate shared natural gas pipeline alignment with road. Also, see Alternative 3, Transportation Corridor key issues, for commonly aligned/ shared transportation corridor. |

**Table 4.14-1: Summary of Key Issues for Soil Resources**

| Impact Causing Project Component | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Erosion | Magnitude: Low, based on limited ground disturbance and shared transportation corridor.<br>Duration: Indefinite.<br>Extent: Project footprint.<br>Potential: Low. | Decreased potential for erosion on a temporary basis during construction and post-construction compared to Alternative 1a due to a smaller area of surface disturbance (acreage). More of the pipeline corridor is common with access roads and less is stand alone, as compared to Alternative 1a.<br>***Summer-Only Ferry Operations Variant:***<br>Same as Alternative 1.<br>***Kokhanok East Ferry Terminal Variant:***<br>Increased erosion potential as compared to Alternative 1. | Magnitude, Extent, and Potential: Increased during construction and operations based on larger acreage of ground disturbance, length, and reduced accessibility.<br>Potential: Increased during post-closure based on extents.<br>Duration: Comparable, based on shared transportation corridor segments.<br>***Summer-Only Ferry Operations Variant:***<br>Same as Alternative 2.<br>***Newhalen River North Crossing Variant:***<br>Same as Alternative 2. | Although the pipeline under this alternative is considered part of the commonly aligned transportation corridor for evaluation, the following key issue is considered:<br>The potential for increased erosion susceptibility of shallow, fine-grained soils in moderate to rough terrain from the port road to Canyon Creek west of Pedro Bay under Alternative 2 would be reduced under Alternative 3 immediately after construction and throughout operations. This is due to continuous road access for monitoring and maintenance of surface stabilization and restoration measures.<br>***Concentrate Pipeline Variant:***<br>Increased erosion potential along co-located pipeline segments due to greater ground disturbances. |

Note:
[1] Footprints include the total impacted area, including both permanent and temporary.
[2] Includes the footprints for the onshore components of the port. Impacts to marine and lake sediments are addressed in Section 4.16, Surface Water Hydrology; Section 4.18, Water and Sediment Quality; and Section 4.22 Wetlands and Other Waters/Special Aquatic Sites.
[3] Includes impacts from the pipeline-only sections of the natural gas pipeline where the pipeline is not co-located with the transportation corridor, as well as other onshore natural gas pipeline components (e.g., compressor station, material sites). The sections of the natural gas pipeline that are co-located with the road are included under the transportation corridor analysis. Impacts to marine and lake sediments are addressed in Section 4.16, Surface Water Hydrology; Section 4.18, Water and Sediment Quality; and Section 4.22 Wetlands and Other Waters/Special Aquatic Sites.
~ = approximately
BMPs = best management practices
HAP = hazardous air pollutant
HDD = horizontal directional drilling
PAG = potentially acid-generating
TSF = tailings storage facility

### 4.14.2 No Action Alternative

Under the No Action Alternative, federal agencies with decision-making authorities on the project would not issue permits under their respective authorities. The Applicant's Preferred Alternative would not be undertaken, and no construction, operations, or closure activities specific to the Applicant's Preferred Alternative would occur. Although no resource development would occur under the Applicant's Preferred Alternative, Pebble Limited Partnership (PLP) would retain the ability to apply for continued mineral exploration activities under the State's authorization process (ADNR 2018-RFI 073) or for any activity not requiring federal authorization. In addition, there are many valid mining claims in the area, and these lands would remain open to mineral entry and exploration by other individuals or companies.

It would be expected that current State-authorized activities associated with mineral exploration and reclamation, as well as scientific studies, would continue at levels similar to recent post-exploration activity. The State requires that sites be reclaimed at the conclusion of their State-authorized exploration program. If reclamation approval is not granted immediately after the cessation of activities, the State may require continued authorization for ongoing monitoring and reclamation work as it deems necessary.

PLP would reclaim any remaining sites at the conclusion of their exploration program. The State has authority to grant reclamation approval after the cessation of reclamation activities and may request continued authorization for ongoing monitoring and reclamation work as deemed necessary. Soils along the transportation corridor, natural gas pipeline corridor, and at the port sites would remain in their current state. There would be no effects on existing soils in the areas of these components. In summary, there would be no direct or indirect impacts on baseline soil conditions from implementation of the No Action Alternative.

### 4.14.3 Alternative 1a

Impacts to soil resources from Alternative 1a would include those related to soil disturbance and erosion. Soil quality is also evaluated for the mine site due to potential fugitive dust impacts from sources of concern. Factors used to evaluate soil impacts include soil type and area of disturbance; erosion based on BMPs, and foreseeable control measures using common industry practices; planned reclamation and objectives; and anticipated effects on soil quality based on planned project activities. Chapter 5, Mitigation, describes PLP's mitigation measures that have been incorporated into the project.

Evaluation of soil impacts assumes that sediment control measures, BMPs, and adaptive control strategies would be established in a water management and sediment control plan prepared prior to construction and operation. The Alaska Pollutant Discharge Elimination System program (APDES) Construction General Permit (CGP) addresses discharge of pollutants from construction for disturbances of at least 1 acre of land, including authorized and unauthorized stormwater and non-stormwater discharges. A permittee is required to contain runoff from exposed soils to minimize erosion and sediment transport. The CGP also requires established conditions that meet water quality standards through operator control measures. The CGP includes filing a signed Notice of Intent and SWPPP with the ADEC. The SWPPP is required to be prepared by an ADEC-qualified person, and establishes sources of pollutants and how control measures would be implemented to meet permit standards. The SWPPP also establishes inspection-related criteria; how corrective actions are addressed; and permit eligibility related to endangered species. Additional information and references to applicable requirements are provided in the ADEC APDES CGP-Final, Permit No. AKR100000 (ADEC 2016); Alaska Storm Water Guide (ADEC 2011); and Alaska Department of Transportation and Public Facilities (ADOT&PF) Best

Management Practices for Erosion and Sediment Control (ADOT&PF 2016). To be issued, the requirements of these permits must be met.

Other agencies that may require additional considerations related to upland soils include the Alaska Department of Natural Resources (ADNR) for an approved Pipeline Right-of-Way (ROW) Lease; the ADOT&PF for a Utility Permit on ROW; Kenai Peninsula Borough; and US Army Corps of Engineers (USACE) Section 404 Permit.

The following subsections describe the potential impacts on soils and soil quality of project components under Alternative 1a (mine site, including material sites, Amakdedori port, transportation corridor, and natural gas pipeline corridor).

### 4.14.3.1 Mine Site

This section describes potential effects of Alternative 1a on soils at the mine site from construction through closure and post-closure management. These effects include soil disturbance, changes to soil quality due to fugitive dust, and erosion.

#### Soil Disturbance

The magnitude and extent of impact would be the disturbance of approximately 8,390 acres of soil at the mine site. Most of the extent of the impact would be soils associated with soil map unit D36MTG (5,796 acres), followed by disturbances of 2,093 acres and 501 acres to soil map units D36HIL and D36HIJ, respectively. The total acreage of soil disturbances includes major earthworks; the duration of the impact would be long-term, over the 4-year construction period, and mine site operations up to closure. The total acreage estimate does not include reclamation of various mine site infrastructure that would be partially restored, or reduced soil disturbances during the closure period. These impacts to soil at the mine site would be certain to occur if the project is permitted and built as described for Alternative 1a.

Temporary impacts to soils at the mine site are limited to less than 1 acre for installation of chambers at the three effluent discharge points. PLP has prepared a Restoration Plan (Owl Ridge 2019a; PLP 2019-RFI 123) outlining their proposed approach for restoring temporarily impacted natural habitats, including aquatic habitats, to a condition that resembles the pre-construction condition, or that of adjacent lands undisturbed by the project (see Appendix M3.0, Restoration Plan).

Mine site facilities not required for post-closure activities would be reclaimed in accordance with an ADNR-approved reclamation plan per Alaska Reclamation Act requirements; and mining reclamation regulations per Alaska Statute (AS) 27.19 and 11 Alaska Administrative Code (AAC) 97. The reclamation performance standard is the adequate reclamation of disturbed areas from mining operations, and to leave the site in a stable condition; or reestablishment of renewable resources on the site within a reasonable period of time by natural processes.

Interim reclamation may be required as needed during mine site operation to stabilize ground surfaces. Where needed, stabilization may include surface roughening, revegetation, mulch, or erosion control fabric. Final reclamation during closure would use a phased approach once mine site operations have ceased. Facilities that would be reclaimed include the pyritic tailings storage facility (TSF), bulk TSF, overburden stockpiles, milling and processing facilities, non-essential roads, and most water management/treatment infrastructure (see Figure 2-4). Mine site infrastructure that would not undergo reclamation includes the open pit (approximately 609 acres); mine water treatment plant (WTP #3) (approximately 3 acres); bulk TSF main seepage collection pond and embankment (approximately 99 acres); south and east seepage collection and recycle ponds (SCRPs) and embankments (approximately 11 acres); power generation facilities (approximately 22 acres); inert monofill (approximately 9 acres) in the disturbed footprint; and limited camp, storage facilities, and access roads (see Figure 2-4). Two surface water runoff diversion channels associated with the bulk TSF would foreseeably remain for the post-closure phase. Reclamation of quarry sites B and C (approximately 860 acres) would include the diversion of surface water runoff and placement of a 3-foot lift of growth medium over the bottoms and sloped areas steeper than 2H:1V; however, steep slopes and benches would remain as they are in some areas of the highwalls. The magnitude and duration of post-closure impacts would be that a total of approximately 1,500 acres would not be reclaimed, and would result in permanent disturbances to existing soil conditions.

Although soil conditions underlying the TSF footprints would result in permanent soil disturbances, each would be reclaimed to conform to designated post-mining land use, as administered by the ADNR. The liner below the pyritic TSF would be removed, and bermed structures would be recontoured. This would be followed by application of salvaged growth media and surface restoration. The bulk TSF would remain in place after controlled dewatering and dry closure, resulting in a permanent landform. The bulk TSF surface would be graded and contoured as needed for drainage control. Growth media would be added for seeding and revegetation, including the embankments.

Indirect soil disturbance impacts are most likely to be associated with erosion and stormwater sediment transport processes, and are evaluated under erosion.

## Soil Quality

The magnitude and extent of project effects on soil quality would be the wet and dry deposition of fugitive dust derived from mine site sources, including mining operations in the pit (e.g., drilling and blasting); material transport, storage, processing, and handling (including ore, waste rock, concentrate, and aggregate); and wind erosion of exposed bulk tailings. This deposition would be long-term, lasting from construction through the life of the project, and would be certain to occur if the project is permitted and built. The cumulative deposition (i.e., loading) of dust throughout construction and operation was evaluated for the potential to impart an adverse change to surface soil chemistry. Dust deposition effects on water quality are discussed in Section 4.18, Water and Sediment Quality.

### *Fugitive Dust Constituents of Concern*

Total potential criteria pollutant and hazardous air pollutant (HAP) emissions were calculated for the mine site and other project components, assuming that each emission unit was operated continuously unless otherwise noted (PLP 2018-RFI 007). Annual fugitive particulate matter (PM) emissions were calculated based on conservative scenarios that assumed worst-case conditions for each activity or source component, such as peak ore-crushing capacity, maximum ore-hauling distance from final pit, and maximum waste rock hauling. Hourly surface meteorological data were obtained from January 2009 to December 2011; processed in accordance with US Environmental Protection Agency (EPA) and ADEC guidance using AERMET; and reviewed and approved by ADEC. Upper air meteorological data were derived from the King Salmon observation station operated by the National Weather Service. Wind directions over the duration of the 3-year period were predominantly from the southeast and northwest, and sustained wind velocities greater than 25 miles per hour were not uncommon (PLP 2018-RFI 009).

Of the 189 HAPs listed in the 1990 Clean Air Act Amendment and 40 Code of Federal Regulations (CFR) Part 63, applicable metals from fugitive sources were further evaluated for incremental increase over the 20-year operations period (Table 4.14-2). Hydrocarbons, anions, and cations are not considered compounds of concern from fugitive dust emissions.

**Table 4.14-2: Calculated Mine Site Post-Dust Deposition Metal Concentrations in Soil**

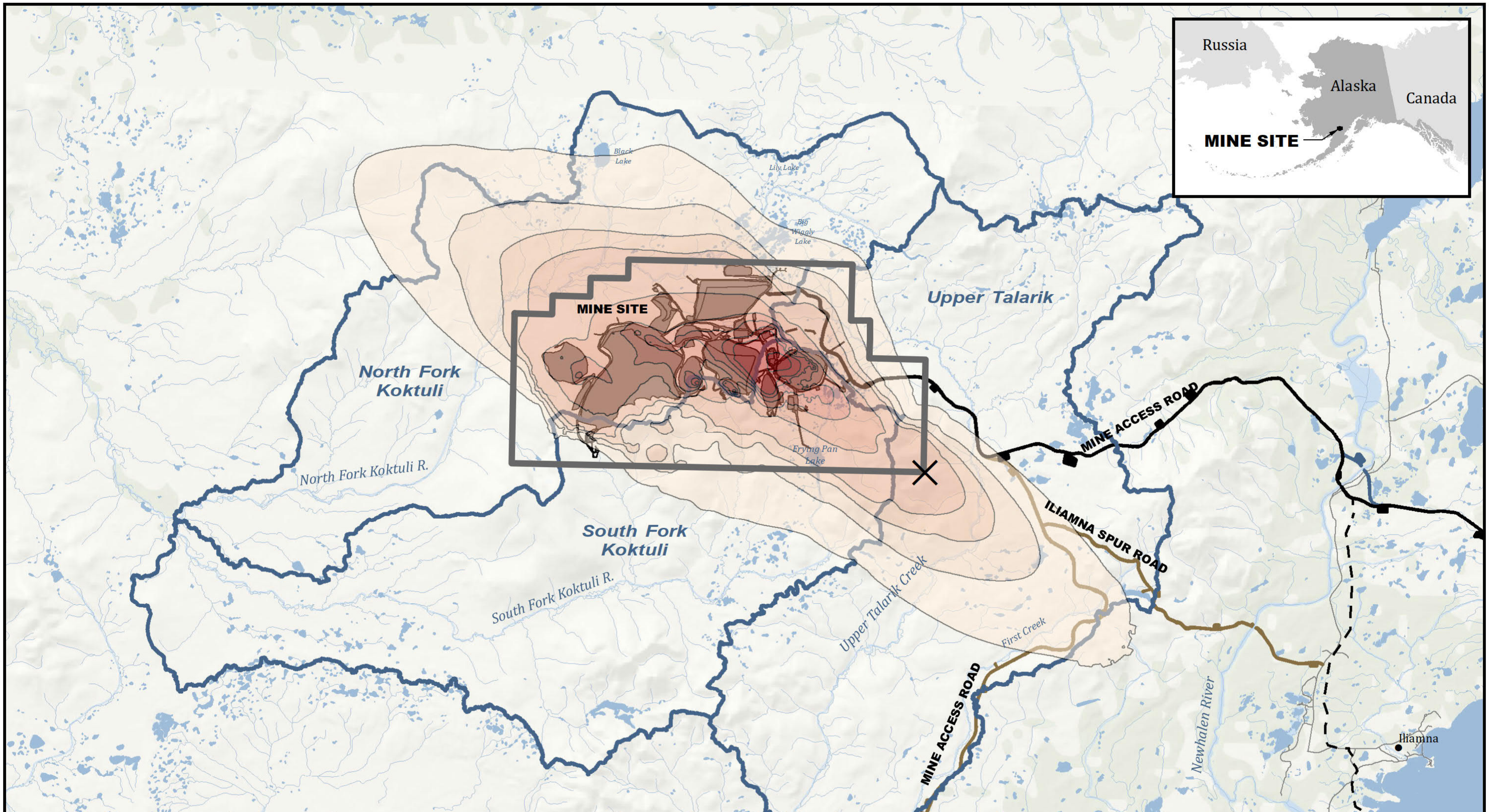
| Analyte | Baseline Mean[1] (mg/kg) | Post-Dust Deposition | | | Comparative Action Levels | |
|---|---|---|---|---|---|---|
| | | Incremental Increase over 20 Years (mg/kg)[2,3] | Baseline + 20 Years of Dust Deposition | Percent Increase after 20 Years | Human Health[4] (mg/kg) | Migration to Groundwater[4] (mg/kg) |
| Antimony | 0.24 | 0.0075 | 0.25 | 3.04% | 33 | 4.6 |
| Arsenic | 10.2 | 0.0589 | 10.3 | 0.57% | 7.2 (inorganic) | 0.2 |
| Beryllium | 0.41 | 0.00213 | 0.412 | 0.52% | 170 | 260 |
| Cadmium | 0.24 | 0.00173 | 0.242 | 0.72% | 76 (diet) | 9.1 |
| Chromium (total) | 17.7 | 0.0733 | 17.77 | 0.41% | 1.0 x $10^5$ ($Cr^3$) | 1.0 x $10^5$ ($Cr^3$) |
| Cobalt | 6.55 | 0.0195 | 6.57 | 0.30% | — | — |
| Copper[5] | 27.4 | 1.69 | 29.09 | 6.18% | 3300 | 370 |
| Lead | 8.74 | 0.0205 | 8.76 | 0.23% | 400 | — |
| Manganese | 388 | 0.693 | 388.69 | 0.18% | — | — |
| Mercury | 0.12 | 0.00013 | 0.12 | 0.11% | 3.1 (elemental) | 0.36 |
| Nickel | 9.16 | 0.0176 | 9.18 | 0.19% | 1,700 (soluble salts) | 340 |
| Selenium | 2.76 | 0.00753 | 2.77 | 0.27% | 410 | 6.9 |

Notes:
[1] Three Parameters Plus 2011a
[2] Based on PLP 2018-RFI 009 total HAPs concentration in dust and EPA 2005.
[3] Assumptions include life of mine (20 years) deposition period, soil mixing zone of 2 centimeters, and bulk soil density of 1.5 grams per cubic centimeter based on US Geological Survey estimate for silty soils (NRCS 2018; EPA 2005).
[4] ADEC 18 AAC 75, Oil and Other Hazardous Substances Pollution Control, September 29, 2018, Table B1. Method Two—Soil Cleanup Levels, Human Health, Over 40 Inch Zone, and Migration to Groundwater (ADEC 2017a). No available reference value per ADEC 18 AAC 75. Additional human health evaluation of all HAP metals is provided in Section 4.10, Health and Safety, based on published EPA Regional Screening Levels (RSLs).
[5] Based on PLP 2018-RFI 009b total HAPs concentration in dust and EPA 2005
$Cr^3$ = trivalent chromium
mg/kg = milligrams per kilogram

### *Dust Deposition on Soils*

Figure 4.14-1 depicts results of modeling dust deposition at the mine site during operations. Potential increase in metal concentration in the top 1 inch of soil at the mine site was estimated using modeling data for airborne metals concentrations and dust deposition (PLP 2018-RFI 009). Description of the approach, model, and parameters is provided in Appendix K4.14.

The expected constituent soil concentration after the 20-year mine life due to operational dust deposition was calculated by adding the incremental increase to baseline soil concentrations provided in Appendix K3.14. Calculated results are summarized in Table 4.14-2. The greatest accumulation of dust deposition at the mine site safety boundary is provided in Figure 4.14-1, which coincides with the greatest prevailing wind direction toward the southeast.




Sources: PLP 2018-RFI009a; PLP 2019-RFI153

US Army Corps of Engineers

2 0 2 4
Miles

Average annual $PM_{10}$ deposition ($g/m^2/yr$)

- 0.3 - 0.5
- 0.5 - 0.7
- 0.7 - 0.9
- 0.9 - 2.0
- 2.0 - 4.0
- 4.0 - 6.0
- 6.0 - 8.0
- 8.0 - 10.0
- 10.0 - 20.0
- > 20.0

Mine Site Safety Boundary, Point of Greatest Dust Deposition Accumulation

Mine Site Safety Boundary

**Action Alternatives**

Natural Gas Pipelines

Alternative 1a

Alternative 1

Alternative 1 Kokhanok East Ferry Terminal Variant

Alternative 2 Newhalen River North Crossing Variant

**Other Features**

Local Roads

Major Drainage Boundary

**DUST DEPOSITION DURING MINE SITE OPERATIONS**

**PEBBLE PROJECT EIS**

**FIGURE 4.14-1**

The calculated percent increase in HAP metals from 20 years of dust deposition at the mine site would not be considered of sufficient magnitude to have an adverse impact on surface soils relative to baseline conditions and ADEC action levels used for purposes of comparative evaluation. The greatest percent increase in baseline metals concentration (3.04 percent) is associated with antimony, although the concentrations with dust are still below ADEC levels. All calculated percent increases of other HAP metals were all below 1 percent, with the exception of copper. With the exception of arsenic, all evaluated metals were well below ADEC levels. The presence of naturally occurring arsenic above the ADEC level is readily apparent, with a reported mean of 10.2 milligrams per kilogram (mg/kg). For these reasons, the incremental arsenic increase of 0.57 percent from fugitive dust in surface soils is considered negligible relative to baseline conditions and documented presence of elevated concentrations in soils throughout the state. The natural occurrence of elevated chromium and arsenic concentrations in soil is acknowledged in ADEC Technical Memorandum, Arsenic in Soil, dated March 2009; and notes 11 and 12 of Table B1 (ADEC 2013d).

Similar to arsenic, elevated baseline concentrations of total chromium are present at the mine site, but well below the ADEC action level for trivalent chromium. Because there are no anthropogenic sources of hexavalent chromium ($Cr^{6+}$), nor are mineral assemblages considered favorable for $Cr^{6+}$ genesis (e.g., chromite), no further evaluation was conducted. Additional human health evaluation of all HAP metals, based on published EPA Regional Screening Levels (RSLs), is provided in Section 4.10, Health and Safety, and includes metals for which no ADEC reference value is shown in Table 4.14-2.

### *Dust Control*

The project design incorporates measures to minimize fugitive dust and prevent or minimize transfer of concentrate dust outside the mine site. The project has developed a conceptual fugitive dust control plan for mitigation and control of fugitive dust and wind erosion related to project activities (PLP 2019-RFI 134; PLP 2019-RFI 135). The final fugitive dust control plan would be developed as the project design advances and would include use of BMPs and best available control technology. Among other measures, the plan would enforce separation of mine site and access road traffic to minimize cross-contamination of vehicles, and would implement the use of sealed containers (i.e., containerized bulk-handling technology) for the transport of concentrate. Wet mill processes, the use of enclosures and dust collection systems in process plant operations, the watering of haul roads, use of wetting material, washing of concentrate containers, and covering and/or revegetation of stockpiled soil would also be used as controls on fugitive dust generation and deposition. See Chapter 5, Mitigation, for more information on BMPs captured in proposed mitigation measures.

Coarse ore would be stockpiled in a covered steel-frame building to minimize dust emissions. Baghouse-type dust collectors would be present at each conveyor-fed ore transfer point between the coarse ore stockpile and semi-autogenous grinding (SAG) (“ball”) mills. Water would be added during operations at the SAG mill to suppress dust. Specialized bulk cargo containers equipped with removable locking lids would contain thickened concentrates for transport to Amakdedori port.

The pyritic tailings and potentially acid-generating (PAG) waste would be stored sub-aqueously during operations, removing the potential for wind erosion and dust dispersion from sources with elevated metals concentrations. The bulk TSF would have tailings beaches, of which areas would be susceptible to wind erosion and fugitive dust emissions throughout operations on a variable basis. The tailings slurry and water component would be actively spigoted into the bulk TSF at variable locations along the main and south embankments and east ridge for development of a consistent tailings beach around the perimeter. Although spigoted distribution of tailings and water are anticipated to result in a sloped, coarser-grained tailings beach that transitions to finer-grained materials beneath the pond, portions of the tailings beach are expected to decrease in moisture content between variable spigot discharge locations on a temporal basis. These portions of the TSF beach would be most susceptible to wind erosion and potential fugitive dust emissions. Mitigation measures would include watering to reduce fugitive dust emissions (see Chapter 5, Mitigation). The bulk TSF would eventually be reclaimed through contouring of surfaces and application of growth media for revegetation and surface stabilization, eliminating the beaches as a dust source following closure activities. Dispersion of post-deposition dust throughout closure and post-closure would progressively diminish through natural and enhanced surface stabilization processes; however, deposition of fugitive dust would likely continue into closure and post-closure phases of mining as service vehicles and closure activities are conducted as needed along travel routes and work areas. The magnitude of dust dispersed during closure and post-closure phases is expected to be negligible relative to fugitive particulate dispersion during mining operations, and would likely be negligible in terms of environmental impacts.

## Erosion

The duration and extent of impacts from hydraulic erosion under planned conditions at the mine site would be during the year-round construction phase, coinciding with the longest period of soil disturbances. The magnitude of the impact of removing vegetative matting would be the exposure of fine-grained silty loam (i.e., volcanic ash mixtures in shallow surface soils [less than 30 inches deep] that are susceptible to water and wind erosion). Deeper soils consisting of coarser-grained glacial till and colluvium mixtures would be comparatively less susceptible to erosion. Much of the finer-grained (i.e., shallow) soil mixtures exposed during construction would be removed due to undesirable engineering properties (e.g., loading and compaction) required for infrastructure construction, and placed in salvaged growth media stockpiles.

Seasonal variations in weather conditions would influence potential erosional susceptibilities of disturbed ground surfaces. The timing of seasonal construction schedules for various project components is provided in PLP 2018-RFI 037. Wind and hydraulic erosion are not anticipated to occur when soils are frozen during winter. Frozen soil conditions generally occur for about 4 or 5 months per year (Hoefler 2010a). The greatest potential for hydraulic erosion would be during rainfall events, which typically occur during the fall. Soil susceptibility to wind erosion is influenced by moisture and particle size. Wind-induced erosion would be comparatively less than hydraulically driven processes in the construction phase, due to seasonal meteorological conditions and cohesive forces associated with soil moisture. A soil matrix composed of larger grains is less capable of retaining moisture, but less susceptible to wind transport. Although finer-grained soils are generally less tolerant to wind erosion, they are more capable of retaining cohesive moisture. Moisture is anticipated to minimize wind erosion of finer-grained surface soils for most of the year; however, the potential for erosion would be greatest during drier periods lasting 1 to 2 months during the summer.

All runoff water that comes in contact with mine site facilities, or is derived from the open pit, would be captured, including any entrained sediment in runoff from erosion (Knight Piésold 2018a). An Erosion and Sediment Control Plan (ESCP) would be developed for the project and BMPs would be implemented to prevent or minimize erosion and sedimentation associated with the project prior to beginning construction (see Chapter 5, Mitigation).

Water management structures (e.g., berms, channels, collection ditches) would be designed to accommodate a 100-year, 24-hour rainfall event. Sediment control ponds would be designed to treat a 10-year, 24-hour rain event, and safely accommodate a 200-year, 24-hour rainfall event. Mine site water management infrastructure would include freshwater diversion channels, an open pit water management pond (WMP), the main WMP, the bulk and pyritic TSFs, the bulk TSF main embankment seepage collection pond, seepage collection and recycle ponds, sediment ponds, and two WTPs. Water management design criteria and structure configurations are further discussed in Section 4.16, Surface Water Hydrology; and in the Operations Water Management Plan (Knight Piésold 2018a).

During construction, runoff upgradient of the TSFs would be intercepted by a cofferdam and released at a discharge point downgradient of all construction activities in the same watershed. Runoff from the TSF embankments during construction would also be captured. Similarly, runoff from larger excavations associated with the construction of long-term infrastructure (e.g., process plant, camps, power plant, and storage areas) would be routed to settling ponds prior to discharge. During operations, comparatively less soil erosion from water would occur because of diminished need for soil removal. Non-contact runoff would be captured in engineered diversion channels and discharged downgradient. In addition, completed construction of most long-term infrastructure would coincide with established water management and sediment control plan measures. Stormwater runoff from mine facilities that only requires sediment removal would be captured in sediment ponds, treated, and discharged under general APDES stormwater permits. Mine site drainage surface water that comes in contact with infrastructure would be diverted to WTPs for processing prior to discharge. Although water and sediment control during the operations phase would emphasize contact water minimization and management, runoff and sediment control measures would continue to be managed through BMPs and adaptive control strategies per the SWPPP(s) (see Chapter 5, Mitigation). Reduction in water management during operations would be limited to concurrent reclamation of overburden stockpiles.

The magnitude, duration, and extent of impacts from planned management of slurried tailings delivered to the bulk TSF would be the transport of dried, fine-grained tailings materials through wind erosion during operations. Bulk tailings would be pumped and discharged through spigots along the interior of the perimeter cell, with the slurry preferentially discharged to maintain an exposed tailings beach between the TSF embankment and supernatant pond. Although this approach minimizes potential risks associated with seepage effects on embankment stability, the fine tailings (e.g., beaches) would be susceptible to wind erosion when dried. Additional information regarding fugitive dust derived from the bulk TSF is presented in the Soil Quality discussion for the mine site.

The mine site would be reclaimed per an ADNR-approved reclamation plan that establishes requirements for designated post-mining land use. The reclamation plan would supplement or describe measures to control and mitigate erosion at the mine site through the post-closure period. Erosion during closure would be less than during construction, primarily because of comparatively less surface disturbances. Erosion would be greater during closure than operations because of reclamation earthwork required during closure. The magnitude of the impacts from reclamation would be the destabilization of large soil surface areas from decommissioning activities. Earthwork associated with the preparation and application of growth media would likely result in erosion until surface stabilization is achieved. At a minimum, similar measures established for construction in the ESCP would address runoff through erosion and sediment controls and BMPs. Additional measures may include future developments in available technologies or practices, and refined adaptive control strategies acquired throughout operations. Removal and reclamation of long-term water management infrastructure would progressively coincide with surface stabilization objectives established in the ADNR-approved reclamation plan.

The duration of impacts from erosion during reclamation from destabilized surfaces would likely continue for several years beyond closure. Prescribed design standards for reclaiming infrastructure and monitoring are established in reclamation plans required by the State of Alaska. Prescribed monitoring would likely occur annually until surface conditions are stabilized and meet land use objectives. Although reclaimed infrastructure would be designed to withstand storm events (e.g., 100-year, 24-hour rain event), monitoring would be necessary immediately after any occurrence.

### 4.14.3.2 Transportation Corridor

This section describes potential effects on soils along the transportation corridor. Impacts associated with the natural gas pipeline on the western side of Cook Inlet are also included in this section, because this segment of pipeline would predominantly coincide (i.e., be buried) with the road prism. Pipeline-only segments (not co-located with a road) of Alternative 1a are addressed under the "Natural Gas Pipeline Corridor" subsection, below.

#### Soil Disturbance

Approximate soil disturbance areas associated with the Alternative 1a transportation corridor include the following total acreages, post-construction acreages, and temporary acreages of disturbance:

- Port access road: south ferry terminal to Amakdedori port—699 acres (total), 411 acres (post-construction), 288 acres (temporary)
- Mine access road: mine site to Eagle Bay ferry terminal site—643 acres (total), 353 acres (post-construction), 290 acres (temporary)
- Kokhanok Airport Spur Road—25 acres (total), 15 acres (post-construction), 10 acres (temporary)
- Explosives Storage Spur Road—6 acres (total), 4 acres (post-construction), 2 acres (temporary)
- Ferry Terminals—37 acres (total), 30 acres (post-construction), 7 acres (temporary)
- Material Sites—380 acres (total, post-construction)

The magnitude of shared pipeline and transportation corridor ground disturbance (total acreage) under this alternative is approximately 1,793 acres, which includes the port and mine site roads, ferry terminals, material sites, and spur and access roads. Total post-construction and temporary acreages are 1,194 acres and 599 acres, respectively.

#### Material Sites

The magnitude of disturbances would include the complete removal and segregation of surface soils and overburden materials considered unsuitable for construction purposes. The duration of the disturbance would be long-term, lasting through the life of the project, but these materials would be salvaged for future reclamation as a growth medium. These impacts on surface soils at material sites would be certain to occur if the project is permitted and constructed as described for Alternative 1a. However, mitigation measures described in the following sections and in Chapter 5, Mitigation, would be expected to reduce impacts. Portions of sites no longer used for material extraction would be progressively reclaimed. This would mainly occur after the construction phase, once the bulk demand for materials has been met with infrastructure completion (e.g., roads). Material sites and access roads would continue to be used throughout operations for maintenance of project infrastructure, as needed. Less soil disturbance would occur during operations than during construction, but soil disturbance during operations would be caused by excavation or blasting on an as-needed basis. A need for materials would also persist throughout the post-closure period for continued road maintenance and other limited post-closure needs. Incremental reclamation of disturbance at materials sites would be required. Typical reclamation at gravel material sites would likely include grading and contouring of sidewall slopes; scarification or ripping to promote surface water infiltration and vegetation growth; application of salvaged growth media; and seeding with proposed mixtures as needed. No sidewall reclamation would be conducted at shot-rock material sites with 20-foot bench heights on exposed rock walls.

## Soil Quality

Dust from truck traffic and wind erosion of roadbed aggregate sourced from materials sites would not be expected to impact chemical concentrations in soils along the access roads. This is because material sites along the access roads are well outside the Pebble deposit, which is supported through available baseline surface soil samples along transportation corridor alternatives (see Appendix K3.14). Although available transportation corridor shallow soils chemistry data are not directly representative of Alternative 1a transportation corridor footprints, they are indicative of soils present among portions of all transportation alternatives outside the mine site study area. The hierarchy of trace elements (i.e., mean concentration) reported in surface soil along transportation corridor alternatives is similar to trends for the mine site (Table 4.14-2). However, in all circumstances, trace element concentrations were lower in the transportation corridor, indicating less mineral-rich conditions than the mine site study area (SLR et al. 2011a).

The reported baseline arsenic concentrations in surface soil samples from the transportation corridor are lower than the mine site study area, but persist at naturally elevated concentrations of up to 50.1 mg/kg, with a reported mean of 4.40 mg/kg. Similarly, mean concentrations of most evaluated analytes were less than half of the reported concentrations at the mine site. For example, the maximum concentration of selenium in the transportation corridor surface soil sample area (2.06 mg/kg) was less than the mean concentration at the mine site (2.76 mg/kg) (see Appendix K3.14).

Because metal concentrations in mine site dust are considered to be of insufficient magnitude to have an adverse impact on surface soils, this is also anticipated for the less mineralized soil conditions along the transportation corridor. Field review has not identified PAG rock at any of the road material sites. If PAG material were to be identified at a material site evaluation prior to use, another suitable material site would be selected (PLP 2018-RFI 035). Therefore, the material sites are not expected to introduce chemical impairments to soil. Transportation of concentrate from the mine site would be in sealed containers, and therefore is not expected to be a source of fugitive dust along the roads.

## Effects from Small Spills of Hydrocarbons or Other Contaminants

Inadvertent release of hydrocarbons or other contaminants would result in a direct impact to soil quality. The likelihood of these small spills from mine-related sources (e.g., mine machinery, product or waste storage facilities, or transfer operations) would be prevented or minimized through the application of BMPs, including the use of certified containers to transfer and store fuels and lubricants; secondary lined containment around bulk storage facilities; and managed storage, reuse, and/or disposal of used fuel products and other potentially toxic materials. Should a small spill occur, response measures and controls would be implemented, including automatic shutoff devices, and in-place spill response equipment and procedures (PLP 2020d). Section 4.27, Spill Risk, describes the potential for and effects of large-volume spills, which would have the potential for greater magnitude and extent of direct effects on surface water and sediment quality.

## Erosion

Similar to all other project components, stormwater and erosion mitigation and control measures would incorporate structural and non-structural BMPs (PLP 2020d) (see Chapter 5, Mitigation and PLP 2018-RFI 071a). Impacts from ground disturbance at pipeline stream crossings (trenching and horizontal directional drilling [HDD] installation) are addressed in Section 4.16, Surface Water Hydrology; and Section 4.18, Water and Sediment Quality. Wind-induced erosion would be comparatively less than hydraulically driven processes throughout all phases of the project along the transportation corridor, due to seasonal meteorological conditions; physical attributes associated with soil types; infrastructure configuration and construction methods; and planned mitigation. Soils capable of retaining moisture in the project area are generally considered to have a low susceptibility to wind erosion, due to inherent moisture content from periodic precipitation or snowmelt throughout the year. For this reason, the potential for wind erosion would be greatest during drier periods lasting 1 to 2 months during the summer. If necessary, wind erosion can be mitigated through dust-control watering during the summer.

The duration and extent of impacts from hydraulic erosion would be through the project life cycle along the transportation corridor. Precipitation events resulting in the greatest erosional losses from surface runoff and flooding generally occur from late September through November, based on erosion assessment observations of the Williamsport-Pile Bay Road, approximately 30 miles northeast of the port access road.

Soil types and general terrain descriptors present along the transportation corridor are summarized in Table 4.14-3. Moderate to rough terrain descriptors are based on the presence of anticipated rock cuts or blasting along portions of route segments in steeper and or shallow bedrock conditions to accommodate road construction. Cut-and-fill construction methods would be more prevalent in moderate to rough terrain. Gentle to moderate terrain coincides with a reduced frequency of anticipated rock cuts, and flatter or rolling landscapes are associated with glacial fluvial and moraine soil conditions. These segments would require comparatively less cut-and-fill construction practices due to less variation in roadbed grade.

**Table 4.14-3: Alternative 1a Approximate Road Terrain and Soil Types**

| ESS Soil Type | Gentle to Moderate Terrain | Moderate to Rough Terrain |
|---|---|---|
| D36HIJ[1] | 4 miles (5%) | — |
| D36HIL[2] | <1 mile (1%) | — |
| D36MTG[3] | 4 miles (5%) | — |
| IA17[4] | 7 miles (10%) | 22 miles (29%) |
| IA7[5] | 27 miles (37%) | 5 miles (7%) |
| IA9[6] | 4 miles (6%) | <1 mile (<1%) |
| Percent Total Terrain Type | 46 miles (63%) | 28 miles (37%) |

Notes:
1 HIJ: Organic material over loamy to coarse-loamy eolian deposits. Hills and plains
2 HIL: Organic material over coarse loamy eolian deposits. Glaciated hills and plains
3 MTG: Organic material (loamy) over gravelly slope colluvium/alluvium. Mountainous to hills and plains
4 IA7: Typic Cryandepts—very gravelly, nearly level to rolling association
5 IA17: Dystric Lithic Cryandepts—loamy, hilly to steep association
6 IA9: Typic Cryandepts—very gravelly, hilly to steep association
ESS = Exploratory Soil Survey of Alaska
Kokhanok airport spur road is not included in the evaluation due to the comparatively short road length and similar conditions to other project access roads
Total length deviates approximately 1 mile from those shown in Table K2-1 due to rounding discrepancy
Source: Rieger et al. 1979; PLP 2020d; NRCS 2019 (see Appendix K3.14)

The length of roads under Alternative 1a is approximately 74 miles. Approximately 46 miles (63 percent) of the transportation corridor generally coincide with gentle to moderate terrain, whereas 28 miles (37 percent) are associated with moderate to rough terrain. Gently sloping or level transportation infrastructure would be less susceptible to erosional processes. This includes ferry terminal sites, access roads, and other terrain-specific infrastructure (Table 4.14-3). Physical conditions more susceptible to hydraulic erosion in moderate to rough terrain along the transportation corridor include poorly drained, fine-grained loess or colluvium on sloped topography, waterbody crossings, road prism drainages (e.g., swales), higher-gradient slopes, and sidehill cuts.

Construction-phase activities that would potentially cause or contribute to erosion include:

- Removal and clearing of vegetation for access roads, material sites, and terminal facilities.
- Overburden clearing and vegetative mat removal for cut and/or fill placement of engineered materials (e.g., aggregate, substrates).
- Overburden management that would include stockpiles or windrows of organic-rich materials and vegetation, or excavated substrates considered unsuitable for infrastructure construction.
- Development of material sites and material site access roads.
- Blasting of bedrock to support roadbed construction.

The magnitude of effects from erosion during construction would vary along project road segments depending on soil types and physical conditions present, seasonal conditions, and construction requirements. The extent of impacts from erosion may be localized at susceptible locations, such as waterbody drainages and crossings (e.g., culverts, bridges, and swales), wetlands, or intermittent sloped topography. Impacts of erosion, although generally expected to only occur during the construction phase, would be long-term because the results of the erosion would be evident until the sites are reclaimed. Broader areas considered more susceptible to runoff and erosion would include continuous segments of road through rough terrain; and to a lesser extent, moderate terrain. These conditions would require steeper roadbed grades and side-hill cuts that could result in greater erosion potential from runoff (i.e., greater energy) and slope failure.

Terrain and soil conditions considered most susceptible to erosion along the transportation corridor are those present along the port access road. Most of the port access road would be predominantly constructed over rough, variable terrain (Table 4.14-3), where fine-grained soil types reportedly overlie shallow bedrock. Although conditions along the port access road appear most vulnerable to hydraulic erosion processes, the evaluation is based on generalized soil descriptions provided in the Exploratory Soil Survey of Alaska (ESS) (Rieger et al. 1979) and does not account for local variations in soil conditions or bedrock outcrops where no soil horizon may exist. With the exception of the northernmost 4- to 6-mile portion of the port access road route, blasting would be required for most roadbed construction, supporting the prevalence of shallow bedrock and moderate to rough terrain conditions (PLP 2018-RFI 084).

Portions of the mine access road northward from the Eagle Bay ferry terminal to the mine access road junction traverse toe slopes of elevated topographic relief in low to moderately sloping terrain. The potential for hydraulic erosion along these route segments is considered greater than those along broader and flat landscapes. Areas of cut-and-fill road construction along toe-slopes would require more drainage control measures, in addition to a greater frequency of perennial and ephemeral waterbody crossing prevalence.

Similar to access roads, the magnitude of effects of hydraulic erosion at material sites would also vary based on source material competency (e.g., shot bedrock or aggregate) and conditions unique to each borrow site location. Construction of material sites and transportation corridor infrastructure would use structural and non-structural BMPs and employ erosion control measures adequate to satisfy appropriate ADEC discharge permit requirements and coverage under an SWPPP (PLP 2020d).

Ground disturbances would be progressively restored throughout construction until stabilization and restoration are achieved. Most disturbances would likely be stabilized during construction, or several years thereafter, at locations considered less susceptible.

The least erosion would likely occur during operations, when stabilization of disturbed surfaces would be achieved through natural recovery, applied restoration measures, and long-term or permanent stabilization measures. Material sites and access roads would be progressively reclaimed. Typical reclamation BMPs at material sites include benching or sloping of sidewalls to suitable grades, based on material types (e.g., aggregate or bedrock); distribution of salvaged overburden growth media on pit floors and slopes; and tracking and seeding.

Continuous feedback from truck traffic during operations and/or prescribed follow-up inspections would identify areas of acute or persistent erosion. Areas of concern would be identified, and additional or more robust measures applied to meet local site-specific conditions. This would most likely be required along rough terrain associated with the port access road, and/or areas requiring permanent drainage controls (e.g., culverts, bridges, swales).

The magnitude of erosion during closure and post-closure would likely be greater than during operations. Some erosion may be cause by the removal and reclamation of long-term facilities (e.g., ferry terminals) before complete restoration and surface stabilization objectives are met. However, most erosion would likely be associated with permanent roads to the mine site. Monitoring frequencies in post-closure would typically be less than during operations, and there would be reduced access to equipment and resources. Required permanent transportation corridor access would result in an indefinite potential for erosion monitoring and maintenance.

### 4.14.3.3 Amakdedori Port

This section describes potential effects on onshore (i.e., upland) soils at the Amakdedori port site during construction through closure. Primary components associated with the Amakdedori port site include a terminal facility, airstrip, water extraction site, overburden stockpile, and a caisson-supported dock. Offshore sediment impacts resulting from intertidal and open-water construction (e.g., dock), operations, and closure of marine facilities are discussed in Section 4.18, Water and Sediment Quality.

#### Soil Disturbance

No current development exists at the Amakdedori port site. Onshore soil disturbances would mostly be attributed to construction of the terminal, uplands overburden stockpile, water extraction site access road, and airstrip. The magnitude and extent of impact would be the disturbance of approximately 29 acres of soil at the onshore portion of Amakdedori port site from construction through operation. Approximately 7 acres of the 29 acres of soil disturbance would be temporary. Temporary disturbances would be reclaimed once no longer used after the construction period. Imported engineered fill from material sites would be sourced from locations discussed under the transportation corridor, and summarized material site soil quality impacts are discussed under Alternative 1, which requires the greatest amount of fill under a comparable scenario.

The duration of these disturbances would be long-term to permanent, and the impact would be certain to occur if the project is permitted and the port is built. Because no construction would be required during operations, subsequent disturbances to soil would likely be limited. With the exception of necessary infrastructure to support shallow-draft tug and barge access to the dock, onshore port facilities would be removed during closure. No additional soil disturbances are anticipated during closure, and restoration of post-disturbance soil conditions would occur through reclamation activities (e.g., scarification, growth media, contouring, and seeding).

## Soil Quality

Engineered fill or locally sourced materials at the port site are not expected to introduce chemical impairments to soils. Material sites that would be used are well outside the Pebble deposit and previous field reviews have not identified the presence of PAG rock at any of the proposed road material sites. Material site evaluations would be conducted prior to use and if PAG material were identified, an alternative material site would be used (PLP 2018-RFI 035). Additionally, coarse-grained engineered fill textures would be less susceptible to erosion or fugitive dust generation, mitigating the potential for associated impacts.

The most probable source/activity of soil quality impairment at the Amakdedori port would be concentrate handling. Sealed bulk containers would be emptied offshore into the hold of bulk carriers (i.e., ship), at a depth of no less than 20 feet below the hatch (PLP 2018-RFI 009c) (see Section 4.27, Spill Risk). The calculated magnitude of total fugitive PM generated on a yearly basis during offshore transfers is 0.002 ton per year (4 pounds). For these reasons, the magnitude and potential of soil quality impact from project activities at the port are considered negligible, and unlikely to impact soil quality in upland conditions. The geographic extent of soil quality impacts (if any) would be confined to the immediate port footprint, of which the duration would be predominantly limited to the construction and operations phases.

## Erosion

Earthwork during construction of the port would incorporate erosion control measures specified in an approved SWPPP. Typical measures may include silt fences, hay bales, temporary sedimentation basins; and repurposed brush for berms and watering for dust suppression. BMPs may include crowning or in-sloping of running surfaces and temporary drainage channels, berms, and catchment basins. Similarly, interim stabilization measures for stockpiled soils would minimize wind and hydraulic erosion processes, which may include dimensional sloping (e.g., reduced slope angles), roughening, and compaction. If necessary, stockpile erosion control and catchment berms would likely mitigate erosional runoff concerns if any material remains as salvaged growth media following post-construction reclamation activities.

Water- and wind-induced erosion would occur at the port site throughout construction, and to a limited extent during operations and closure. The caisson dock design would reduce the potential for erosion. Hydraulic erosion during operations would be less than during construction due to little additional soil removal and effects of established SWPPP design features (e.g., culverts, swales). Erosion during closure would be less than during construction, but likely greater than during operations. Exposed ground surfaces at sites of removed infrastructure not required for post-closure would be susceptible to wind and water erosion for an interim period until reclamation and restoration activities are completed. The potential for erosion would be mitigated using measures similar to those described for construction. See Section 4.16, Surface Water Hydrology, for a discussion of sediment transport at Amakdedori.

### 4.14.3.4 Natural Gas Pipeline Corridor

This section describes potential effects of Alternative 1a on onshore soils from pipeline infrastructure on the eastern side of Cook Inlet, pipeline-only (not co-located with a road) segments on the western side of Cook Inlet, and pipeline landings (on the western side of Cook Inlet and on the southern and northern shoreline of Iliamna Lake). Pipeline impacts for segments of the pipeline coincident with the transportation corridor on the western side of Cook Inlet are addressed above.

#### Soil Disturbance

The magnitude of onshore soil disturbances from pipeline infrastructure on the eastern side of Cook Inlet is approximately 3 acres. This would include the compressor station, laydown area, access road, metering pad, and HDD work area, of which less than 1 acre would be disturbed on a temporary basis.

The magnitude and extent of impact on the western side of Cook Inlet would be the disturbance of approximately 219 total acres of soil associated with the onshore pipeline-only segment from Newhalen to the mine access road (175 acres over low-sloping terrain) and pipeline-associated disturbance at the mine site, ferry landings, and Amakdedori port. Soil types associated with the pipeline corridor on the western side of Cook Inlet are common to the transportation corridor described above. Impacts would be short-term during construction, and would be expected to occur if the project is permitted and the gas pipeline is built. Pipeline activities resulting in disturbances to unconsolidated sediment associated with wetlands, subsea, and waterbodies (e.g., streams, lake) settings are described in Section 4.22, Wetlands and Other Waters/Special Aquatic Sites; Section 4.18, Water and Sediment Quality; and Section 4.16, Surface Water Hydrology.

#### Erosion

Similar to other project components, mitigation and control measures would incorporate structural and non-structural BMPs to address erosion, sedimentation, and stormwater runoff (PLP 2020d). Pipeline construction would follow guidelines and accepted common practices for stabilization and sedimentation control for pipeline projects (USACE 2018c) (see Chapter 5, Mitigation).

The topography associated with the pipeline infrastructure on the eastern side of Cook Inlet is gently sloping or nearly level. Reported soil survey attributes (physical properties) for the silty loam soils associated with these conditions are considered to have a “slight” hazard of erosion by water (organic mat/top cover removed) but are vulnerable (“severe”) to erosion by wind (USDA 2005). Although the slight erosion hazard by water is primarily associated with low-angle slopes for these soil types in the disturbed footprint, this does not preclude accelerated erosional processes attributed to human-made ground disturbances such as channelized surface water runoff. Use of HDD would provide a sufficiently wide setback distance between the project footprint and Cook Inlet bluff (about 200 feet); project activities are not expected to contribute to ongoing natural erosion in this area (Section 3.15, Geohazards and Seismic Conditions).

Trenching for pipeline construction would require the removal of vegetation and excavation of soil, sediments, and rock, which would result in increased potential for impacts associated with erosion, sedimentation, and runoff. The potential for these impacts would be reduced after construction activities cease and vegetation is re-established. The magnitude, duration, extent, and potential for these impacts would be the same as those associated with the removal of vegetation for road construction.

Erosion impacts would be short-term, mainly during construction and would be mitigated through erosional controls and BMPs. Stockpile management practices that would minimize the potential for hydraulic and wind erosion would include strategic positioning relative to ground slopes and receiving waterbodies (e.g., set-back distance); placement in low-slope profiles; surface roughening; or runoff capture through filter structure placement (see Chapter 5, Mitigation).

### 4.14.4 Alternative 1

The potential impacts of Alternative 1 on the mine site, transportation corridor, Amakdedori port location, and natural gas pipeline corridor are described in the following subsections. Alternative 1 variants are also discussed.

#### 4.14.4.1 Mine Site

The magnitude, duration, extent, and likelihood of impacts to soils in the mine site would be the same as those described under Alternative 1a.

#### 4.14.4.2 Transportation Corridor

Under Alternative 1, the total acreage of transportation corridor soil disturbance is less than Alternative 1a; however, the port access road from the south ferry terminal to Amakdedori port and Kokhanok spur road would be the same. Therefore, impacts for the port access road would be the same as discussed above for Amakdedori port for Alternative 1a. Under Alternative 1, the mine access road would trend south from the mine site to a north ferry terminal on Iliamna Lake. The south ferry terminal would be at the same site as described for Alternative 1a.

Impacts at material sites, changes to soil quality, and effects from small spills of hydrocarbons or other toxins would be the same as those described under Alternative 1a. The following subsections discuss soil disturbance and erosion effects specific to Alternative 1.

**Soil Disturbance**

Approximate soil disturbances associated with the Alternative 1 transportation corridor include the following total acreages, post-construction acreages, and temporary acreages of disturbance:

- Port access road—699 acres (total), 411 acres (post-construction), 288 acres (temporary)
- Mine access road—565 acres (total), 341 acres (post-construction), 224 acres (temporary)
- Kokhanok Airport spur road—25 acres (total), 15 acres (post-construction), 10 acres (temporary)
- Iliamna spur road—191 acres (total), 119 acres (post-construction), 72 acres (temporary)
- Explosives spur road—6 acres (total), 4 acres (post-construction), 2 acres (temporary)
- Ferry terminals—34 acres (total), 27 acres (post-construction), 7 acres (temporary) approximate
- Material sites—251 acres (total, post-construction)

Cumulative total acreages of soil disturbance for Alternative 1 transportation corridor components include 1,778 total acres (1,744 total acres excluding ferry terminals), 1,171 post-construction acres, and approximately 607 temporary acres.

## Erosion

As described above, wind and hydraulically induced erosion of soils would occur along the access road corridors. Construction-phase activities that would potentially cause or contribute to erosion are the same as those described for Alternative 1a. Physical conditions more susceptible to hydraulic erosion along the transportation corridor include poorly drained, fine-grained loess or colluvium on sloped topography, waterbody crossings, road prism drainages (e.g., swales), higher-gradient slopes, and side-hill cuts. As described for Alternative 1a, the magnitude of effects from erosion during construction would vary along project road segments depending on soil types and physical conditions present, seasonal conditions, and construction requirements. Approximate transportation corridor road lengths traversing gentle to moderate and moderate to rough terrain under Alternative 1 are listed in Table 4.14-4.

**Table 4.14-4: Alternative 1 Road Lengths, Terrain, and Soil Types**

| ESS Soil Type | Gentle to Moderate Terrain | Moderate to Rough Terrain |
|---|---|---|
| D36HIJ | 4 miles (5%) | None |
| D36HIL | <1 mile (1%) | None |
| D36MTG | 4 miles (5%) | None |
| HY4 | 1 mile (2%) | None |
| IA17 | 7 miles (9%) | 22 miles (28%) |
| IA7 | 19 miles (24%) | 5 miles (7%) |
| IA9 | 12 miles (15%) | 3 miles (4%) |
| Percent Total Terrain Type | ~47 miles (61%) | 30 miles (39%) |

Notes:
1 HIJ: Organic material over loamy to coarse-loamy eolian deposits. Hills and plains
2 HIL: Organic material over coarse loamy eolian deposits. Glaciated hills and plains
3 MTG: Organic material (loamy) over gravelly slope colluvium/alluvium. Mountainous to hills and plains
4 IA7: Typic Cryandepts—very gravelly, nearly level to rolling association
5 IA17: Dystric Lithic Cryandepts—loamy, hilly to steep association
6 IA9: Typic Cryandepts—very gravelly, hilly to steep association
Kokhanok airport spur road is not included in the evaluation due to the comparatively short road length and similar conditions to other project access roads
Total length deviates approximately 1 mile from those shown in Table K2-9 due to rounding discrepancy
ESS = Exploratory Soil Survey of Alaska
Source: Rieger et al. 1979; PLP 2020d; NRCS 2019 (see Appendix K3.14)

The port access road corridor would be the same as described for Alternative 1a. Erosional impacts along the port access road are described above.

Approximately 47 miles (61 percent) of the transportation corridor generally coincide with gentle to moderate terrain, whereas 30 miles (39 percent) generally correspond with moderate to rough terrain. The Iliamna spur road, which is exclusive to this alternative, would require continuous and multiple segments of blasting (see Figure 3.13-5). The mine access road would be least susceptible to hydraulic erosion for transportation segments exclusive to this alternative based on terrain types traversed and soil conditions. The mine access road segment exclusive to this alternative also has a blasting frequency that is comparable to the mine access road segment under Alternative 1a (i.e., Eagle Bay to mine access road).

Alternative 1 has approximately 3 additional miles of total length and moderate to rough terrain requiring blasting construction methods compared to Alternative 1a. Although the total acreage of soil disturbance under this alternative is about 15 acres less than Alternative 1a, it would likely require more cut-and-fill road construction and use of erosion control and mitigation measures.

For these reasons, the potential for erosion under Alternative 1 is considered comparable or appreciably greater than Alternative 1a.

All other aspects of the discussion of erosion along Alternative 1a transportation corridor also apply to this alternative. Similar to Alternative 1a, the duration and extent of impacts from hydraulic erosion would be throughout the entire project life cycle along the transportation corridor.

### 4.14.4.3 Amakdedori Port

The Amakdedori port is the same as described for Alternative 1a. However, under Alternative 1, the port design would include a sheet pile solid fill dock rather than a caisson-supported dock as described for Alternative 1a. Offshore sediment impacts resulting from intertidal and open-water construction (e.g., dock), operations, and closure of marine facilities are discussed in Section 4.18, Water and Sediment Quality.

#### Soils Disturbance

Soil disturbances would mostly be attributed to construction of the terminal. Other soil disturbance would be due to the uplands overburden stockpile, water extraction site access road, and airstrip. Although the Alternative 1 port includes a sheet pile solid fill dock rather than a caisson-supported dock as described for Alternative 1a, the onshore port disturbance would be the same as Alternative 1a. The magnitude and extent of impact would be the disturbance of approximately 29 acres of soil at the Amakdedori port site from construction through operation.

This magnitude of soil disturbances at the port would include the complete removal of soil cover at the terminal during construction and placement of engineered fill at the terminal. The duration of these disturbances would be long-term to permanent, and the impact would be certain to occur if the project is permitted and the port is built. Because no construction would be required during operations, subsequent disturbances to soil would likely be limited. With the exception of necessary infrastructure to support shallow-draft tug and barge access to the dock, onshore port facilities would be removed during closure. No additional soil disturbances are anticipated during closure, and restoration of post-disturbance soil conditions would occur through reclamation activities (e.g., scarification, growth media, contouring, and seeding).

#### Soil Quality

Potential impacts to soil quality would be the same as those described for Alternative 1a.

#### Erosion

Erosion effects under Alternative 1 would be the same as those for Alternative 1a. See Section 4.16, Surface Water Hydrology, for a discussion of sediment transport at Amakdedori.

### 4.14.4.4 Natural Gas Pipeline

This section describes potential effects of Alternative 1 on onshore soils from pipeline infrastructure on the eastern and western side of Cook Inlet, including the pipeline landings (on the western side of Cook Inlet and on the southern and northern shoreline of Iliamna Lake). Pipeline-related impacts for segments of the pipeline coincident with the transportation corridor on the western side of Cook Inlet are addressed above under “Transportation Corridor.”

#### Soil Disturbance

The magnitude of acreage of onshore soil disturbances from pipeline infrastructure on the eastern side of Cook Inlet would be the same as that described for Alternative 1a.

Under this alternative, there are relatively short pipeline segments that would be constructed separate from the transportation corridor (i.e., pipeline-only segments). The magnitude and extent of impacts on the western side of Cook Inlet associated with these segments of pipeline would be the disturbance of approximately 61 acres of soil. Soil types associated with the pipeline segments on the western side of Cook Inlet are common to the transportation corridor and are described above. Impacts would be short-term during construction and would be expected to occur if the project is permitted and the gas pipeline is built. Pipeline-related disturbances to unconsolidated sediment associated with wetlands, subsea, and lake settings are described in Section 4.22, Wetlands and Other Waters/Special Aquatic Sites; Section 4.18, Water and Sediment Quality; and Section 4.16, Surface Water Hydrology.

#### Erosion

General erosion impacts and mitigation and control measures along the natural gas pipeline corridor are the same as those described for Alternative 1a. The pipeline-only segment under this alternative is much shorter than that for Alternative 1a and would impact about 157 fewer acres. Although erosional impacts for both Alternative 1a and Alternative 1 would be short-term during construction and would be mitigated through erosional controls and preventative measures (BMPs), the overall potential for impacts would be less under Alternative 1. This is because Alternative 1a has a larger combined pipeline and transportation corridor acreage of disturbance.

### 4.14.4.5 Alternative 1—Summer-Only Ferry Operations Variant

This variant would require an increase in soil disturbance associated with the construction of designated concentrate container storage areas at the mine site and Amakdedori port. The magnitude and extent of impacts on soil would be the disturbance of approximately 33 additional acres of storage area at the mine site, and approximately 27 additional acres at Amakdedori port, yielding a total of approximately 60 additional acres under this variant compared to Alternative 1. The duration of these impacts would be long-term, remaining throughout the mine operations; but not permanent, because these areas would be reclaimed during closure. These disturbances to soil would be certain to occur if the project is permitted, the Summer-Only Ferry Operations Variant is chosen, and the project is built.

Impacts to soil quality would be expected to be the same as Alternative 1; however, the potential for soil quality impacts could be greater due to additional concentrate handling and transport steps required under this alternative.

This variant would also temporally compress road traffic during ice-free months, which could result in a greater potential for hydraulic and wind erosion along the transportation corridor.

### 4.14.4.6 Alternative 1—Kokhanok East Ferry Terminal Variant

Differences between this variant and the base case Alternative 1 are limited to transportation corridor and pipeline-only segments between ferry terminal(s). Despite a shorter transportation route and reduced ferry terminal footprint, the total acreage of soil disturbance under this variant would be slightly greater than, but comparable to Alternative 1. The magnitude and extent of impacts on soil would be the disturbance of approximately 13 additional acres along the transportation corridor, primarily due to material site acreage, and approximately 25 additional acres associated with the natural gas pipeline component, yielding a total of approximately 38 additional acres under this variant compared to Alternative 1. Impacts on soils associated with the transportation corridor would be long-term and would be expected to occur if the project is permitted and the east ferry terminal is built. Impacts to soils associated with construction of the pipeline would be short-term during construction, and would be expected to occur if the project is permitted and the gas pipeline is built.

Although soil disturbance acreage is slightly greater under this variant than under the base case Alternative 1, the potential for erosion is likely to be less. This is based on a shorter road length and a greater proportion of soil disturbances associated with material sites. Roads generally require a greater diversity of erosion control measures (e.g., waterbodies, cross slopes, inclines); whereas material sites inherently consist of coarser-grained materials (or bedrock) that are less susceptible to hydraulic and wind erosion. Furthermore, sediment runoff at material sites is more likely to be retained in the footprint of disturbance (e.g., depressions).

#### 4.14.4.7 Alternative 1—Pile-Supported Dock Variant

Although the Pile-Supported Dock Variant would reduce impacts to marine sediments compared to the sheet pile solid fill dock described for Alternative 1, the onshore port disturbance to soils would be the same as described for Alternative 1. Offshore sediment impacts resulting from intertidal and open-water construction (e.g., dock), operations, and closure of marine facilities are discussed in Section 4.18, Water and Sediment Quality.

### 4.14.5 Alternative 2—North Road and Ferry with Downstream Dams

The following section describes impacts to soil resources under Alternative 2. Infrastructure descriptions, usage, physical reclamation, and closure would be the same as Alternative 1a, but would occur at the locations described under this alternative.

#### 4.14.5.1 Mine Site

The bulk TSF dam at the mine site would be constructed using different methods under this alternative (i.e., downstream method with buttress). The magnitude of the impact of this construction method on soils would result in an increased impoundment footprint compared to Alternative 1a, and the overall total increase in additional acreage would be approximately 107 acres. Overall, the duration and extent of impacts to soil from ground disturbances would be comparable to Alternative 1a; however, there would be greater impact magnitude based on the increased acreage of disturbance. Erosion impacts would be the same as Alternative 1a; however, there would be an increased potential for erosion based on infrastructure build-out.

#### 4.14.5.2 Transportation Corridor

<u>**Soil Disturbance**</u>

Transportation corridor components under Alternative 2 would also incorporate two ferry terminals on Iliamna Lake, and road access to the mine and port (i.e., Diamond Point port). The road would bypass all but 5 miles of the existing Williamsport-Pile Bay Road; however, these sections would require upgrades to accommodate larger vehicles associated with the project. The magnitude and extent of total soil disturbance acreages, post-construction acreages, and temporary acreages of disturbance associated with Alternative 2 transportation infrastructure (including the co-located portion of roadbed pipeline) include:

- Mine access road: mine site to Eagle Bay ferry terminal site—644 acres (total), 353 acres (post-construction), 291 acres (temporary)
- Port access road: Pile Bay ferry terminal to Diamond Point port site—347 acres (total), 209 acres (post-construction), 138 acres (temporary)
- Ferry terminal sites—30 acres (total), 25 acres (post-construction), 5 acres (temporary)

- Material sites and access roads—321 acres
- Explosives storage spur road—6 acres (total), 4 acres (post-construction), 2 acres (temporary)

The cumulative total acreage of upland soil surface disturbances associated with the transportation corridor under Alternative 2 is approximately 1,349 acres, of which 912 are post-construction acres and 437 are temporary. Although disturbance mechanisms, nature of impacts, and erosion mitigation and control measures during construction, operations, and closure of transportation corridor infrastructure would be comparable to those described under Alternative 1a, the overall magnitude of soil disturbance would be less. Although the mine access road under both Alternative 1a and this alternative are the same, Alternative 2 would require fewer total miles of road because the port road for Alternative 2 is approximately 20 miles shorter. Alternative 1a and Alternative 2 would have the same ferry terminal at Eagle Bay, but the other terminal locations would differ. The footprint for the terminal at Pile Bay under Alternative 2 would be 5 acres less than that for the south ferry terminal location under Alternative 1a. The duration of and potential for impacts would be comparable to Alternative 1a.

## Soil Quality

Impacts to soil quality along the transportation corridor under Alternative 2 would be the same as described for the corridor under Alternative 1a.

## Erosion

Soil types and general terrain descriptors present along the Alternative 2 transportation corridor are summarized in Table 4.14-5. Terrain descriptors are based on the presence of shallow bedrock or terrain requiring blasting to accommodate road construction.

**Table 4.14-5: Alternative 2 Approximate Road Terrain and Soil Types**

| ESS Soil Type | Gentle to Moderate Terrain | Moderate to Rough Terrain |
|---|---|---|
| D36HIJ | 4 miles (7%) | None |
| D36HIL | <1 mile (1%) | None |
| D36MTG | 4 miles (7%) | None |
| IA7 | 22 miles (41%) | 1 mile (2%) |
| IA9 | 4 miles (8%) | <1 mile (1%) |
| RM1 | 8 miles (14%) | 5 miles (10%) |
| SO11 | 4 miles (8%) | 1 mile (2%) |
| Percent Total Terrain Type | 46 miles (85%) | 8 miles (15%) |

Notes:
[1] HIJ: Organic material over loamy to coarse-loamy eolian deposits. Hills and plains
[2] HIL: Organic material over coarse loamy eolian deposits. Glaciated hills and plains
[3] MTG: Organic material (loamy) over gravelly slope colluvium/alluvium. Mountainous to hills and plains
[4] IA7: Typic Cryandepts—very gravelly, nearly level to rolling association
[5] RM1: Rough Mountainous Land – Steep rocky slopes
[6] IA9: Typic Cryandepts—very gravelly, hilly to steep association
[7] SO11: Humic Cryorthods—silty volcanic ash over gravelly till, hilly to steep association
ESS = Exploratory Soil Survey of Alaska
Total length deviates approximately 1 mile from those shown in Table K2.1 due to rounding discrepancy
Source: Rieger et al. 1979; PLP 2020d; NRCS 2019 (see Appendix K3.14)

A greater proportion of coarse-grained materials is present along the transportation corridor route based on generalized soil descriptions provided in the ESS, whereas the occurrence of finer-grained silt/sand loam mixtures is reportedly less prevalent than Alternative 1a (Table 4.14-3). Therefore, less wind erosion is anticipated under this alternative, based on the prevalence of coarser-grained substrates along the transportation corridor; a comparatively smaller acreage of soil disturbance that would reduce the potential for wind shear on disturbed surfaces; and a reduced vehicle travel distance for dust dispersion. Because the route under this alternative is also lower in elevation than Alternative 1, overall wind-driven forces (e.g., velocity) are also likely to be less. However, this would not preclude occurrence of episodic high-wind processes that are commonly associated with valley features present along the port access road.

Most hydraulic erosion mechanisms, nature of impacts, and mitigation and control measures during construction, operations, and closure of transportation corridor infrastructure would be comparable to those described under Alternative 1a. Similar to Alternative 1a, hydraulic erosion susceptibility under this alternative would be greatest in steep, hilly to mountainous terrain along the southernmost port access road segment.

Heavy precipitation and flooding during fall months have previously resulted in significant hydraulic erosion losses along the Williamsport-Pile Bay Road (KPB 2014; USACE 2007a). Specific conditions that resulted in impassable erosion washout at multiple points along the Williamsport-Pile Bay Road in the fall of 2003 included culvert and bridge crossings, and surface water erosion in drainages aligned adjacent (e.g., swale or ditch) to the road (USACE 2007a).

Although the route is commonly aligned with 5 miles of the existing Williamsport-Pile Bay Road, the remaining road would be newly constructed to minimize conditions historically susceptible to erosional processes along the current Williamsport-Pile Bay Road alignment. The southernmost uplands road segment has comparatively fewer cross cuts along toe-slopes in areas of greater vertical relief, and traversed terrain is considered to be gentler and moderate in character (Table 4.14-5). Rock cuts along the southernmost uplands segment and other discrete segments would require blasting; however, it would be comparatively less than the port access road under Alternative 1a. Furthermore, the road alignment, which would be shared with the existing Williamsport-Pile Bay Road, would be improved to accommodate large trucks associated with the project.

Approximately 3 miles of road extending from the Diamond Point port site would follow the coastline of Iliamna Bay. This coastline road segment is considered most susceptible to erosion under all alternatives. The coastal road is situated along the toe-slopes of mountainous terrain and would likely be subjected to marine-driven processes. The topographic relief immediately adjacent to the road from the port is characteristic of a high-energy environment, where natural hydraulic erosion and slope failure processes are likely to be more prevalent. Portions of roadway along this coastline segment could also be more susceptible to tidal action: ice scour/rafting, storm surge, and wave action. Additional discussion regarding slope failure processes and occurrence are presented in Section 4.15, Geohazards and Seismic Conditions.

In summary, the greatest magnitude of corridor erosion under Alternative 2 would occur along the port access route. Erosion along the port access route under Alternative 2 would likely be less than Alternative 1a, based on a smaller acreage of soil disturbance and presence of terrain types that are associated with a reduced erosion potential. However, the initial 2 miles of road extending from the port under Alternative 2 could be the most erosion-susceptible segment of road. This nearshore segment of road is unique to Alternative 2 and Alternative 3—North Road Only and would require enhanced design and mitigation measures to account for the high-energy environment. The duration of these impacts would be long-term, and they would be expected to occur if Alternative 2 is chosen, the project is permitted, and the transportation corridor is built.

### 4.14.5.3 Diamond Point Port

## Soil Disturbance

Soils in the port footprint under Alternative 2 are reportedly associated with rough, mountainous land (RM1) consisting of sparsely vegetated soil over shallow bedrock or stones/boulders. The port terminal facility and dredge material stockpile would result in soil disturbances. The magnitude of onshore soil disturbances at Diamond Point port would be approximately 50 acres, of which 9 acres would be temporary and 41 acres would be post-construction. The estimated acreage of disturbance includes the footprints of the port terminal facility and uplands disposal of dredged materials (e.g., stockpile). The magnitude of dredge material stockpile footprints would total approximately 16 acres and would be managed similarly to overburden stockpiles. The total acreage of soil disturbance at Diamond Point port is approximately 72 percent greater than Amakdedori port under Alternative 1a and Alternative 1 (approximately 21 acres greater).

Dredge stockpiles would include berms to contain sediments, collection of seepage, and stormwater runoff, as well as treatment in settling ponds prior to discharge (PLP 2018-RFI 099). These effects on soils would be long-term and certain to occur if Alternative 2 is chosen and the Diamond Point port is permitted and built.

Most soil disturbance mechanisms and impacts during construction, operations, and closure at the port would be similar in magnitude, duration, and extent to those described under Alternative 1a; however, disturbances unique to this alternative include the following:

- Blasting of shallow bedrock at discrete locations to accommodate port infrastructure
- Uplands disposal of dredge material

Soil disturbances during construction would involve grading and contouring of ground surfaces, and extensive blasting of shallow bedrock to accommodate port construction. Removal of soil considered unsuitable for construction purposes would be limited due to prevalent shallow bedrock and coarse alluvium outwash. The bermed dredge material stockpile would be built immediately adjacent to the port terminal to receive spoils from dredge channel clearance.

Because no additional construction would be required during operations, soil disturbances during port operations would primarily be limited to dredge material stockpile expansion from maintenance dredging. The magnitude of dredged materials to be stockpiled would be, at a minimum, half of the material dredged for channel construction and maintenance (approximately 325,000 cubic yards). This material would be disposed of onshore in a bermed facility. Soil disturbance impacts associated with the dredge material stockpile could range from the direct burial of existing soils, to potential acute or obvious changes associated with any stockpiled marine sediment in an upland environment. These impacts would be long-term, lasting for the duration of the project, and would be expected to occur if Alternative 2 is chosen and permitted, and the Diamond Point port is constructed.

## Soil Quality

Impacts to soil quality along the transportation corridor under Alternative 2 would be the same as those described for the corridor under Alternative 1a.

## Erosion

Most hydraulic erosion mechanisms, nature of impacts, and mitigation and control measures during construction, operations, and closure of port facilities would be comparable to those described under Alternative 1a. The magnitude, duration, extent, and potential of impacts due to erosion would also be comparable to Alternative 1a. Because coarse alluvium outwash and shallow bedrock conditions at the Diamond Point port site are less susceptible to erosion compared to the Amakdedori port site, the period of greatest ground disturbance during port facility construction would generally result in less erosion under Alternative 2 compared to Alternative 1a. However, unique conditions specific to this alternative that could potentially increase erosional susceptibility or require additional design and mitigation measures throughout construction, operations, and post-closure include the following:

- Uplands disposal of dredge material
- Topographic relief and slope stability

Hydraulic erosion of stockpiled dredge materials would be mitigated through proper impoundment and drainage design. Stockpiled materials could be susceptible to wind erosion, depending on the physical attributes of dredge materials (particle size distribution and cohesion); interim surface stabilization measures; constructed dimensions; and frequency and magnitude of coastal and seasonal winds. Physical conditions that are considered less susceptible to wind erosion include high moisture contents or frozen conditions; larger particle sizes; presence of surface cover, and lower slope angles to reduce wind shear. Mitigation measures that may reduce the potential for wind erosion include wind breaks, snow fencing, reduced slope angles, or watering during increased periods of susceptibility. Final closure of the stockpile would include drainage and surface stabilization. Typical measures that could facilitate stockpile surface stabilization include slope and top-cover engineering, tracking (rolling), seeding, and repurposing of material as growth media.

The topographic relief immediately inland of the eastern port footprint (to the jetty/causeway) is characteristic of an environment where natural hydraulic erosion and slope failure processes are likely to be more prevalent. Sloped ground conditions bordering the port footprint have a greater potential for increased surface water runoff, which could result in greater rates of scouring or aggradation. This could potentially include slope failure processes that indirectly impact port infrastructure. Recent slope failure occurrence (e.g., landslide) is present along the access road that would extend from the port to the jetty. These conditions would require additional design and mitigation measures; however, the potential for slope failure to compromise discrete portions of port infrastructure would likely persist. This would also include infrastructure at the base of headwall cuts in bedrock. Additional discussion regarding slope failure processes and occurrence are presented in Section 4.15, Geohazards and Seismic Conditions.

### 4.14.5.4 Natural Gas Pipeline Corridor

The eastern landfall of the pipeline under Alternative 2 would be at Ursus Cove. The pipeline would be constructed below grade along a valley floor (trench installation), and resurface at the Diamond Point port site after the short (trenched and buried) marine crossing of Cottonwood Bay. The magnitude of effects would be disturbance to 5.5 miles of uplands that coincide with shallow bedrock and coarse soil textures (e.g., boulder and cobble) in rough mountainous terrain; however, it is likely that an appreciable gravelly sand colluvium is present along the valley floor. The pipeline from the port would follow a shared road corridor towards the Pile Bay ferry terminal. The pipeline-only (not co-located with a road) segment between the Pile Bay and Eagle Bay road off-takes would be 36 miles in length.

#### Soil Disturbance

The magnitude and extent of upland ground disturbance associated with pipeline-only components under Alternative 2 totals approximately 1,106 acres that include:

- Pipeline-only construction ROW—777 acres (temporary)
- Material sites—298 acres (permanent)

- Compressor station infrastructure—2 acres (permanent)
- Temporary construction access—29 acres (temporary)

Although the pipeline construction corridor would be 150 feet wide during construction to accommodate trench spoils and heavy equipment traffic, complete removal of the overlying vegetative mat would be limited to an 8-foot span directly above the trench (see Figure 2-48). The total acreage of vegetative mat that would be completely removed during construction is approximately 40 acres. Shallow soil on the spoils and working sides of the trench would mostly be limited to disturbances from working equipment resulting in ground compaction, rutting, or tearing of ground surfaces. The duration of impacts would be comparable to Alternative 1a; however, the magnitude and extent would be greater due to a larger area of post-construction and temporary soil disturbances.

Construction would occur year-round along simultaneous or overlapping construction efforts on segments; construction would include preliminary ROW clearing and preparation, followed by pipeline installation, and rehabilitation/commissioning. Temporary pipeline camps and material sites would be required.

Soils that are more susceptible to surface disturbances (e.g., wetlands) would incorporate additional mitigation measures and BMPs. Working pads constructed of swamp mats along the working ROW would be used to minimize surface disturbances during summer months, and frost-packing of the entire construction ROW during winter months. Frost-packing would involve clearing the snow from the ROW to achieve a frost depth of 2 feet below ground surface. Although no other mitigation and restoration activities have been specified, common practices that could be used during construction include salvaging of timber for corduroy matting or ice-pad construction. To the extent practicable, backfilling would occur as soon as possible to minimize additional equipment efforts or soil disturbances. Temporary impoundment of saturated spoils and/or drainage control measures for water accumulation in the trench may be required for construction in wetlands.

Most mitigation and restoration measures would be implemented during and immediately after construction; however, follow-up measures may be necessary on a case-by-case basis, particularly after winter construction activities. Surface disturbances are expected to recover within the first few years following construction. Soil disturbances during operations would be less than during the construction period. The permanent pipeline ROW may require periodic brush-clearing to accommodate routine and non-routine pipeline monitoring and maintenance over the operational period. Disturbances may result from intermittent corrective maintenance activities or additional surface stabilization measures on a case-by-case basis.

## Erosion

Similar to other project components, mitigation and control measures would incorporate structural and non-structural BMPs to address erosion and stormwater runoff. Soils corresponding to pipeline-only segments are summarized under Alternative 3 in Table 4.14-6. Approximately 44 miles of pipeline-only segments under this alternative follow the same transportation route as that under Alternative 3.

The magnitude and extent of hydraulic and wind erosion impacts would be greatest along pipeline segments in moderate to rough terrain, where finer-grained silty loess or volcanic ash materials are present at shallow depth. The duration and potential of these impacts would be similar to Alternative 1a. A 24-mile pipeline-only segment from the port access road to Canyon Creek west of Pedro Bay generally coincides with finer-grained silty volcanic ash soils (shallow) overlying glacial till. Slopes range from hilly to steep, and slightly less than half of this segment (12 miles) may require some blasting. Based on the presence of rougher terrain (e.g., blasting), steeper slopes, and finer-grained shallow soils, this segment is considered more susceptible to erosion relative to other sections of the pipeline route to the mine site.

Erosion management during and immediately after construction is anticipated through applied erosional control measures and BMPs. Activities that could potentially accelerate or influence erosional processes in upland areas during the construction include clearing and grading of ground surfaces for access; trench excavation and spoils management (e.g., windrows and stockpiles); and backfilling.

Although no erosional controls or BMPs are specified, pipeline construction would foreseeably incorporate guidelines and acceptable common practices for stabilization and sedimentation control for pipeline projects (USACE 2018c). Sediment barriers or filter structures consisting of silt fences, straw bales, filter bags, brush berms, or other comparable material(s) could be used to retain sediment in surface water runoff. Series of interceptor dikes and diversion ditches equipped with wattles or sediment retention measures would manage surface runoff and flow conditions (e.g., direction, velocity, and run) on steeper gradients. Similarly, placement of trench plugs or ditch breakers in the open-cut trench on steeper gradients could control runoff of sediment–laden water movement under channelized flow conditions. If necessary, sediment entrained in dewatering activities could be filtered prior to discharge using a variety of comparable alternatives (natural vegetation, silt fencing, filter bags, hay bales), or clarification prior to controlled discharge through sediment catchment basins or settling ponds.

Trench spoils would be temporarily stockpiled for pipeline installation. To the extent practicable, stockpiled soils would foreseeably be segregated for backfill characteristics (e.g., drainage and basal materials) and surface cover (e.g., organic mat). Stockpile management practices that would minimize the potential for hydraulic and wind erosion include positioning relative to ground slopes and receiving waterbodies (e.g., set-back distance); placement in low-slope profiles, surface roughening, or runoff capture through filter structure placement.

Erosional controls and preventative measures to manage runoff to surface waters at open-cut waterbody crossings may include seasonal construction (low flow) windows; temporary bladder (water) dams during bed excavation, and filter structures (silt fencing and straw bales). Rig mats and placement of larger preassembled pipeline sections across variable wetland crossings would minimize surface disturbance and erosion potential. Sediment controls and surface water processes at waterbody crossings and wetlands are further discussed in Section 4.16, Surface Water Hydrology; and Section 4.22, Wetlands and Other Waters/Special Aquatic Sites, respectively.

Surface stabilization would be concurrent with, and immediately after construction. Temporary measures may include selective placement of segregated salvaged materials, mulch, brush barriers, or matting. Additional stabilization and restoration measures may also include seeding on a case-by-case basis until surface stabilization objectives are achieved. Post-construction or operations phase, inspections may identify localized conditions requiring installation of long-term surface stabilization controls. Areas considered more susceptible to erosion, where longer-term surface stabilization controls may be required to promote recovery, include sloped topography in silty volcanic soil conditions, wetlands, and waterbody crossings. Pipeline maintenance and monitoring would likely require differential pipeline settlement evaluation. Although the potential for differential settlement occurrence is perceived to be limited based on the general absence of permafrost conditions throughout the project area, variations could potentially occur due to frost action processes. Materials most susceptible to frost action would include poorly drained soils above a shallow water table, such as depressions or along valley bottoms. Silt loam and sandy loam mixtures, which are anticipated to be most prevalent along the alignment, are likely to have moderate frost action. To a lesser extent, areas of poorly drained organic-rich soils on low-angle slopes are likely to have high frost action characteristics (Appendix K3.14).

The least amount of anticipated erosion would occur during closure and post-closure. The pipeline would be abandoned in place, and areas requiring more intensive surface stabilization measures would likely be addressed over the period of operation. Surface facilities associated with the pipeline would be removed and reclaimed.

#### 4.14.5.5 Alternative 2—Summer-Only Ferry Operations Variant

The Alternative 2 Summer-Only Ferry Operations Variant would have the same impact at the mine site as the Alternative 1 variant. However, the magnitude of impacts from the Alternative 2 Summer-Only Ferry Operations Variant would result in 23 additional acres of disturbance along the Williamsport-Pile Bay Road for seasonal storage of concentrate containers, of which 2 acres would be on a temporary basis. The additional transportation corridor acreage of disturbance under this variant is correspondingly greater than Alternative 2, but is still significantly less than Alternative 1a, Alternative 1, or the Alternative 1 Summer-Only Ferry Operations Variant. Although soil quality impacts would be the same as Alternative 2, a greater (perceived) potential exists for soil quality impacts due to additional concentrate handling and transport steps.

The duration of the additional disturbances associated with seasonal storage would remain throughout the period of mine operations and be reclaimed during closure. No other pipeline, transportation corridor, or mine site infrastructure would change under this variant.

#### 4.14.5.6 Alternative 2—Newhalen River North Crossing Variant

Under this variant, impacts to soil resources at the mine, port, and along the natural gas pipeline would be the same as Alternative 2; however, this variant would increase the total soil disturbance acreage by 19 acres along the transportation corridor compared to the Alternative 2 base case. Because this variant would only increase the total acreage of soil disturbance by approximately 1 percent compared to Alternative 2, it is considered comparable.

#### 4.14.5.7 Alternative 2—Pile-Supported Dock Variant

Impacts to soil resources under this variant would be the same as those described for Alternative 2.

### 4.14.6 Alternative 3—North Road Only

A continuous overland access road would connect the port site north of Diamond Point to the mine site. The magnitude, duration, extent, and potential of impacts to soil resources at the mine site would be the same as Alternative 1a. Impacts at the port site north of Diamond Point would be similar to those described under Alternative 2, with some slight variation in magnitude and location.

Because the natural gas pipeline would predominantly be aligned with the transportation corridor under this alternative, both are collectively evaluated together for soil disturbance and erosion impacts. However, the magnitude of impacts under Alternative 3 for the pipeline-only segments is approximately 138 acres of soil disturbance, which includes the compressor station and access road, material sites, and an HDD pullback work area. The following section describes impacts for the transportation corridor and port that would be appreciably different under Alternative 3.

#### 4.14.6.1 Transportation Corridor

<u>**Soil Disturbance**</u>

The gas pipeline trench would be adjacent to the road (road-bed prism) to facilitate construction, maintenance, and inspection. The pipeline(s) would use vehicle bridges to span major stream crossings, and HDD drilling or trenching across smaller drainages as appropriate. No Iliamna

Lake ferry infrastructure would be required under this alternative, based on the continuous overland route to the mine site. Estimated magnitudes of total, post-construction, and temporary acreages (including barge landing) of shared transportation corridor and pipeline ground disturbances under this alternative include:

- North access road, shared road corridor/pipeline(s)—1,727 acres (total), 1,077 acres (post-construction), 650 acres (temporary)
- Spur and access roads—16 acres (total), 10 acres (post-construction), 6 acres (temporary)
- Shared transportation and pipeline material sites—604 acres (does not include material sites for the pipeline-only segments).

The total magnitude of acreage of ground disturbance from material sites and shared road and pipeline under this alternative is approximately 2,350 acres, or approximately 25 percent greater than Alternative 1a. Total shared transportation and pipeline acreages under Alternative 3 (2,465 acres) are significantly greater than Alternative 2 (1,345 acres); however, this does not include pipeline-only acreages (approximately 1,135 acres) under Alternative 2 that would be expected to recover to pre-disturbance conditions during the operations phase. The permanent need for transportation corridor access throughout post-closure under Alternative 3 would create a contiguous, permanent ground disturbance in the footprint, unlike the pipeline-only segments associated with Alternative 2. This impact would occur if Alternative 3 is chosen, and if the project is permitted and the transportation corridor as described for Alternative 3 is built.

## Erosion

Soil types corresponding to transportation corridor terrain under Alternative 3 are summarized in Table 4.14-6.

**Table 4.14-6: Alternative 3 Approximate Road Terrain and Soil Types**

| ESS Soil Type | Gentle to Moderate Terrain | Moderate to Rough Terrain |
|---|---|---|
| D36HIJ | 3.8 miles (5%) | None |
| D36HIL | 0.4 mile (1%) | None |
| D36MTG | 3.6 miles (4%) | None |
| IA7 | 29 miles (35%) | 1.8 miles (2%) |
| IA9 | 4.1 miles (5%) | 0.5 mile (1%) |
| RM1 | 7.6 miles (10%) | 5.0 miles (6%) |
| SO11 | 12.9 miles (14%) | 13.5 miles (17%) |
| Percent Total Terrain Type | 61.6 miles (73%) | 20.7 miles (27%) |

Notes:
1 HIJ: Organic material over loamy to coarse-loamy eolian deposits. Hills and plains
2 HIL: Organic material over coarse loamy eolian deposits. Glaciated hills and plains
3 MTG: Organic material (loamy) over gravelly slope colluvium/alluvium. Mountainous to hills and plains
4 IA7: Typic Cryandepts—very gravelly, nearly level to rolling association
5 IA9: Typic Cryandepts—very gravelly, hilly to steep association
6 RM1: Rough Mountainous Land—steep rocky slopes
7 SO11: Humic Cryorthods—silty volcanic ash over gravelly till, hilly to steep association
Total length deviates approximately 1 mile from those shown in Table K2-1, Appendix K2, due to rounding discrepancy
ESS = Exploratory Soil Survey of Alaska
Source: Rieger et al. 1979; PLP 2020d; NRCS 2019 (see Appendix K3.14)

Mitigation and control measures for erosion and stormwater runoff would incorporate structural and non-structural BMPs common to transportation and pipeline construction practices described under Alternative 1a, Alternative 1, and Alternative 2. The greatest potential for hydraulic and wind erosion impacts would correspond with invasive ground disturbance during construction. Disturbed surfaces would remain susceptible to erosion until concurrent or follow-up stabilization is achieved. Permit-required mitigation measures and BMPs are anticipated to alleviate most conditions throughout or immediately after construction.

More robust mitigation and follow-up stabilization measures during and after construction are likely to be required in areas of moderate to rough terrain, where fine-grained soil conditions exist. This coincides with the pipeline-only segment from the port road to Canyon Creek west of Pedro Bay under Alternative 2 (SO11 soils). The least amount of erosion would likely occur during operations, when stabilization of disturbed surfaces would be achieved through natural or applied restoration and stabilization measures, and continued (i.e., real-time) monitoring along the corridor. Erosion throughout post-closure would likely be greater than the operations phase, based on an indefinite need for transportation corridor access; a reduced erosion monitoring frequency; and reduced access to equipment and resources.

#### *Summary of Erosion Impacts*

Enhanced design and mitigation measures would be implemented along discrete segments; in particular, the segment of coastline road through rugged terrain from Diamond Point port, approximately 2.5 miles for Alternative 3. More robust mitigation and restoration measures may be needed in moderate to rough terrain with finer-grained soil conditions (SO11 soils). The duration of erosion would vary from completion of the activity (e.g., construction or reclamation), to an indefinite period in post-closure. The extent of erosion effects would be mostly limited to the immediate vicinity of disturbance or footprint.

The overall magnitude, extent, and potential for erosion under this alternative are considered to be greater than the transportation corridor for Alternative 2, based on total footprint acreage of contiguously shared transportation and pipeline alignment, presence of fine-grained soils in moderate to rough terrain, and increased number of waterbody crossings. The duration would be comparable to Alternative 2, because both alternatives indefinitely retain transportation corridor infrastructure.

### 4.14.6.2 Diamond Point Port

Impacts associated with the port site under Alternative 3 are similar in type to those described for the Alternative 2 Diamond Point port. Soil disturbances would mostly be attributed to construction of the terminal and onshore dredge material storage areas. The magnitude and extent of impact would be the disturbance of approximately 36 acres of soil at the Diamond Point port site from construction through operation. This area of disturbance is greater than Alternative 1a and Alternative 1 (approximately 24 percent), and less than Alternative 2 (approximately 28 percent). Approximately 4 acres of the 36 acres of soil disturbance would be temporary. Temporary disturbances would be reclaimed once no longer used after the construction period. Alternative 3 includes a caisson-supported dock design similar to Alternative 1a; however, it would be constructed in shallower water. As a result, an increased amount of dredging would be required and therefore require increased dredge material storage on uplands. Material dredged during construction would be stored inside a bermed stockpile in an upland area adjacent to the port access road west of Williamsport (PLP 2020d). Impacts to soils associated with the storage of dredged material would be similar in type to those described for Alternative 1a; however, the magnitude of impacts may be increased as a result of the increased volume of material stored. Additionally, because of the upland location of dredge storage sites away from marine waters, there is potential for high salinity runoff to impact soil quality adjacent to stockpiles. Offshore sediment impacts resulting from intertidal and open-water construction, operations, and closure of marine facilities are discussed in Section 4.18, Water and Sediment Quality.

#### 4.14.6.3 Alternative 3—Concentrate Pipeline Variant

This variant includes a high-density polyethylene-lined steel pipeline that would convey slurried copper and gold concentrates from the mine site to the port facility (PLP 2018-RFI 066). The pipeline would be predominantly buried sub-grade in the same trench as the gas pipeline, with approximately 36 inches of top cover. Impacts to soil resources at the mine site and port would be the same as those described under Alternative 2; however, a small soil disturbance increase would be anticipated due to a concentrate pipeline pump house at the mine (1 acre).

The shared transportation and concentrate pipeline corridor would increase the road corridor width by less than 10 percent, resulting in a proportional soil disturbance increase. The duration and geographic extent of soil disturbance and erosion would be the same as Alternative 3; however, there would be an appreciable increase in erosion magnitude and potential, based on the additional acreage of disturbance associated with the transportation corridor to accommodate the concentrate pipeline. Impacts on soil quality would be the same as for Alternative 3. However, the potential for an uncontrolled release of concentrates is considered less likely, because there are no container (concentrate) transport, handling, or storage activities under this variant. The concentrate pipeline variant using a return-water pipeline option would not result in any increased footprint and would not be expected to result in any additional impacts to soil resources.

### 4.14.7 Cumulative Effects

Impacts to soils resources would include those related to soil disturbance and erosion, and deposition of dust from mining activities potentially affecting soil quality. The cumulative effects analysis area for soils encompasses the footprint of the project, including alternatives and variants, the Pebble Project expansion scenario (including road, pipeline, and port facilities), and any other reasonably foreseeable future actions (RFFAs) in the vicinity of the project that would result in potential synergistic and interactive effects. In this area, a nexus may exist between the project and other past, present, and RFFAs that could contribute to a cumulative effect on soils. Section 4.1, Introduction to Environmental Consequences, details the comprehensive set of past, present, and RFFAs considered for evaluation as applicable. A number of the actions would be considered to have no potential of contributing to cumulative effects on soils in the analysis area. These include offshore-based developments; activities that may occur in the analysis area but are unlikely to result in any appreciable impact on soil resources (such as tourism, recreation, fishing, and hunting); or actions outside of the cumulative effects analysis area.

#### 4.14.7.1 Past and Present Actions

Past and present actions that have impacted soils in the analysis area are limited and include transportation development where existing roads intersect the project footprint, and mineral exploration in locations where past or current activities have impacted soils (e.g., work pads or camp areas). Although these actions affect localized areas, they are additive to other actions that may occur, slightly increasing the total cumulative effect on geologic resources. Overall, the cumulative effects on soils from past and present actions are minimal in extent and minor in magnitude for all alternatives.

### 4.14.7.2 Reasonably Foreseeable Future Actions

RRFAs that could contribute cumulatively to soils impacts, and are therefore considered in the analysis of cumulative effects to soils, include: Pebble Project expansion scenario; mining exploration activities for Pebble South, Big Chunk South, Big Chunk North, Fog Lake, and Groundhog mineral prospects; onshore oil and gas development; road improvements and the continued development of the Diamond Point Rock Quarry.

The contribution of RFFAs to cumulative effects on soils are summarized by alternative in Table 4.14-7.

**Table 4.14-7: Contribution to Cumulative Effects on Soils**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Pebble Project Expansion Scenario | **Mine Site:** The mine site footprint would have a larger open pit and new facilities to manage water and store tailings and waste rock, which would contribute to cumulative effects on geologic resources through removal of overburden, waste rock, and ore. Pebble Project expansion and associated development would be similar for all alternatives.<br>**Other Facilities:** A north access road and concentrate and diesel pipelines would be constructed from Eagle Bay along the Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay. Pipeline construction would have potentially limited impacts on soils from trenching activities.<br>**Magnitude:** The Pebble Project expansion scenario footprint would impact approximately 31,892 total acres, compared to 9,612 total acres under Alternative 1a.<br>**Duration/Extent:** The duration and extent of cumulative impacts to soil would vary from temporary soil disturbance during construction to permanent soil removal in the footprint of mine and other project facilities.<br>Similarly, erosion would vary from minimal surface stabilization efforts to indefinite erosion maintenance (e.g., roads, mine site infrastructure).<br>Additional modeling would be warranted at the time of permitting to re-evaluate and refine fugitive dust scenarios (e.g., identification and quantification of parameters) through comparison of baseline, mine operation, and foreseeable conditions, and comparison to regulatory thresholds at the time of permitting. | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** A north access road and concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay. Pipeline construction would have potentially limited impacts on soils from trenching activities.<br>**Magnitude:** The Pebble Project expansion scenario footprint would impact approximately 32,418 total acres, compared to 9,608 total acres under Alternative 1. The Pebble Project expansion under this alternative is greater than Alternative 1a.<br>**Duration/Extent:** The duration and extent of cumulative impacts to soil would be similar to duration and extent of Alternative 1a, although affecting a larger amount of acreage.<br>**Contribution:** The contribution to cumulative effects from Alternative 1 would be appreciably more than all other alternatives. | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** The north access road would be extended, similar to Alternative 1a. Concentrate and diesel pipelines would also be constructed, similar to Alternative 1a.<br>**Magnitude:** Overall expansion would impact 31,528 acres, which is less acreage than the Pebble Project expansion scenario for Alternative 1a (31,892 acres), given that a portion of the north road and all of the gas pipeline would already be constructed.<br>**Duration/Extent**: The duration and extent of cumulative impacts to soil would be similar to duration and extent of Alternative 1a, although affecting a larger amount of acreage.<br>**Contribution:** The contribution to cumulative impacts would be similar to Alternative 1a, but affecting a smaller amount of acreage. | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** Overall expansion would use the existing north access road; concentrate and diesel pipelines would be constructed along the existing road alignment and extended to a new deepwater port site at Iniskin Bay.<br>**Magnitude:** Overall expansion would impact 31,541 acres, which is less acreage than Alternative 1a (31,892 acres) and Alternative 1 (32,418 acres), given that the north access road and gas pipeline would already be constructed. However, the overall expansion would be greater than Alternative 2.<br>**Duration/Extent:** The duration and extent of cumulative impacts to soil would be similar to duration and extent of Alternative 1a, although affecting a smaller amount of total acreage.<br>**Contribution:** The contribution to cumulative impacts would be similar to Alternative 1a, although |

**Table 4.14-7: Contribution to Cumulative Effects on Soils**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | **Contribution:** This contributes to cumulative effects on soil through removal of overburden and surficial bedrock, tailings/waste rock storage, and water management. However, the area in the Kvichak and Nushagak river watersheds is relatively undeveloped, and effects would be limited to the project footprint, which is a relatively small area in the watersheds. | | | affecting a smaller amount of acreage. |
| Other Mineral Exploration Projects | **Magnitude:** Mining exploration activities, including additional borehole drilling, road and pad construction, and development of temporary camp facilities would contribute a small amount of soil disturbance at discrete locations, depending on landowner permitting and restoration requirements. For example, the 2018 drilling program proposed by PLP consisted of 61 geotechnical boreholes and 19 diamond-drilled core boreholes with diameters ranging from 2 to 8 inches.<br>**Duration/Extent:** Exploration activities typically occur at a discrete location for one season, although a multi-year program could expand the geographic area affected in a specific mineral prospect. Table 4.1-1 in Section 4.1, Introduction to Environmental Consequences, identifies 7 mineral prospects in the analysis area where exploratory drilling is anticipated (4 of which are in relatively close proximity to the Pebble Project).<br>**Contribution:** This contributes to cumulative effects of soil disturbance, although the areal extent of disturbance is a relatively small portion of the Kvichak/Nushagak watersheds. Assuming compliance with permit requirements, contributions to soil erosion and quality would be minimal. | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |

**Table 4.14-7: Contribution to Cumulative Effects on Soils**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Oil and Gas Exploration and Development | **Magnitude:** Onshore oil and gas exploration activities could involve seismic and other forms of geophysical exploration, and in limited cases, exploratory drilling. Seismic exploration would involve temporary overland activities, with permit conditions that avoid or minimize soil disturbance. Should it occur, exploratory drilling would involve the construction of temporary pads and support facilities, with permit conditions to minimize soil disturbance and restore drill sites after exploration activities have ceased.<br>**Duration/Extent:** Seismic exploration and exploratory drilling are typically single-season temporary activities. The 2013 Bristol Bay Area Plan Amendment shows 13 oil and gas wells drilled on the western Alaska Peninsula, and a cluster of 3 wells near Iniskin Bay. It is possible that additional seismic testing and exploratory drilling could occur in the analysis area, but based on historic activity, it is not expected to be intensive.<br>**Contribution:** Onshore oil and gas exploration activities would be required to minimize surface disturbance, and would occur in the analysis area, but distant from the project. The project would have minimal contribution to cumulative effects. | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |
| Road Improvement and Community Development Projects | **Magnitude:** Road improvement projects would take place in the vicinity of communities, and have impacts through grading, filling, and potential increased erosion. Communities in the immediate vicinity of project facilities, such as Iliamna, Newhalen, and Kokhanok, would have the greatest contribution to cumulative effects. Some limited road upgrades could also occur in the vicinity of the natural gas pipeline starting point near Stariski | Similar to Alternative 1a. | Similar to Alternative 1a. | Similar to Alternative 1a. |

**Table 4.14-7: Contribution to Cumulative Effects on Soils**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | Creek, or in support of mineral exploration previously discussed.<br>The Diamond Point Rock Quarry has potential to increase soil disturbance and erosion in the analysis area. The estimated area that would be affected is approximately 140 acres (ADNR 2014a).<br>**Duration/Extent:** Disturbance from road construction would typically occur over a single construction season. Geographic extent would be limited to the vicinity of communities and Diamond Point.<br>**Contribution:** Road construction would be required to minimize surface disturbance, and would occur in the analysis area, but removed from the project. The project would have minimal contribution to cumulative effects. | | | |
| Summary of Project contribution to Cumulative Effects | Overall, the contribution of Alternative 1a to cumulative effects to soils, when taking other past, present, and reasonably foreseeable future actions into account, would be minor in terms of magnitude, duration, and extent, given the limited acreage affected and permit requirements regarding soil disturbance and erosion. | Similar to Alternative 1a, although slightly more acreage would be affected by Pebble Project expansion. | Similar to Alternative 1a, but less acreage would be affected by Pebble Project expansion. | Similar to Alternative 1a, but less acreage would be affected by Pebble Project expansion than either Alternative 1a or Alternative 1, but more than Alternative 2. |

Notes:
PLP = Pebble Limited Partnership

# 4.15 GEOHAZARDS AND SEISMIC CONDITIONS

This section describes potential impacts of seismic and other geologic hazards (geohazards) on project components that could affect the environment. The Environmental Impact Statement (EIS) analysis area for geohazards ranges from the immediate vicinity of the project footprint (e.g., slope instability) to regional areas with geohazards that could affect project facilities from long distances (e.g., earthquakes, volcanoes).

The impact analysis for geologic hazards considered the following factors:

- Magnitude—impacts are assessed based on the magnitude of the impact, as indicated by the anticipated effects of various possible geologic hazard events (e.g., repairable damage to mine features, ground settlement).
- Duration—impacts are assessed based on the project phase during which they are expected to occur (e.g., certain structures removed at closure), and how long repair of potential damage or interruption of activities may last.
- Geographic extent—impacts are assessed based on the location and distribution of occurrence of the expected effects from potential geologic hazard events (e.g., distant earthquake effects on mine site and port structures).
- Potential—impacts are assessed based on the likelihood of a geologic hazard event to occur during and after project development (e.g., based on expected recurrence interval[1] for certain geologic hazards).

The impact analysis incorporates an understanding of the probability of occurrence, and of planned mitigation in the form of planning, design, construction, operations, maintenance, and surveillance that can meaningfully reduce impacts from geohazards through closure and post-closure. Based on Pebble Limited Partnership (PLP) plan documents and engineering reports, planned mitigation methods, described in Chapter 5, Mitigation (e.g., design and monitoring to withstand or detect geohazards), are considered part of the project description, and the impacts analysis includes this understanding. In some cases, planned mitigation may not be specified, but is considered typical or standard engineering practice. In cases where planned mitigation is unknown or unclear and the situation is not commonly addressed, the impact analysis takes the lack of planned mitigation into account.

The review of geohazards and seismic effects on project facilities and the related potential for effects on the environment are based on a conceptual level of design and analysis for critical structures, such as the mine site embankments. Therefore, there are uncertainties regarding the potential behavior of these structures in the event of geohazards-type impacts. This section describes how these effects would continue to be evaluated as design progresses through State permitting, following accepted industry practice and standard of care. The National Environmental Policy Act (NEPA) does not require that engineering plans are at an advanced design level; and frequently, conceptual-level design information is used to analyze impacts. Sufficient information for a complete application was submitted by the Applicant, and therefore, USACE must evaluate the application, including proceeding with the NEPA analysis. If the design changes appreciably after the NEPA process, USACE would evaluate whether permit modifications or re-evaluation under NEPA would be needed. A description of uncertainties, assumptions used in the analyses, and related risk due to the conceptual level of design are disclosed in this section (and in Appendix K4.15, Geohazards and Seismic Conditions) where they affect the impact analysis. In

[1]**Recurrence interval** (or return period) is an estimate of the probability or frequency that certain geohazards are expected to occur, based on geologic and seismologic evidence.

addition, mitigation measures that would reduce the level of uncertainty and risk are described in this section, and in Appendix M1.0, Mitigation Assessment.

This section describes the following potential impacts related to geohazards:

- Stability of major mine structures during operations and closure.
- Effects of earthquakes on project facilities.
- Effects of unstable slopes on project facilities.
- Effects of geotechnical conditions and coastal hazards on port structures and pipeline landfalls (e.g., shallow bedrock).
- Effects of tsunamis and seiches on port and ferry terminals.
- Effects of volcanoes on project facilities.

Potential impacts to the environment resulting from geohazard-caused upset conditions, such as an embankment failure, are addressed in Section 4.27, Spill Risk. Impacts from water and ice hazards, such as waves and lake ice, are discussed in Section 4.16, Surface Water Hydrology. As described in Section 3.14, Soils, permafrost has not been encountered in the mine site or other project areas based on field investigations; therefore, potential effects from permafrost hazards are not addressed in this section.

Scoping comments expressed concerns that major faults occur in the project area and may affect project facilities. Commenters requested that the EIS include detailed information about seismically active areas, geological faults and tectonic activity, and corresponding design features. They also requested information on how the project facilities, particularly the tailings storage facilities (TSFs), would withstand earthquakes; and an analysis of potential impacts from volcanic activity from Augustine Volcano, especially at Amakdedori port and along the pipeline.

## 4.15.1 Summary of Key Issues

**Table 4.15-1: Summary of Key Issues for Geohazards and Seismic Conditions**

| Impact Causing Project Component | Alternative 1a | Alternative 1 | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| **Mine Site** | | | | |
| Tailings Storage Facility and Water Management Pond Embankment Stability | Low probability of embankment instability based on preliminary static stability analysis: FoS 1.9 to 2.0 based on downstream slopes of 2.6H:1V for TSFs and 2H:1V for WMPs; additional geotechnical and stability analyses to be incorporated into advanced design stages.<br>Temporary repairable damage in OBE, and <1-foot displacement in MCE based on pseudo-static analysis and target seismic FoS of 1.2; would not result in effects | Same as Alternative 1a: Static FoS of 1.9 to 2.0 based on downstream slopes of 2.6H:1V for TSFs and 2H:1V for WMPs; and <1-foot displacement in MCE based on target seismic FoS of 1.2. | Downstream Bulk TSF Embankment: Design provides marginal additional static or seismic stability over Alternative 1a design. Static stability: FoS 1.9 to 2.0 based on downstream slope of 2.6H:1V for both designs. Seismic (pseudo-static) stability: downstream design has 0.04 foot less displacement than buttressed- | Same as Alternative 1a: Static FoS of 1.9 to 2.0 based on downstream slopes of 2.6H:1V for TSFs and 2H:1V for WMPs; and <1-foot displacement in MCE based on target seismic FoS of 1.2. |

**Table 4.15-1: Summary of Key Issues for Geohazards and Seismic Conditions**

| Impact Causing Project Component | Alternative 1a | Alternative 1 | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | on environment outside of footprint; additional seismic modeling to be conducted in final design.<br>Duration long-term with removal of pyritic TSF and WMPs at closure and dry closure of bulk TSF. | | centerline design for 2 of 4 MCEs.<br>Other TSF and WMP Embankments: Same as those for Alternative 1a. | |
| Open Pit Slope Stability | Low to medium likelihood of localized unstable slopes in pit in early closure, to be mitigated through targeted groundwater depressurization while lake rises.<br>Landslide-induced pit lake wave would not overtop rim. | Same as those for Alternative 1a. | Same as those for Alternative 1a. | Same as those for Alternative 1a. |
| Container Storage and Pumphouse | No variants are analyzed for this alternative: Low likelihood of earthquake toppling effects at container storage area with foundation preparation. | **Summer-Only Ferry Operations Variant:** Low likelihood of earthquake toppling effects at container storage area with foundation preparation. | **Summer-Only Ferry Operations Variant:** Same as those for Alternative 1. | **Concentrate Pipeline Variant:** Impacts at pumphouse are similar to those for Alternative 1a. |
| **Transportation Corridor** | | | | |
| Ferry Terminals and Operations | Earthquakes: Low likelihood of temporary ground-shaking effects such as cracking, spreading, and settlement of terminals.<br>Low likelihood of tsunamis, seiches, and unstable slope effects. | Ground-shaking impacts are similar to those for Alternative 1a.<br>Landslide-induced lake tsunamis: slightly lower likelihood of impacts on Alternative 1 north ferry terminal than for Eagle Bay ferry terminal for Alternative 1a.<br>**Summer-Only Ferry Operations Variant and Kokhanok East Ferry Terminal Variant:** Slightly lower potential for lake tsunami impacts than Alternative 1a and Alternative 1 | Ground-shaking impacts are similar to those for Alternative 1.<br>Landslide-induced tsunamis: slightly higher potential for impacts than Alternative 1a or Alternative 1 ferry terminals and crossings.<br>**Summer-Only Ferry Operations Variant:** Slightly lower potential for lake tsunami impacts than Alternative 2 due to fewer ferry operations. | No geohazards effects because there would be no ferry terminals. |

**Table 4.15-1: Summary of Key Issues for Geohazards and Seismic Conditions**

| Impact Causing Project Component | Alternative 1a | Alternative 1 | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | | base case due to fewer ferry operations. | | |
| Road Construction and Operations | Unstable slopes: Minor areas along mine access road (e.g., near Roadhouse Mountain). Low likelihood of impacts expected with typical engineering and construction practices.<br>No variants are analyzed for this alternative. | Unstable slopes: Fewer impacts along the mine access road than Alternative 1a.<br>**Summer-Only Ferry Operations Variant and Kokhanok East Ferry Terminal Variant:** Impacts would be similar to Alternative 1a and Alternative 1 base case. | Unstable slopes: Higher likelihood of impacts along road corridor than Alternative 1a or Alternative 1; effects would be temporary and localized with engineering controls and maintenance.<br>Liquefaction: Higher potential at Pile and Iliamna river crossings than for Alternative 1a or Alternative 1.<br>**Summer-Only Ferry Operations Variant:** Impacts would be similar to Alternative 1.<br>**Newhalen River North Crossing Variant:** Impacts would be similar to Alternative 1a and Alternative 2 base case. | Unstable slopes: Slightly higher likelihood of effects than Alternative 2 due to longer route in steep terrain; effects would be similar to Alternative 2 with engineering controls and maintenance.<br>Liquefaction: Potential would be similar to Alternative 2.<br>Landslide-induced lake tsunamis: low likelihood of effects on eastern parts of the road close to lakeshore.<br>**Concentrate Pipeline Variant:** Low likelihood of minor spills due to unstable slopes. |
| **Ports** | | | | |
| Dock and Port Facilities Construction and Operations | Caisson dock stability: Low likelihood of stability effects on dock, assuming additional geotechnical and stability evaluations in final design.<br>Unstable Slopes: Low likelihood of effects.<br>Tsunamis: Low to moderate likelihood of temporary (repairable) effects such as dock or fuel tank damage, assuming additional site-specific analysis in final design.<br>Volcanic ash from Augustine Volcano: Low | Sheet pile dock stability: Slightly higher likelihood of stability effects and damage from boulders or shallow bedrock, scour, and potential for fill escape than for Alternative 1a.<br>Unstable Slopes: Same as Alternative 1a.<br>Tsunamis: Slightly higher likelihood of effects on sheet pile dock due to cross-sectional area. | Sheet pile dock stability: Slightly higher likelihood and extent of stability effects than Alternative 1 sheet pile dock due to 4x larger structure and finer seabed/fill material, increased liquefaction potential, buried boulders, and 10-foot elevation change at mudline on either side of the northwestern corner of the dock.<br>Unstable Slopes: Higher likelihood of effects than | Caisson dock stability: Slightly higher likelihood of foundation, stability, and liquefaction effects than Alternative 1a caisson dock due to finer seabed material and buried boulders; and slightly higher likelihood of these effects than Alternative 2 due to greater elevation change (12- to 15-feet) on either side of the caissons.<br>Unstable Slopes: Higher likelihood of |

**Table 4.15-1: Summary of Key Issues for Geohazards and Seismic Conditions**

| Impact Causing Project Component | Alternative 1a | Alternative 1 | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | likelihood of port operations interruption. | **Pile-Supported Dock Variant:** Higher likelihood of damage/repairs needed during project life due to shallow bedrock; similar or lower likelihood of stability effects than caisson or sheet pile dock.<br>**Summer-Only Ferry Operations Variant:** Slightly higher likelihood of debris impacts during tsunami due to increased container storage. | Alternative 1a due to steep alluvial fan material in port area.<br>Tsunamis: Slightly lower intensity than for Alternative 1 due to lower predicted run-up elevation, though higher likelihood of local landslide-generated tsunamis.<br>Volcanic ash from Augustine Volcano: Slightly higher likelihood of effects than for Alternative 1a and Alternative 1 during winter due to prevailing winds.<br>**Pile-Supported Dock Variant:** Higher likelihood of damage/repairs needed during project life than other dock designs due to shallow bedrock; and lower likelihood of stability effects than sheet pile dock. | effects on port facilities than Alternative 1a and Alternative 2 due to rockslide/rockfall potential at port facilities and talus slopes adjacent to dredged material storage area.<br>Tsunamis: Slightly higher intensity at port facilities than Alternative 2 due to higher predicted runup elevation; lower likelihood of effects on caisson dock than for Alternative 2 due to smaller cross-sectional area; likelihood of landslide-generated tsunamis similar to Alternative 2.<br>Volcanic ash from Augustine Volcano: Impacts would be the same as those for Alternative 2.<br>**Concentrate Pipeline Variant:** Unstable slope effects on the storage facility same as Alternative 3.<br>Tsunamis: Same likelihood as for Alternative 3 port facilities, but with slightly higher risk of contaminant release. |
| **Natural Gas Pipeline Corridor** | | | | |
| Construction and Operations—Offshore Cook Inlet | Low likelihood of pipe damage from liquefaction or exposed bedrock.<br>Low likelihood of scour effects due to pipeline burial and minimum depth of cover (1 to 2 feet), or on-bottom | Same impacts as those for Alternative 1a. | Liquefaction, bedrock, and scour: Impacts in Cook Inlet would be similar to those for Alternative 1a.<br>Low likelihood of active fault crossing | Liquefaction, bedrock, and scour: Impacts would be similar to those for Alternative 1a.<br>Surface faults: Same as those for Alternative 2. |

**Table 4.15-1: Summary of Key Issues for Geohazards and Seismic Conditions**

| Impact Causing Project Component | Alternative 1a | Alternative 1 | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | stability analysis for segment with no cover.<br>No active fault crossing effects expected. | | (Bruin Bay fault) and displacement effects. | |
| Construction and Operations—Coastal Cook Inlet | Low likelihood of pipe damage from coastal hazards (e.g., boulder rafting, scour, sediment drift). Pipeline burial below mudline and depth of cover (3 to 5 feet) would be sufficient to avoid hazards. | Same impacts as those for Alternative 1a. | Similar impacts to those for Alternative 1a, except for slightly higher liquefaction potential in estuarine deposits. | Similar impacts to those for Alternative 2, except for 1 mile longer in liquefiable estuarine deposits. |
| Construction and Operations—Upland Areas | Low likelihood of unstable slope effects on pipeline. | Similar impacts to those for Alternative 1a.<br>**Kokhanok East Ferry Terminal Variant:** Similar impacts to those for Alternative 1a and Alternative 1 base case. | Unstable slopes: Low-medium likelihood of effects (such as operations interruption or rupture) between Diamond Point and Roadhouse Mountain; expected to be mitigated through typical engineering controls and monitoring.<br>Liquefaction: Higher potential for impacts than that for Alternative 1a and Alternative 1, due to more areas of wide alluvial and estuarine deposits. | Same impacts as those for Alternative 2. |

Notes:
[1]Slope angle expressed as ratio of horizontal (H) distance to vertical (V) change in elevation.
FoS = Factor of Safety
H:V = horizontal/vertical
MCE = Maximum Credible Earthquake
OBE = Operating Basis Earthquake
TSF = Tailings Storage Facility
WMP = Water Management Pond

## 4.15.2 No Action Alternative

Under the No Action Alternative, no construction, operations, or closure activities specific to the Applicant's Preferred Alternative would occur. Although no resource development would occur, PLP would retain the ability to apply for continued mineral exploration activities under the State's authorization process, as well as any activity that would not require federal authorization. In addition, there are many valid mining claims in the area, and these lands would remain open to mineral entry and exploration by other individuals or companies.

Current State-authorized activities associated with mineral exploration and reclamation and scientific studies would be expected to continue at levels similar to recent post-exploration activity. The State requires reclaiming sites at the conclusion of their State-authorized exploration program. If reclamation approval is not granted immediately after the cessation of reclamation activities, the State may require continued authorization for ongoing monitoring and reclamation work as it deems necessary.

Effects on project components from geohazards, seismic events, and other geotechnical conditions would not occur, and no impacts on the environment would result from such effects. Natural geohazards such as those described in Section 3.15, Geohazards and Seismic Conditions, would continue to affect existing communities and infrastructure in the region.

## 4.15.3 Alternative 1a

### 4.15.3.1 Mine Site

This section describes potential effects of seismic events and other geohazards on major structures at the mine site; the ability of the structures to withstand these hazards; and the likelihood that such hazards could produce related environmental impacts. Figures in Chapter 2, Alternatives, display the mine site layout; and Table K4.15-1 in Appendix K4.15 provides the buildout dimensions of embankments and impoundments that would contain tailings, waste rock, and/or contact water at the mine site. This section also addresses potential geohazard effects on the open pit.

#### Embankment Construction Material

The embankments for the tailings storage and water management facilities would be constructed of rockfill and earthfill materials obtained from drilled and blasted bedrock removed from quarries A through C,[2] and the overburden in the open pit (see Chapter 2, Alternatives, Figure 2-4). Analyses were completed to determine the quantities of on-site embankment construction materials and project-related needs. Appendix K4.15 (see Table K4.15-2 and Table K4.15-3) provides embankment material quantities that would be generated by quarries A through C and the open pit overburden, as well as the embankment material needs for the relevant mine site–related facilities.

Based on the material properties, quantities, and assumptions provided by PLP (2018-RFI 015b; PLP 2019-RFI 108a; PLP 2019-RFI 008e update); the combination of quarries A through C and the open pit overburden could generate about 4 to 5 percent less compacted rockfill and earthfill material than needed to construct the embankments. These results are based on various conservative assumptions regarding bulking, compaction, and usable material reduction factors assigned in Table K4.15-2. The effect of changing these assumptions is described in Appendix K4.15. For example, if slightly higher but still reasonable bulking factors were used based on numbers in the literature (e.g., Look 2007), the calculated compacted rockfill available from the quarry and pit sources would be higher than needed for embankment rockfill and road maintenance. As described in Chapter 5, Mitigation, the material balance (surplus/deficit) would be further refined as the design and site investigation programs are advanced; and if necessary, the base elevation of the quarries would be lowered to increase earthfill and rockfill material availability (PLP 2018-RFI 015a). In particular, quarry A in the bulk TSF footprint could be expanded if needed to meet material requirements during construction without impacting the overall footprint. An expansion of quarry A would also provide additional tailings storage capacity.

[2]Quarry A is shown on Figure 2-4 in the footprint of the bulk TSF; this quarry would be developed before the construction of the bulk TSF.

Therefore, the likelihood that additional rockfill material would be needed as the project progresses, with related project footprint increases, is low.

Appendix K4.15 describes the availability of low-permeability material expected from open pit overburden stripping that may be used as liner bedding, embankment core zones, and the bulk TSF closure cover, depending on detailed design. Pit overburden deposits mainly consist of low-permeability clayey sands and gravels derived from glacial drift and glacial lake deposits (see Figure 3.13-2) that would be segregated into appropriate stockpiles based on material gradations. If additional low-permeability materials are needed, they would be sourced from embankment foundation excavations and other site preparations. It is expected that the pit and other mine excavations would provide the sufficient amount of low-permeability material to meet the requirements for these materials specified in the detailed design. For example, the estimated volume needed for both liner bedding and the bulk TSF closure cover represents about 38 to 44 percent of the pit overburden, and about 10 to 20 percent of total overburden (including other excavations).

## Embankment and Impoundment Design and Construction

The embankments and impoundments could be impacted by geohazards, such as instability associated with seepage, internal erosion,[3] foundation conditions, high precipitation, and earthquakes. The embankments would therefore be designed, constructed, and operated to remain stable during these events, including under both static (non-seismic) and seismic conditions.

All embankments would be subject to State of Alaska regulations per Chapter 17 in Title 46 of the Alaska Statutes (AS 46.17) and Article 3 Dam Safety of Chapter 93 in Title 11 of the Alaska Administrative Code (11 AAC 93). The Dam Safety and Construction Unit (Dam Safety) of Alaska Department of Natural Resources (ADNR) would be responsible for “supervision” of the safety of the embankments and for administration of the Alaska Dam Safety Program (ADSP). A draft revision of *Guidelines for Cooperation with the Alaska Dam Safety Program* (dam safety guidelines) (ADNR 2017a) is in the public domain, but has not yet been formally adopted by ADNR. A portion of the dam safety guidelines regarding periodic safety inspections were formally adopted by ADNR in 2003 by reference in 18 AAC 93. Subsequent revisions to the guidelines (ADNR 2005b, 2017a) have not been adopted in regulations, and may not be enforceable under AS 46.17 or 11 AAC 93 (ADNR 2020).

The regulatory requirements are obligatory, and typically considered as the “minimum” standard of care. The intent of the ADSP is to provide for the protection of human lives, property, and the environment, including anadromous fish streams, through consistency in design approach, construction, and operation of water and TSF. The draft ADSP dam safety guidelines do not dictate how a facility is to be designed and constructed, but do describe a minimum standard of care, indicating that designs should follow a higher standard based on accepted industry standards and procedures (i.e., what a reasonable person or expert in the industry would consider foreseeable risk and the standard of care). Mitigation measures such as those described below that rely on proven engineering controls are more appropriate in reducing dam failure risk than relying on compliance with State regulatory programs (ADNR 2020; Cobb 2019; Fourie 2009; Morgenstern 2018; Silva et al. 2008).

[3]**Internal erosion**, also referred to as piping, is the formation of voids in a soil caused by the removal of material by seepage, and occurs when the hydraulic forces exerted by water seeping through the pores and cracks of the material in the embankment are sufficient to detach particles and transport them out of the embankment structure.

The current level of embankment design is considered to be at an advanced conceptual to initial preliminary level. As the design advances, it would go through preliminary and detailed design levels, terms which are explained in the draft guidelines (ADNR 2017a), and are accepted globally as state-of-practice design terminology. Prior to construction, all embankment starter dams and all embankments that would be built to their full height at the outset would undergo initial application package preparations (complete with conceptual design information), preliminary and detailed designs, final construction package preparation, safety reviews, and submittals by a qualified engineer to ADNR for Certificates of Approval to Construct a Dam. Also prior to construction, each embankment raise would undergo a separate design and safety review that would be adjusted as necessary, based on knowledge from previous raise constructions, TSF operations, and tailings characterizations, followed by submittals to ADNR for a Certificate of Approval to Modify a Dam.

Prior to operations, following the completion of each starter dam, full embankment, or embankment raise construction, a construction completion report would be submitted to ADNR for a Certificate of Approval to Operate a Dam. Therefore, no operations would be permitted to start until the construction completion report is approved and the certificate is issued. Also, all dam repairs, removals, and abandonments require separate designs, safety reviews, and submittals to ADNR for Certificates of Approval to Repair, Remove, and Abandon a Dam, respectively.

The following summarizes geohazard considerations for the design and construction of the major embankments and impoundments, including the bulk TSF, pyritic TSF, water management ponds (WMPs), and seepage collection ponds (SCPs). More detailed information is provided in Appendix K4.15.

**Bulk TSF.** The bulk TSF would be designed to impound the bulk tailings, and includes a main (north) embankment and a south embankment with the following design, construction, and monitoring elements to prevent geohazard-related impacts:

- Siting in a single tributary watershed surrounded by bedrock knobs to focus potential impacts in one watershed and incorporate natural containment elements.
- Foundations to be placed on competent bedrock for increased embankment stability. All overburden soils and weathered bedrock in the embankment footprint areas would be removed to expose the competent bedrock.
- Main embankment starter dam downstream-constructed[4] to a maximum height of 265 feet, followed by centerline-construction[5] of the upper 280 feet of the embankment to reduce the footprint, with a buttressed downstream slope to enhance stability (total maximum height 545 feet). This would result in an overall downstream embankment slope of 2.6 horizontal (H): 1 vertical (V), including benches, with intermediate slopes designed at 2H:1V; and a serrated near-vertical upstream face for the 280-foot-high centerline part (see Chapter 2, Alternatives, Figure 2-8).
- Main embankment operated as a permeable flow-through structure with continuous engineered filter zone to control drainage in the embankment, prevent internal erosion, and remain functional after a seismic event.

[4]**Downstream construction** is a method of dam (embankment) construction in which a rockfill dam is raised in the downstream direction by placement of fill on top of the dam crest and downstream slope of the previous raise.

[5]**Centerline construction** is a method of dam (embankment) construction in which a rockfill dam is raised by concurrent placement of fill on top of the dam crest; the upstream slope, including portions of the tailings beach; and the downstream slope of the previous raise.

- South embankment constructed using downstream methods to a maximum height of 300 feet. The downstream embankment slope would be 2.6H:1V. The upstream embankment slope would be flatter, at 3H:1V, to facilitate the placement of a liner on the slope.
- South embankment operated as an impervious structure with a liner on the upstream face (or a low-permeability core zone), combined with a grout curtain in bedrock, and engineered filter zone to protect the liner (or core) and prevent internal erosion. The upstream liner or core zone would key into a concrete plinth to form a continuous seepage barrier with the grout curtain, which would be keyed into bedrock to prevent leakage beneath the embankment.
- Tailings storage impoundment containing thickened tailings with a small pond on the surface away from the main and south embankments, covering only about one-fourth to one-third of the total surface area (see Table K4.15-1).
- Underdrains in natural tributary drainages beneath the impoundment, an aggregate drain at a topographic low point beneath the main embankment to provide a preferential seepage path from the tailings to downstream of the embankment toe, and additional underdrains running parallel to the embankment to allow for drainage of seepage collected along the embankment.
- Water management to protect all embankments from seepage pressure-related instability, with excess pond water pumped to the main SCP of the bulk TSF and/or the main WMP.
- Drainage ditches around the toes of the embankment slopes to prevent erosion and undercutting, and to allow drainage water to flow unimpeded to the SCPs.
- Diversion channels and rockfill embankment material that minimize erosion on the downstream face of the embankments.
- Freeboard to contain the entire inflow design flood above the tailings beach, and account for potential seismic deformation of the embankment crests so that water cannot overtop the embankment crests.
- Water balance model that incorporates an analysis of historic trends and extremes to account for potential climate change effects on runoff and pond size (see Section 3.16 and Appendix K3.16, Surface Water Hydrology).
- Wide tailings beach to keep pond water away from the embankments, and thereby reduce seepage pressures on the embankments and promote subsurface drainage to the main flow-through embankment with pond development against bedrock high to the southeast.
- Reduced tailings volume by using thickened tailings discharge methods that would increase the density and decrease the water content of the deposited tailings, and by additional pumping capacity to remove excess pond water to the main WMP.
- Dry closure methods to improve stability for permanent in-place closure, with a closure cover design that would minimize infiltration, regrading, and surface drainage to promote runoff, tailings consolidation, and long-term internal drainage.
- Monitoring performed during construction, operations, closure, and post-closure.

**Pyritic TSF**—The pyritic TSF would be designed to impound pyritic tailings, potentially acid-generating (PAG) waste rock, and metal-leaching (ML) materials in a co-placement[6] manner during operations, which would be moved to the open pit at closure. This form of tailings and waste rock co-disposal is in common use globally (Habte and Bocking 2017). Examples of existing and planned co-disposal TSF operations are discussed in Appendix K4.15.

The pyritic TSF would include a continuous embankment around the northern, eastern, and southern sides that have been named the north, east and south embankments, respectively, with the following design and construction elements to prevent geohazard-related impacts:

- The majority of the pyritic TSF would be in a single tributary valley bounded by high ground on the western side to focus potential impacts in one watershed and incorporate a natural containment element.
- North, east, and south embankments prepared by removing overburden to competent bedrock over the entire embankment footprints, and downstream-constructed to maximum heights of 335, 225, and 215 feet, respectively.
- Fully lined TSF with liner underlain by a layer of processed bedding material (sand and gravel) to protect and cushion the liner from exposed ground surface materials, and underdrains to collect and convey any seepage to the downstream SCPs.
- Liner overlain and protected by processed materials (sand and gravel) after liner installation to prevent damage to liner from punctures and damage during waste rock placement.
- Waste rock placed in a ring over the processed sand and gravel around the inside perimeter of the TSF.
- Tailings discharged into the TSF from sub-aqueous discharge points during operations to minimize oxidation and potential acid generation with the tailings surface level maintained at all times below the waste rock surface level.
- Water levels maintained on top of the tailings and waste rock for the full life of the facility, with freeboard maintained to account for inflow design flood, wave run-up, wind set-up, seismic deformation, and excess pond water pumped to the main WMP.
- Tailings, waste rock, and any impacted underlying materials moved into the open pit at closure.
- After closure, the liner removed and embankments graded/recontoured to conform to the surrounding landscape and promote natural runoff and drainage.
- Monitoring included during construction, operations, and closure.

The presence of colluvium and solifluction deposits on the sides of the impoundment that are subject to frost creep could lead to potential stretching of the upper liner on valley side slopes before it is covered. Liner deformation is expected to be minimized by placement of liner bedding material prior to installation, and placement of the protective layer and PAG waste rock fill on top of the liner that would buttress such movement.

**WMPs and SCPs**—Two primary WMPs would be at the mine site (the main WMP north of the pyritic TSF, and the open pit WMP) to impound contact and open pit water, respectively. The SCPs would be sited downstream of the TSF embankments, including those associated with the bulk TSF main and south embankments, and the pyritic TSF north, east, and south embankments.

[6] **Co-placement** is a co-disposal method in which tailings and waste rock are transported independently to the same storage facility, but not pre-mixed to form a single discharge stream. Examples are waste rock end-dumped into a TSF, or waste rock placed to create internal berms or retaining walls of a TSF.

The facilities would include the following design and construction elements to prevent geohazard-related impacts:

- WMPs fully lined with an engineered filter zones, and SCPs with low-permeability and engineered filter zones keyed into grout curtains, to minimize seepage and risk of internal erosion.
- Rockfill embankments to promote stability and safety under static and seismic loading conditions.
- Main WMP embankment to have a maximum height of 190 feet and 225-acre footprint prepared by removing overburden so that the embankment is constructed on competent bedrock.
- Open pit WMP embankment design concept requiring potential weak foundation conditions encountered in the overburden materials (e.g., glacial lake deposits) to be excavated.
- Pond water volumes managed through reuse in the process plant, and treatment and discharge.
- Monitoring/seepage pumpback wells downgradient to detect and capture potential liner leakage.
- At closure, the WMPs to be removed and embankments graded/recontoured to conform to the surrounding landscape and promote natural runoff and drainage.
- Monitoring included during construction, operations, closure, and post-closure.

The main WMP would be composed of a 225-acre reservoir with 190-foot-high embankment, which is in line with the largest geomembrane-lined water storage reservoirs in the world. Comparable examples in the US and worldwide are described in Appendix K4.15.

## Seepage Analysis

A seepage analysis was conducted of the bulk TSF based on a 2-dimensional model (SEEP/W), which resulted in predicted seepage rates for use in the site-wide water balance model (see Section 4.16, Surface Water Hydrology), and informed the behavior of the phreatic surface for understanding the stability of the embankments. Details of the seepage model assumptions, input parameters, material layout, boundary conditions, and results are provided in Appendix K4.15.

Sensitivity analyses were run to evaluate the effect of uncertainties in various parameters. Overall seepage rates estimated for the bulk TSF main embankment at the end of operations ranged from 3.6 to 18 cubic feet per second (cfs) for the various sensitivity analyses. The results indicated that seepage flow is most sensitive to recharge rates on the tailings beach, the distance of the supernatant pond from the dams, and isotropy of the coarse tailings unit; and less sensitive to changes in tailings and bedrock hydraulic conductivity values. The increase in recharge and pond size in the sensitivity analyses demonstrates the range of seepage flow that could occur due to increased precipitation from climate change. Based on the likelihood that the tailings would be anisotropic, Knight Piésold (2019o) selected a range of 3.5 to 5.5 cfs as a best estimate for use in the mine site water balance model. In post-closure, seepage rates were estimated to be about 10 to 30 percent of those during operations depending on closure cover type, ranging from 0.3 to 1.2 cfs through the main embankment, and 0.1 to 0.6 cfs through the south embankment. The post-closure results were less sensitive to the presence or absence of a seasonal pond than the operations results (Knight Piésold 2019o; PLP 2019-RFI 006b, c).

The model also provided information on the behavior of the phreatic surface in the embankments. As shown in Figure K4.15-3, the phreatic surface next to the main embankment is expected to vary with the history of spigotting tailings in the area, as well as the ability of the tailings to segregate. Operational practices to maintain the desired width of tailings beach and keep the pond away from the dams would entail varying the tailings discharge locations, resulting in a phreatic surface elevation that could vary along the length of the embankment at any given time. The seepage model also shows how the phreatic surface is expected to decline in early closure after the end of spigotting, resulting in more stable embankment conditions in post-closure (PLP 2019-RFI 006b, -RFI 008h, and -RFI 130). Refined seepage analyses in the preliminary and detailed designs would consider tailings grain-size distribution based on additional test work, a plan for discharging tailings into the impoundment, and further analysis on the range of input parameters to assess the plausible range of flow conditions that could exist (PLP 2019-RFI 006c).

The flow-through design of the bulk TSF main embankment is intended to promote unsaturated conditions in the coarse tailings deposited near the embankment and reduce porewater pressures in the embankment fill materials. This has been identified as a Best Available Technology (BAT) principle for tailings dams by the expert panel that reviewed the Mount Polley dam failure (Morgenstern et al. 2015). As noted above, the large, continuous, engineered filter zone in the embankment is intended to control internal erosion, while promoting internal drainage and reduction of the phreatic surface, which enhances stability.

PLP 2019-RFI 006c and PLP 2019-RFI 008h provide a summary of centerline dams worldwide that are currently operating and have heights and seepage similar to what is estimated for the bulk TSF main embankment. For example, the Gibraltar and Brenda mines in British Columbia and the Montana Resources' Continental Mine in Montana have centerline or modified-centerline TSFs in the range of 385 to 750 feet in height, and seepage flows in the range of 2 to 10 cfs in operations and 1 to 2 cfs in closure. It is noted that the centerline constructions of these three example TSFs are different than the construction planned for the bulk TSF main embankment, in that the Gibraltar and Brenda TSF dams are raised by cyclone tailings sands, and the Continental TSF embankment has alluvial soils on its upstream slopes to reduce tailings migration into the rockfill. The seepage rates recorded through these three example dams that are of similar heights to the bulk TSF main embankment are similar to the seepage rates estimated through the bulk TSF main embankment.

## Preliminary Static Stability Analyses

Preliminary analyses were completed to evaluate the stability of the embankments under static and non-seismic conditions based on the current conceptual levels of design. The following summarizes the static stability analysis. A more detailed discussion is presented in Appendix K4.15. The following major embankments were analyzed for static stability: bulk TSF main and south pyritic TSF north, main WMP, open pit WMP, and bulk TSF main SCP.

**Input Parameters and Methods**—Input parameters for the preliminary analyses were based on the results of field and office studies, and included the embankment configurations and assumed rockfill material, foundation material, and stored material parameters listed in Table K4.15-5. The analyses were completed using the software program SLOPE/W. Potential slip surfaces analyzed are shown on Figure K4.15-4 through Figure K4.15-9.

The preliminary analyses assumed homogeneous conditions for the foundation materials, with strength parameters selected based on both drillhole data and typical values in the literature (see Table K4.15-5). A summary of foundation materials and potential weak zones encountered in drillholes completed to date is provided in Appendix K4.15 for each of the major embankments. Foundation conditions would be further investigated and parameters for stability analysis refined as design progresses through State permitting (see Chapter 5, Mitigation).

**Results and Target Factor of Safety**—The results of the preliminary static stability analyses predicted the analyzed embankments would have a static factor of safety[7] (FoS) between 1.9 and 2.0 (see Table K4.15-6). The minimum allowable FoS is an important design factor that is determined by the Applicant based on standards of engineering practice and can be different for various components and phases of mine design (e.g., liners, underdrains, pit slope failure in post-closure). For the purpose of static loading, PLP has indicated it would meet or exceed a target FoS of 1.8 (Knight Piésold 2019p; PLP 2018-RFI 008g).

The current conceptual-level design FoS values are considered adequate for determining low probabilities of instability; for comparing different types of embankments such as downstream and centerline; and for PLP project planning. Acceptably reliable FoS values for preliminary and detailed design and final construction package purposes would be refined based on additional geotechnical investigation of tailings and embankment fill characteristics during the advanced preliminary and detailed stages of the designs.

The ADNR (2017a) draft guidelines under the ADSP do not specify a minimum FoS that must be met. The purpose of the guidelines is to outline the typical information required, while recognizing that every dam is unique. It is the dam engineer's responsibility to use an industry standard-based approach to design, which includes specification of a minimum FoS and respective analyses as part of a minimum standard of care, and to defend the design based on the level of detail in the engineering. The level of detail in engineering work has more influence on the likelihood of failure than increasing the FoS on a less detailed design (Silva et al. 2008). Therefore, there is much uncertainty in evaluating the stability of the mine site embankments based on a conceptual-level design.

There are three areas of uncertainty with respect to embankment stability at the current level of design: 1) the extent that the thickened tailings would segregate to promote coarser material and a deeper phreatic surface near the embankment; 2) the extent that pore pressures in the newly placed, potentially soft and loose tailings would reduce sufficiently to provide a stable upstream slope of the first raise; and 3) how to schedule and construct the first raise with its upstream part over tailings placed in less than 2 years (estimated time for starter dam to fill to capacity). These are discussed in more detail in Section K4.15. Uncertainties need to be resolved during the preliminary and detailed design processes and early during the first year of operations. This would minimize the potential that a deeper failure surface (up to the depth of the lowest centerline raise) could result in more of the centerline part of the embankment (below just the most recent raise) sliding into potentially undrained tailings, which could set the mass in motion with adverse consequential effects on the TSF in a downstream direction.

The technical key to addressing these three uncertainties is to obtain geotechnical characteristics of the tailings, which can only be accomplished after tailings deposition has begun and actual deposited tailings become available for geotechnical investigations and raise design, including seepage, stability, consolidation, pore-pressure, and liquefaction analyses. Initial geotechnical investigation results obtained in the first year of operations are needed to provide data on the extent of segregation that is being achieved, pore pressures within the tailings, consolidation rates of the tailings, and depth of the phreatic surface in the tailings and embankment. These geotechnical data can then be used in analyses to provide stable and safe centerline raises, starting with the first raise above the starter dam and initial deposited tailings. Chapter 5, Mitigation, describes some of the additional geotechnical investigation and engineering design

[7]**Factor of safety** is the ratio of the strength of a structure to an applied load, or the ratio of forces resisting failure to those driving failure. It can be a calculated number from a stability analysis, or a target number imposed by regulation or engineering standards and practices. An FoS of exactly 1 means that a structure would support only the applied load and no more; i.e., failure is impending. A structure with an FoS of 2 would fail at twice the design load.

work that would be completed during detailed design, including additional seepage, stability, and liquefaction analyses. Additional recommendations for tailings geotechnical investigation and stability analyses are provided in Appendix M1.0, Mitigation Assessment. The scope of additional work would be specified in an initial application package after the EIS is complete (PLP 2019-RFI 008g). The application package would include descriptions of the conceptual designs and a design scope that would "define the proposed level of work, methodologies, levels of analysis, and approaches to determine and evaluate those parameters that are required for the safe design and construction of the dam" (ADNR 2017a).

**Closure**—As described above and in Appendix K4.15, the long-term stability of the bulk TSF main embankment would be enhanced through a reduction in seepage flow after tailings deposition stops; removing the pond, promoting runoff, and limiting infiltration through closure cover design; and consolidation and long-term internal drainage of the tailings. As described in Chapter 5, Mitigation, analysis of tailings properties that promote internal drainage near the embankments would be completed during detailed design and monitored through operations. If required to maintain conditions that achieve long-term drainage and stability goals (i.e., reduced phreatic surface and pore pressures at the embankment), alternative drainage-enhancing features would be considered, such as vertical or horizontal drains (PLP 2019-RFI 130).

**Comparison to Other Centerline-Constructed Dams**—PLP (2019-RFI 008h) provides a summary of 11 centerline dams that are currently operating globally and have some similarities to the bulk TSF main embankment. Three of the dams are directly comparable to the planned bulk TSF main embankment with regard to centerline construction. The Constancia dam is zoned rockfill with a vertical clay core and is higher than 328 feet. The 318-foot-high Highland Valley H-H Dam is an earthfill dam with a vertical core, random fill and tailings placed upstream, and variable waste fill placed downstream. The 750-foot-high Continental dam is rockfill with a centerline-constructed segment. All three dams have configurations and materials like those planned for the bulk TSF main embankment, except that Constancia and Highland Valley H-H have vertical cores, so they are not "flow-through" dams. The engineered filter zones in the bulk TSF, consisting of graded sands and gravels, is expected to be more effective than these low-permeability core examples in lowering the phreatic surface in the embankment and promoting stability. The Continental dam has alluvium on its upstream face to prevent tailings migration into the dam, so it can be considered a partial flow-through dam. The Constancia and Highland Valley H-H dams are lower—and the Montana Resources dam is higher—than the planned bulk TSF main embankment. These dams were still being raised at the time of preparation of this EIS.

Three additional dams are described as "modified centerline" dams, or hybrids of centerline and upstream or downstream construction with rockfill raises (Alumbrera, Fort Knox, and Montana Tunnels dams), and are somewhat comparable to the bulk TSF main embankment configuration. The Alumbrera dam is described as a rockfill/earthfill dam; is projected to be 540 feet high; and has a free-draining starter dam. The Fort Knox dam is rockfill, 350 feet high, and had planned centerline raises but was raised as a downstream-to-centerline hybrid. The Montana Tunnels dam is rockfill; was permitted to 410 feet in 2008; and started downstream with raises closer to upstream than centerline. Additional discussion of comparable dams in PLP (2019-RFI 008h) is provided in Appendix K4.15.

## Preliminary Seismic Stability Analysis

**Active Surface Faults**—The mine site is situated in a regionally seismically active area caused by the convergence of the Pacific and North American tectonic plates. A description of the known active faults in the project area is provided in Section 3.15, Geohazards and Seismic Conditions. Because no mine facilities would be constructed on top of known active surface faults, it is unlikely there would be ground surface rupture effects on embankments and other mine facilities. The type of effects that could occur in the event that facilities or infrastructure were unknowingly built on an active fault that experienced surface rupture could include pipeline rupture, instantaneous displacement (lateral or vertical offset) of roads, or cracking and shearing of embankments and buildings.

The closest potentially active fault to the mine site is the Lake Clark fault. Section 3.15 provides a summary of evidence and uncertainties in the interpretation of the recency of faulting on this structure. The closest documented surface exposure of this fault is 14 miles from the mine site. Several possible extensions of this fault have been identified based on regional geophysical data as close as 6 miles from the mine site (see Figure 3.15-2), although these are not necessarily active faults, and field studies have not shown evidence of fault offset of surficial deposits in the area (Hamilton and Klieforth 2010; Haeussler and Waythomas 2011; Koehler 2010). Evidence of repeated paleo-liquefaction events as close as 8 miles southwest of the mine site (Higman and Riordan 2019) could suggest Holocene earthquake activity on either a buried Lake Clark fault extension or deeper subduction-related seismicity.

The implication of these uncertainties for the impact analysis is discussed in Appendix K4.15. The effect of a closer location of the Lake Clark fault on ground-shaking estimates for mine structures is discussed below under Seismic Hazard Analysis. Potential impacts from possible surface rupture at the fault extensions are discussed below under Transportation Corridor, and Natural Gas Pipeline. Chapter 5, Mitigation, and Appendix M1.0, Mitigation Assessment, describe PLP plans to continue to investigate the Lake Clark fault as design progresses (PLP 2019-RFI 139), and additional fault study recommendations that would help identify (or rule out) the potential splay locations and recency of faulting closer to the mine site.

**Seismic Hazard Analyses**—The TSF embankments at the mine site would be regulated as Class I (high) hazard potential dams under the ADSP draft dam safety guidelines (ADNR 2017a; PLP 2017). Based on these draft guidelines, two levels of design earthquake must be established for Class I dams (see Table K4.15-7):

- *Operating Basis Earthquake* (OBE) that has a reasonable probability of occurring during the project life (return period of 150 to more than 250 years), for which structures must be designed to remain functional, with minor damage that could be easily repairable in a limited time. In other words, minor damage within allowable design criteria may be sustained at the TSF embankments following an OBE earthquake.
- *Maximum Design Earthquake* (MDE) that represents the most severe ground shaking expected at the site (return period from 2,500 years up to that of the Maximum Credible Earthquake [MCE]), for which structures must be designed to resist collapse and uncontrolled release.

The size of an earthquake that can be expected is related to its return period, or how often it would occur. Moderate to large earthquakes (such as the OBE) occur occasionally and can be expected to occur during the life of the mine. Very large earthquakes occur very infrequently (with long return periods), but it is protective to consider them as the MDE that dams would have to withstand. Earthquake(s) selected for the MDE control the design of the dams, not the more frequent OBE.

The OBE can be defined based on probabilistic evaluations, with the level of risk (probability that the magnitude of ground motion would be exceeded during a particular length of time) being determined commensurate with the hazard potential classification and location of the dam (ADNR 2017a). The MDE may be defined based on either probabilistic or deterministic evaluations, or both (ADNR 2017a).

Ground shaking from earthquakes is typically presented in terms of peak ground acceleration (PGA), measured as a fraction (or percent) of gravity (g), which represents the initial intensity of an earthquake as it is applied to a structure, such as the TSF embankments. The degree of ground shaking and structural damage expected is related to earthquake magnitude, distance from active faults, and duration of shaking. For example, small local earthquakes may cause more ground shaking than large, more distant earthquakes; and large distant earthquakes with a lower PGA but longer shaking duration may cause more damage than smaller nearby earthquakes with a higher PGA. Therefore, the selected OBE or MDE may be based on more than one earthquake scenario. Several potential earthquakes were evaluated in the probabilistic and deterministic seismic hazard analyses to develop the OBE and MDE (see Appendix K4.15).

A conservative OBE corresponding to a return period of 475 years was adopted for the Pebble TSF designs (Knight Piésold 2019d). Based on the probabilistic seismic hazard analysis (see Table K4.15-8), the estimated PGA associated with this return period is 0.16g (or 16 percent of gravity acceleration).

The MCE was selected as the MDE for the Pebble TSFs (Knight Piésold 2019d). Based on the results of the deterministic seismic hazard analysis (see Table K4.15-9), earthquake magnitudes and ground shaking associated with the MCE considered in TSF embankment design include:

- A magnitude 6.5 shallow crustal earthquake from an unknown fault assumed to occur directly beneath the mine site, with a PGA of 0.56g.
- A magnitude 8.0 intraslab subduction earthquake (similar to the source of the magnitude 7.1 Anchorage earthquake on November 30, 2018), with a PGA of 0.61g.
- A magnitude 7.5 earthquake on the Lake Clark fault, with a PGA of 0.32g.
- A magnitude 9.2 megathrust earthquake with a PGA of 0.16g.

As noted above, one of the four MCEs selected for the MDE of mine site embankments is on a similar seismic source to that which caused the November 30, 2018 Anchorage earthquake. Dam inspections conducted in the region following the Anchorage earthquake indicate results ranging from no damage to minor cracking (Cobb 2019), which is similar to expectations following an OBE. The mine site embankments would be designed to withstand an MCE from the same intraslab subduction zone source, but nearly 10 times larger than the Anchorage earthquake.

The selection of four earthquake scenarios as MCEs to be considered in embankment design appears to be appropriate and conservative for site conditions. Appendix K4.15 provides further discussion of the seismic sources, ground motion models, and probabilistic and deterministic evaluations completed for the project to evaluate potential ground shaking associated with these earthquakes. Response spectra that show how ground shaking changes with time during each of the MCEs are also provided in Appendix K4.15 (see Table K4.15-10 and Figure K4.15-12). As described below under Seismic Deformation Analysis, the four earthquakes were used as input to preliminary seismic (pseudo-static) stability analyses for the major embankments at the mine site.

The probabilistic and deterministic seismic hazard analyses would be updated in final design, incorporating best practices for analysis and updated US Geological Survey (USGS) ground motion data as available (PLP 2018-RFI 008c; PLP 2019-RFI 008h). Further analyses of the effects of these earthquakes on the embankments would include compiling acceleration time-history records from past earthquakes that match each of the MCEs, which would be used as inputs to model the behavior of the embankments during the full duration of ground shaking in a maximum earthquake (see Chapter 5, Mitigation).

**Preliminary Seismic Deformation Analysis**—Preliminary pseudo-static deformation analyses were completed to predict the response of the major mine site embankments to a seismic event, based on MCEs from the four potential seismic sources (faults) noted above, with magnitudes ranging from 6.5 to 9.2. The input parameters, methods, and results from these analyses are provided in PLP 2019-RFI 008g, -RFI 008i, and -RFI 130, and are summarized in Appendix K4.15.

As shown in Table 4.15-2, predicted displacements from the preliminary analyses ranged from negligible (less than 0.03 foot) to 0.23 foot for the open pit WMP under the deep intraslab earthquake scenario, although displacement estimates are minimal in either case, and would not affect the integrity of the structure.

The current design of the mine site embankments is considered conceptual, and the pseudo-static results are considered preliminary. As described in Appendix K4.15, the pseudo-static method and input parameters used do not consider pore pressures, site-specific weak zones in the foundations, dynamic response of the embankments for the full length of ground shaking, or additive effects from aftershocks, and do not provide estimates of crest settlement; therefore, uncertainties regarding these factors remain. As described in Chapter 5, Mitigation, and below under Numerical Modeling, additional seismic stability analyses and crest deformation estimates would be completed and updated for each embankment structure as design progresses and additional field data are collected to support the understanding of geotechnical and hydrogeological conditions. The estimated crest deformation/settlement values would be added to the minimum freeboard requirements for the embankments, so that the minimum required freeboard would be maintained after the MDE event.

**Table 4.15-2: Preliminary Seismic Stability Analysis Results for Mine Site Embankments**

| MCE Earthquake Magnitude (M), Source | PGA[1] | Downstream Deformation ($D_{84\%}$ in foot)[2,3] | | | | | |
|---|---|---|---|---|---|---|---|
| | | Bulk TSF Main | | Bulk TSF South | Pyritic TSF North | Main WMP | Open Pit WMP |
| | | Buttressed-Centerline Construction[4] | Downstream Construction[5] | | | | |
| M9.2, Megathrust | 0.16 g | Negligible, <0.03 | Negligible, <0.03 | Negligible, <0.03 | Negligible, <0.03 | Negligible, <0.03 | Negligible, <0.03 |
| M8.0, Deep Intraslab | 0.61 g | 0.07 | Negligible, <0.03 | Negligible, <0.03 | Negligible, <0.03 | Negligible, <0.03 | 0.23 |
| M7.5, Lake Clark Fault | 0.32 g | Negligible, <0.03 | Negligible, <0.03 | Negligible, <0.03 | Negligible, <0.03 | Negligible, <0.03 | 0.03 |
| M6.5, Background | 0.56 g | 0.07 | Negligible, <0.03 | Negligible, <0.03 | Negligible, <0.03 | Negligible, <0.03 | 0.20 |

Notes:
[1] Measured as a fraction of gravity, g
[2] Based on the pseudo-static method of Bray and Travasarou (2007)
[3] $D_{84\%}$ = maximum estimated displacement along slip surface at 84% confidence level
[4] Alternative 1a, Alternative 1, and Alternative 3
[5] Alternative 2
M = Earthquake Magnitude
MCE = Maximum Credible Earthquake
PGA = Peak Ground Acceleration
TSF = Tailings Storage Facility
WMP = Water Management Pond
Source: PLP 2019-RFI 008g, -RFI 008i, and -RFI 130

**Post-Liquefaction Analysis**—As noted above, the bulk TSF main embankment design would result in a serrated near-vertical upstream face at the dam crest for the upper 280 feet of the embankment that would partially rest on tailings. The potential for this configuration to liquefy was initially reviewed by geotechnical, tailings, and dam subject matter experts (SMEs) during the EIS-Phase Failure Modes and Effects Analysis (FMEA) (AECOM 2018l). As discussed, the stability analysis results rely mostly on the strength of rockfill materials directly beneath and downstream of successive raises in the core zone and buttresses versus on the strength of the tailings (see Figure 2-8). In other words, regardless of the low strength assigned to the tailings, the overall embankment did not fail in a downstream direction. Therefore, the SMEs concluded that the likelihood of global instability of the buttressed centerline embankment design would be very low.

Additional preliminary stability analyses were subsequently conducted on the bulk TSF main embankment to further evaluate the potential effects of tailings liquefaction on embankment stability. The methods, input parameters, and results of these analyses are provided in Knight Piésold (2019p) and PLP 2019-RFI 008g, -RFI 008h, and -RFI 130, and are summarized in Appendix K4.15.

As shown in Table K4.15-11, three cases evaluated stability in an upstream direction from the portion of embankment rockfill that is centerline-raised on top of tailings beach material, and six cases evaluated the effect of tailings liquefaction on global embankment stability in a downstream direction. The different cases looked at the effects of: 1) reducing the volume of tailings post-liquefaction due to expulsion of porewater and contraction of the solid particles; 2) varying the depth of liquefaction from 100 feet to the full depth of the tailings; 3) increasing the phreatic surface by assuming that the engineered filter zone is fully blocked; 4) evaluating a slip surface that extends through both the tailings and about half of the embankment; and 5) downstream construction (versus modified centerline).

In all upstream cases, tailings liquefaction would result in some deformation of the embankment rockfill, particularly the upstream edge of rockfill that is constructed on top of the tailings beach. Based on these simulations, the deformations are expected to be constrained in the upstream zone of the dam due to the blocking effect of the tailings, and would not compromise the overall integrity of the embankment. There would be some near-surface deformation effects in the tailings, but their movement in an upstream direction would be limited by the tailings mass in the impoundment. In all downstream cases evaluated, tailings liquefaction did not affect the global stability of the embankment, and the FoS remained well above the target of 1.2 (selected based on Canadian Dam Association [CDA 2014] guidelines).

The current design of the bulk TSF main embankment is considered conceptual, and the post-liquefaction results preliminary. Several sources of uncertainty in these analyses were identified in an independent review by AECOM (2019n). These include the unknown ability of the thickened tailings to segregate into a coarse fraction at the tailings beach, and ensure proper drainage (reduction of the phreatic surface) through the upstream embankment shell and engineered filter zone; the stability of the embankment in the event of liquefaction under static conditions, and during the full duration of ground shaking; methods that take pore pressures into account; additional cases with slip surfaces through both the tailings and embankment; and additional cases that evaluate shallow phreatic surfaces, including where drainage is impeded throughout the downstream rockfill shell.

Given the uncertainties described above, conclusions that post-liquefaction stability would remain above the target FoS are preliminary, and would require additional analysis in the future to demonstrate with confidence. It is acknowledged that some of these analyses can only be completed using numerical modeling techniques, which PLP has committed to completing as design progresses (as described below and in Chapter 5, Mitigation). Recommendations are provided in Appendix M1.0, Mitigation Assessment, for incorporating the above uncertainties into the future liquefaction stability analyses. Further mitigation measures or design changes may be warranted to reduce uncertainties and improve stability, and could be implemented as the design proceeds through ADSP permitting reviews.

**Numerical Modeling**—The above seismic stability analyses are considered preliminary. As described in Appendix K.4.15, dynamic response analyses using numerical modeling methods would be required to further evaluate potential amplification of seismic waves as they propagate through the foundation material, tailings deposit, and embankments. The application of numerical modeling to the design at its current stage would be inappropriate, because it would rely on ongoing geotechnical analyses and State permitting reviews that have not yet been completed. As described in Chapter 5, Mitigation, PLP has committed to conducting additional detailed modeling, including deformation, settlement, and liquefaction analyses, as well as additional geotechnical investigation and tailings testing to refine input parameters, as part of the ongoing design of the TSFs and other embankments. Additional detailed modeling, including analyses using Fast Lagrangian Analysis of Continua (FLAC) numerical modeling software, would be completed during detailed design of the facilities to better define embankment displacement estimates (PLP 2018-RFI 008a; PLP 2019-RFI 008g).

**Post-Closure Phase**—As described in Appendix K4.15, the mine site embankments would be designed to withstand an earthquake with a return period up to 10,000 years. Preliminary static, pseudo-static, and post-liquefaction stability analyses have been completed based on end-of-operations conditions when the pond, tailings, and phreatic surfaces would be at their maximum or highest condition. Given that tailings would continue to consolidate, runoff from the closure cover would be promoted, infiltration restricted, and the phreatic surface would drop over time; the results of these analyses are expected to be protective of conditions following closure (PLP 2019-RFI 008g, -RFI 130). As described in Chapter 5, Mitigation, stability and seepage analyses specific to the closure conditions of the facility would be conducted during detailed closure design and would include an independent panel review. These analyses would be updated as required under State permitting throughout the latter stages of operations. Regular mass stability and seepage monitoring would continue throughout closure (PLP 2019-RFI 130; PLP 2019-RFI 135).

**Monitoring and Emergency Action Plan (EAP) Requirements**—As described in Appendix K4.15, monitoring would be included in all phases of the life of the mine site embankments. This would include construction quality assurance and control plans to assure that the embankments are built according to approved designs; an Operations and Maintenance (O&M) manual describing water management procedures, monitoring, and embankment inspections; and monitoring for mass stability and seepage after closure. An EAP would be prepared per draft ADSP guidelines that would include a dam break analysis with inundation maps and a description of actions to be taken in the event of a dam failure.

**Summary of Stability Effects**—As described in Section 4.1, Introduction to Environmental Consequences, NEPA requires that potential effects of a project be analyzed in relation to certain factors such as magnitude, duration, extent, and likelihood. The following summary is intended to provide a description of mine site geohazard effects on embankment stability in terms of these factors and is not intended to be a summary of technical engineering and design issues. Due to the conceptual stage of design, the stability analyses described above are considered preliminary, and would require additional analyses in the future to demonstrate with confidence. Uncertainties that remain are described above and in Appendix K4.15, along with mitigations such as future detailed analyses that would be conducted as design progresses to reduce uncertainties.

The magnitude of direct effects on mine embankments from earthquakes, floods, static loading, slope failure, and foundation conditions could range considerably, and are directly related to the likelihood of occurrence. Effects may not be measurable where designs are adequate for expected geohazards with a moderate likelihood of occurrence, such as embankment displacements from moderate earthquakes, large precipitation events, or known unstable foundation conditions that are removed in construction. In terms of duration, effects in the event of an OBE could include damage that would be repairable in the short-term (e.g., months). In the event of an MDE, effects could range up to damage that would not be easily repairable, but would not be expected to lead to structural collapse or uncontrolled release of contaminated materials. Assuming that facilities are planned, designed, constructed, operated, maintained, and surveilled as proposed, in terms of extent, potential damage to facilities and indirect effects on the environment would be expected to remain within the footprint of the mine site. As described in Chapter 5, Mitigation, PLP would establish an independent review board to review embankment designs and stability analyses as engineering analysis progresses.

The duration of effects would vary depending on the facility and likelihood of geohazard occurrence. In the case of earthquake damage that would be easily repairable, impacts would be infrequent, but not longer than the life of the mine for facilities that would be removed at closure (e.g., embankments at the pyritic TSF). Impacts could occur in perpetuity for structures that would remain in place (e.g., bulk TSF embankments). Based on the conceptual designs, and assuming current standard of engineering practice would be followed, the likelihood of global instability of the major embankments was considered to be very low (i.e., less than 1 in 10,000 probability) by geotechnical experts in the EIS-Phase FMEA (AECOM 2018l). Indirect effects on other downstream resources in the unlikely event of an embankment spill or release are discussed in Section 4.27, Spill Risk.

## Open Pit Slopes

Unstable pit slopes could lead to operations disruptions, safety hazards to workers, or potential slumping of the pit rim in closure. The location of the water table with respect to the open pit slopes is an important factor in determining their stability during operations and closure. During operations, the water table would be kept back away from the slopes through groundwater pumping or active drains to maintain stability for active mining operations. During closure, dewatering pumps would eventually be turned off, and the water table and pit lake would rise.

**Slope Stability Modeling**—Numerical modeling was completed by SRK (2012, 2018c, 2019b) and PLP (2018-RFI 023a, 2019-RFI 023b) to predict the stability of four sections of the open pit walls with known weak rock conditions under five water table scenarios in late operations, early closure, and post-closure (Table 4.15-3, Figure K4.15-14, and Figure K4.15-15). As described in Appendix K4.15, the analyses evaluated both static and seismic conditions, and included modeling of disturbance factor zones that represent the predicted bedrock damage caused by blast damage, as well as rock mass relaxation[8] and crustal rebound[9] due to the excavation of the open pit (Hoek 2012). Long-term chemical weathering was taken into account in the assignment of rock strengths (SRK 2019b). The modeling targeted a minimum acceptable FoS for the open pit walls of 1.3 for static conditions, and 1.05 for dynamic (earthquake) conditions. These values recognize that there would only be a single entry into the pit, and any instability involving the ramp could impact the operations. After closure, the target FoS for static conditions would be reduced to 1.1 due to the lack of access required into the pit, but this would be further reviewed during detailed design.

[8] **Rock mass relaxation** is the unloading of rock stresses due to the removal of bedrock (e.g., underground mines and/or open pits).

[9] **Crustal rebound** is the rise of a land mass due to removing an overlying weight or mass, such as excavating bedrock during open pit mining, which could be significant enough to be measurable, and therefore included in the computer modeling.

In terms of magnitude, the modeling results (Table 4.15-3) showed an FoS greater than target values for three of four pit sections (B through D), indicating they would be stable under both static and earthquake loadings. An FoS below target values (indicating potentially unstable conditions) was determined for Section A through the northwestern side of the pit under both static and dynamic loadings in early closure after dewatering ceases ("pumps off" scenario in Table 4.15-3), but before the lake has risen. The unstable results for Section A are associated with weak rock near faults in the lower part of the pit. The results of the continued "active drains" scenario in early closure (see Figure K4.15-16) suggest that with continued depressurization in the localized area of Section A during early closure activities (e.g., backfilling), the pit wall would be stable. The results of the half-full pit lake scenario (see Figure K4.15-17) indicate Section A would be stable after the lake provides a buttressing effect on the lower slopes.

**Table 4.15-3: Pit Wall Stability Modeling Results**

| Section | Operations EoM | Early Closure Phase 1—Active Drains | Closure Phases 1 and 2—Pumps Off | Closure Phase 2—Half Pit Lake | Closure Phases 3 and 4—Final Pit Lake | Operations EoM | Early Closure Phase 1—Active Drains | Closure Phases 1 and 2—Pumps Off | Closure Phase 2—Half Pit Lake | Closure Phases 3 and 4—Final Pit Lake |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Static FoS** | | | | | **Dynamic[1] FoS** | | | | |
| A | 1.3 | 1.3 | **0.8**[2] | 1.4 | 1.4 | 1.2 | 1.3 | **0.7** | 1.4 | 1.4 |
| B | 1.6 | 1.6 | 1.4 | 1.4 | 1.9 | 1.4 | 1.4 | 1.2 | 1.2 | 1.7 |
| C | 1.4 | 1.4 | 1.2 | 1.2 | 2.2 | 1.2 | 1.2 | 1.1 | 1.1 | 2.0 |
| D | 1.4 | 1.4 | 1.4 | 1.3 | 1.4 | 1.2 | 1.2 | 1.2 | 1.2 | 1.1 |

Notes:
[1] Dynamic stability due to earthquake loading, based on a PGA of half 0.14 g (similar to 1-in-475-year earthquake, Table K4.15-8); use of half PGA derived from documented experiences at open pit mines (Read and Stacey 2009; Azhari 2016).
[2] Bold = potential unstable condition
EoM = end of mine
FoS = factor of safety
Source: PLP 2019-RFI 023b

**Sensitivity Analyses**—Sensitivity analyses were conducted that evaluated effects on pit wall stability from: 1) increasing earthquake ground shaking levels; and 2) reducing rock strength parameters. These were conducted only on the scenario in Table 4.15-1 with the worst results (i.e., after dewatering ceases ["pumps off" scenario]), but before the lake has risen. The results of increasing ground shaking levels (see Table K4.15-14) indicate that in addition to the unstable condition at Section A during early closure described above, Section D reaches an unstable FoS (below the target criteria of 1.05) at ground shaking levels above a PGA of 0.20g, which is roughly equivalent to the 1-in-1,000-year earthquake (see Table K4.15-8).

Results of reducing the rock strength input parameters in the model by 25 percent showed the potential for increased risk of movement associated with a fault zone higher up in Section A. The approximate area of potential instability reaches about 650 feet back from the pit rim (see Figure K4.15-18 and Figure K4.15-19) and could affect soils and wetlands in this area. The risk of failure along Section A would be highest during the Phase 2 closure period, when the water table is rebounding, but before the lake provides additional buttressing capacity above the backfilled material. This period of time is estimated to be about 15 years in early closure. The results are considered conservative in that they do not take into account the buttressing effect of approximately 1,000 feet of backfilled tailings and waste rock that would be placed in the pit as the water table rebounds (Knight Piésold 2018d: Figure 5.1), although about 450 feet of Section A weak rock would remain exposed above the final lake level without any dewatering or buttressing by the lake. Additional effects from physical weathering (freeze/thaw) could include sloughing at bench crests and inter-ramp slopes but are not expected to result in deep-seated failure (SRK 2019b).

**Landslide-Induced Pit Lake Wave**—An analysis was conducted to examine the effect of a potential earthquake-induced landslide into the full pit lake in post-closure, and the likelihood that such an event could create a tsunami wave that overtops the pit rim. Tsunamis were computed for two potential landslide scenarios, along Section A and Section D (see Figure K4.15-14), selected because they exhibited the lowest FoS' in the dynamic (seismic) stability analysis in Table 4.15-3 for the full pit lake scenario. The methods, input parameters, and results of the tsunami modeling are presented in AECOM (2019p, 2020) and described in Appendix K4.15. Initial maximum wave amplitudes of about 300 feet (see Figure K4.15-20) were estimated and propagated across and around the lake in the model. These do not overtop the rim, although they reach close to the rim in the slide scenario for Section A.

## Other Geohazard Considerations

**Quality Assurance/Quality Control (QA/QC)**—A Construction QA/QC Plan would be developed to assure all quarries, embankments, impoundments, and liners are constructed and operated in accordance with the approved designs and specifications. The plan would specify actions for approving embankment materials, construction methodology, field testing, surveying, monitoring, and documentation. ADNR (2017a) guidelines provide details on plan requirements, personnel responsible for QA/QC, key inspection items, and required post-construction document submittals.

**Mining-Induced Seismicity**—Induced seismicity refers to earthquakes and tremors that are thought to be caused by human activity through altering the stresses and strains in the earth's crust. Mining-related activities such as rock mass relaxation, crustal rebound, blasting associated with the excavation of an open pit, dewatering that can reduce load on faults and weaken them, introduction of fluid pressure such as a pit lake, and mass shifts such as rock removal from an open pit or accumulations behind dams, have the potential to generate induced seismicity. Induced seismicity can be associated with altering subsurface porewater pressure in a region known to be cross-cut by faults, as is the case at the Pebble open pit, whether they are active or not. Because some of these are opposing effects (e.g., dewatering versus increased pore pressure), they are complex conditions that are difficult to predict (Klose 2012; McGarr et al. 2002).

The USGS (2018f) compiled a list of mining-related induced seismicity in the US over the 27-year period between 1973 and 2000, during which there was a total of 47 seismic events attributable to mining-related induced seismicity. The recorded tremors were generally small, ranging in magnitude between 2.0 and 4.8. One of the events occurred at the Usibelli Coal Mine in Alaska, with a magnitude 3.3 attributed to blasting, and possibly concurrent rock mass relaxation. Like the Pebble mine site, Usibelli Coal Mine is an open pit operation situated in a seismically active area (WSM 2018). Induced seismicity has been reported in areas of open pits or quarries in the range of less than magnitude 2.5 to 4.6, and higher levels have been documented at large impounded reservoirs in the range of magnitude 4.3 to 6.5 (McGarr et al. 2002).

The open pit slope analysis above assumed seismic conditions that are greater than the highest-magnitude mining-related induced seismic event cited above. For example, the highest ground shaking used in the pit wall seismic sensitivity analysis was 0.30g (see Table K4.15-14), which is roughly equivalent to an earthquake of magnitude 7.5 on the Lake Clark fault (see Appendix K4.15, Table K4.15-9). In addition, the pseudo-static (seismic) stability analysis performed in support of the mine site design (Table 4.15-2) took into consideration unknown shallow crustal earthquakes (Knight Piésold 2019d) up to magnitude 6.5, which is similar to how a large mining-related induced seismic event would likely behave.

**Seismic Impacts on Contact Water Pipelines**—The EIS-Phase FMEA reviewed the likelihood of a release occurring at the mine site in the event of rupture of a contact water pipeline during an earthquake. These are discussed in AECOM (2018l) and in Section 4.27, Spill Risk. The possibility that such an event could shut down the bulk TSF main SCP reclaim pipeline in post-closure and cause the SCP to fill to the point of overflowing is analyzed in PLP 2019-RFI 130 and described in Appendix K4.15. Based on a range of inflow (dry to wet) and starting water level conditions, it could take anywhere between 3 weeks and 15 months for the SCP to reach capacity after a reclaim pipeline shutdown. As described in Chapter 5, Mitigation, personnel and redundant equipment would be maintained on site throughout post-closure, so that repairs could be conducted as needed (PLP 2019-RFI 130).

**Seismic Impacts on Hydrogeology**—The potential exists for impacts on hydrogeology resulting from a seismic event, such as changes in groundwater levels, volumes, chemistry, and the location of seeps. However, these types of changes also commonly occur in the absence of seismic events due to other factors such as weather conditions (e.g., precipitation, temperatures) and changes in water chemistry (e.g., precipitation of naturally occurring constituents and/or bacteria in the water).

Groundwater conditions would be monitored throughout all stages of the mine project for both flow and chemistry purposes (PLP 2019-RFI 135; PLP 2019g) (see Section 4.17, Groundwater Hydrology, and Section 4.18, Water and Sediment Quality). The ADSP draft dam safety guidelines include a requirement for an “extraordinary inspection” for impacts if a major earthquake were to occur during project operations (ADNR 2017a). The O&M manual also has specific requirements regarding inspections after a major earthquake. The inspection would identify adherence to design criteria for all major structures to ensure they continue to perform as designed. Changes to the groundwater monitoring program, facility design, and/or operation would be implemented as necessary to ensure protection of the environment.

### 4.15.3.2 Transportation Corridor

#### Earthquakes—Surface Faulting and Ground Shaking

The transportation corridor would not cross any known active surface faults (see Section 3.15, Geohazards and Seismic Conditions, Figure 3.15-1). Possible splays of the Lake Clark fault cross the mine access road between the mine site and Eagle Bay terminal (see Figure 3.15-2), and a trace of the Bruin Bay fault zone crosses the port access road within several miles of the Amakdedori port site. However, there is no evidence of Holocene offset at the surface at these locations (Haeussler and Waythomas 2011; Hamilton and Klieforth 2010; Koehler 2010; Koehler et al. 2013; Plafker et al. 1994). Therefore, effects on the road from surface fault displacement are considered unlikely to occur.

As described in Section 3.15, major earthquakes can cause liquefaction along the road corridor in areas of shallow groundwater and liquefiable-type sediments such as silty fine sands. Effects could be like those of the November 2018 Anchorage earthquake, in which a number of roads experienced effects such as buckling, lateral spreading, cracking, ground settlement, and roadbed collapse. These effects could occur at drainages described in Section 3.18, Water and Sediment Quality, as having fine sand and silt substrates along the mine and port access roads and could cause temporary disruption in operations until repairs can be made.

Earthquakes can also cause damage to bridges such as shearing of pilings from liquefaction, settlement, or lateral spreading (Ledezma et al. 2011). However, these types of effects are unlikely to occur at the Newhalen and Gibraltar river bridge crossings, because these drainages contain incised bedrock and boulder-cobble substrates and banks that are not likely to be subject to liquefaction (PLP 2019e, 2020d).

The magnitude of impacts on ferry terminals from ground shaking in the event of a major earthquake would include direct effects such as cracking, spreading, and settlement of terminal platforms, or damage to the ferry during construction. However, because the terminals would not include fuel tank storage facilities, indirect effects on the environment from tank rupture would not be expected.

## Seiches and Tsunamis

Earthquake-induced seiches can damage shoreline structures, boats, and moored vessels in enclosed waterbodies, particularly if the natural period of a moored ship matches that of a seiche (Kabiri-Samani 2013). The historical occurrence of seiches in Iliamna Lake is unknown (see Section 3.15, Geohazards and Seismic Conditions) (PLP 2018-RFI 013). In terms of magnitude, seiches several feet high have been documented in Southeast Alaska and in harbors in the Pacific Northwest during past major Alaska earthquakes (McGarr et al. 1968; Barberopoulou et al. 2004; CBJ 2018). However, seiches are more likely to occur in these narrow bodies of water than in Iliamna Lake. A preliminary estimate of seiche potential in Iliamna Lake was conducted based on a 60- by 15-mile area representing the wide part of the lake where the ferry would operate under Alternative 1a (AECOM 2018d). The results indicate the natural oscillation period of an earthquake-induced seiche would fall well outside the period range where earthquake ground motions carry the most energy, suggesting that earthquake-induced seiches would not be expected to occur, or would be on the order of inches. In comparison, wind waves on Iliamna Lake have been documented up to about 6 feet (USACE 2009a).

Tsunamis could also occur in Iliamna Lake from an earthquake-triggered landslide. Examples of landslide-induced tsunami predictions for other inland waterbodies in Alaska include Bradley Lake on Kenai Peninsula and Lynn Canal at Skagway, where wave heights of 10 to 20 feet have been suggested (CASA 1982; Stone & Webster 1987). Well-known rockslide-induced tsunamis with runups well over 100 feet have been documented in saltwater on Uminak Island and Lituya Bay, Alaska (Rozell 2019; Ward and Day 2010).

Although steep slope deposits do not occur near any of the Iliamna Lake infrastructure under Alternative 1a, earthquake-triggered landslides may be possible along coastal areas at the eastern end of the lake, where steep slope deposits occur along Knutson and Pile bays, and potentially steep underwater delta deposits have built up near the mouth of Pile River (Higman and Riordan 2019). A landslide-induced tsunami originating in these areas would be expected to dissipate to the west, as the lake widens away from enclosed bays and islands, which can reflect and trap wave energy locally. Recommendations are provided in Appendix M1.0, Mitigation Assessment, to further evaluate the likelihood of a landslide-induced tsunami originating in the eastern end of the lake to affect the Eagle Bay terminal.

Tsunamis could also occur in Iliamna Lake from underwater fault offset or tectonic tilting, although the likelihood of these occurring is considered less than that of a landslide-induced tsunami. Active faults have not been mapped crossing Iliamna Lake (see Figure 3.15-1). Uncertainties regarding the recency of activity on the closest potentially active fault to Iliamna Lake, the Lake Clark fault, are discussed above under Mine Site, and in Section 3.15 and Appendix K4.15, Geohazards and Seismic Conditions. The potential for tectonic tilting during a magnitude 9 megathrust subduction zone event (similar to the 1964 earthquake) was estimated based on the USGS Slab2 geometric model (Hayes 2018). Tilting during such an event is predicted to be minimal in the Iliamna Lake area (uplift on the order of 1 foot or less) due to the depth of the megathrust in this area (see Figure K4.15-11).

## Unstable Slopes

In terms of potential extent of impacts from unstable slopes, several small areas of unstable slope deposits occur along the mine access road: about 2 miles and 6 miles east of the mine site, 3 to 6 miles west of the Newhalen River bridge, on the southern side of Roadhouse Mountain near Eagle Bay, and the southern end of the port access road (see Section 3.15, Geohazards and Seismic Conditions) (Detterman and Reed 1973; Hamilton and Klieforth 2010). Over-steepened, potentially unstable slopes could also be created during the development of the geologic material sites. Landslides can be triggered by earthquakes, exacerbated by precipitation increases caused by climate change, and can cause downstream effects from erosion and sedimentation (e.g., Fan et al. 2019). As described in Appendix K3.1, Introduction to Affected Environment, traditional ecological knowledge (TEK) suggests that increased precipitation and freeze-thaw events have been occurring in the region due to climate change, which could cause increased erosion or risk of landslides along these areas of the transportation corridor.

Typical engineering and construction practices such as engineered cuts, benching, and drainage controls (see Chapter 2, Alternatives, Figure 2-20) would be used at these locations to minimize the potential for landslide impacts on the roads, material sites, and disruption of truck haulage. Therefore, if such effects were to infrequently occur, the duration and extent of impacts on the project and related effects on environmental resources would be easily repairable in the short-term, and of limited extent in the immediate vicinity of the road footprint.

As discussed in Section 3.15, the Eagle Bay ferry terminal location is underlain by bedrock, and the south ferry terminal location by both bedrock and surficial deposits consisting of beach and lake terrace sand and gravel, neither of which is prone to unstable slope conditions (see Figure 2-25).

Based on the topography along the road corridor of Alternative 1a, avalanches would not be expected to occur during mine operations.

### 4.15.3.3 Amakdedori Port

## Earthquakes

**Seismic Hazard Analysis**—Site-specific seismic hazard analyses were conducted for the Amakdedori port site as described in Appendix K4.15. In terms of magnitude, the predicted ground shaking at the port would be roughly double that predicted for the mine site, reflecting the closer proximity of the port to potential subduction zone earthquakes and the Bruin Bay fault (see Figure 3.15-1 and Figure 3.15-2; and Figure K4.15-10 and Figure K4.15-11). The caisson dock would be designed to withstand an OBE with a return period of 475 years, and an MDE with a return period of 2,475 years (Knight Piésold 2013; PLP 2020-RFI 160). As described in Table K4.15-14, an MDE with this return period would have a PGA of 0.51g at the Amakdedori port site based on the probabilistic analysis. The deterministic analysis (see Table K4.15-15) shows that the biggest contributors to seismic hazard at the port site are the Bruin Bay fault, with a maximum credible acceleration of 1.04g, and the deep intraslab subduction event (similar to the source of the November 2018 Anchorage earthquake) with a PGA of 0.96g.

The type of damage that could occur on a caisson structure during an earthquake might be similar to that experienced during the 1995 Kobe, Japan earthquake (magnitude 7.2), in which concrete caisson walls were among the port structures affected. Ground shaking during the Kobe, Japan earthquake was similar to that predicted for the MDE at Amakdedori (PGA of about 0.5g). The

Kobe structures experienced displacements up to 10 feet laterally and 6 feet vertically due to caissons tilting and pushing out foundation soil, which consisted of imported loose decomposed granite (Nozu et al. 2004).

Caissons are routinely used in high seismic areas throughout the coast of California, Washington, and British Columbia, such as at the Deltaport and Roberts Bank terminals in the Vancouver, BC area, where designs consider loading from seismic accelerations and supporting ground conditions (PLP 2020-RFI 160). As described further below, ground shaking estimates from the seismic hazard analyses are typically used as input to stability analyses to identify how much facility deformation would result during a major earthquake. As a result of these analyses, designs are modified as projects progress to final design to avoid the possibility of global stability failure. As described in Chapter 5, Mitigation, the seismic hazard analyses would be updated in final design, and the geometry and location of the Bruin Bay fault relative to the port site would be further evaluated to refine the deterministic analysis (Knight Piésold 2013, 2019d; PLP 2018-RFI 008c).

In the event of major earthquake damage that temporarily disrupts operations at the port, emergency supplies and equipment would be transferred to onshore infrastructure by landing on Amakdedori beach with a barge or landing craft (PLP 2020-RFI 160).

**Container Toppling**—It is possible that stacked containers at the port could topple over in a major earthquake and rupture, releasing some of the concentrate. The likelihood of this occurring is considered relatively low, similar to the return periods of major earthquakes at the port site. No toppling effects were reported from stacked containers at the Port of Alaska during the November 2018 magnitude 7.1 Anchorage earthquake, in which PGAs of about 0.3g were recorded near the port (Walker and Murren 2019). This would be similar to the shaking predicted for a 1-in-475-year earthquake at Amakdedori (see Table K4.15-14). In other words, it would likely take a major earthquake with lower likelihood of occurrence to create a toppling hazard.

The concentrate containers would be 6 feet high (shorter than the industry standard of 8 feet) and would be stacked up to three containers high (shorter than the industry standard of five or six containers). Locked pins that fit the containers together would add to stability during ground shaking. In the event that toppling and container spillage does occur, effects on the environment are expected to be similar to those described in Section 4.27, Spill Risk, for concentrate spills.

**Stability of Caisson Dock**—The types of geohazards impacts that could affect the stability of the caisson dock include foundation or slope conditions, erosion at the base of the caissons, and structural instability such as tilting, cracking, or shearing as a result of seismic loading. Liquefaction of the seabed could also cause damage, although the foundation conditions at the Amakdedori site (described below) may be too coarse and inhomogeneous for liquefaction to occur. Icing and waves that would increase loading on the dock are discussed in Section 4.16, Surface Water Hydrology.

At closure, some of the port facilities would be reconfigured to support a smaller operation, with some terminal facilities and port infrastructure being decommissioned (SRK 2019d). Therefore, the duration of geohazards impacts on the dock would be long-term, lasting throughout operations and possibly into post-closure.

**Foundation Conditions**—As described in Section 3.15, Geohazards and Seismic Conditions, information on foundation materials at the dock site is limited, but suggests that subsurface deposits consist primarily of sand and gravel with shallow bedrock and buried boulders. Subsurface conditions such as buried sensitive clay layers, which are known to occur elsewhere in Cook Inlet (e.g., at the Port of Alaska) and could increase the risk of sliding failure in an earthquake, likely do not exist at the Amakdedori port site.

Additional geotechnical investigation would be conducted as the project design progresses, and would likely include completing boreholes, rock cores, in situ tests that measure density and other properties (standard penetration tests [SPTs] or cone penetrometer tests [CPTs]), and additional geophysical surveys. It is anticipated that there would be at least one CPT or SPT per caisson location along with representative boreholes along the length of the structure (PLP 2020-RFI 160).

Prior to installing the prefabricated caissons, the seafloor would be prepared to create a level compact surface by excavating 2 to 3 feet of sediment and temporarily storing it on a barge, which would be used to backfill the caissons. Although geotechnical conditions at the port site could be variable, bedrock may be sufficiently deep to allow for sediment excavation during ground preparation (Terrasond 2019).

**Stability Analyses**—The port design is currently at a conceptual level and stability analyses have not been conducted for the caisson dock. A stability analysis that takes both static and seismic loads into account would be considered state-of-practice for this type of structure in this seismic setting (Alikhani et al. 2003; Matsui et al. 2001). The marine structural design would be developed in general conformance with design and reference standards such those published by American Society of Civil Engineers (ASCE 2014, 2017a), American Association of State Highway and Transportation Officials (AASHTO 2020), and British Standards Institution (BSI 2012) for maritime works; would incorporate industry design and checking standards supervised by professional engineers; and an independent structural/quality review process to ensure conformance with applicable codes and standards (PLP 2020-RFI 160).

PLP would establish appropriate design methodology once the geotechnical program is complete. Liquefaction assessment would be completed initially to determine the type of modeling needed for assessing lateral soil spreading in the event of an earthquake. If more detailed slope stability analysis is necessary, FLAC software may be used to estimate soil movement and overall performance of the structure. Conventional geotechnical design methodologies would be used to determine other parameters applicable to design of the caisson and bridge supporting structures, such as ground-bearing capacity, lateral-slope-sliding resistance, and estimated settlement. Should the seabed conditions be found to be susceptible to liquefaction, ground improvement work would be considered during the design process (PLP 2020-RFI 160).

**Erosion Potential**—Another potential hazard is that of erosion from currents undermining the base of the caissons. Nearshore tidal and inlet circulation currents are known to occur in Kamishak Bay, as well as seafloor scour near areas of shallow bedrock (Intecsea 2019). The likelihood of scour undercutting the caisson foundation is considered low, given that ground preparation below mudline at the footprint of each caisson would partially key them into the seafloor, and adjacent sediment is expected to backfill around the base of the caissons. The addition of armoring material (e.g., rock rubble) around the foundation could also be considered, depending on the results of further analyses in detailed design.

**Environmental Effects**—Based on the prefabricated box design of the concrete caissons, release of fill material would not occur from erosion at the base, but could occur in the event of shearing or cracking of the caisson columns during a major earthquake. The fill material for the caissons would be sourced from excavated seafloor material, as well as from a local geologic materials site (blasted granitic material) or imported by ship (PLP 2018-RFI 005), and could range from sand and gravel material (the same as that present on the seafloor) to rockfill. In the event of loss of fill from the caissons, the released material could cause a temporary turbidity plume in the water column. Dock damage in the event of a major earthquake could also disrupt barging and concentrate lightering activities, potentially causing a buildup of concentrate containers at the port and ferry terminals. Additional analyses during detailed design would confirm that port construction, operations, and closure would be protective of the environment.

## Unstable Slopes

The Amakdedori port site is underlain by raised beach terrace deposits consisting of sand and gravel (see Section 3.15, Geohazards and Seismic Conditions), which are not prone to unstable slope conditions. The prefabricated concrete caissons would be constructed of different heights to account for the seafloor slope ranging from about -2 feet mean lower-low water (MLLW) at the inshore end of the trestle to about -20 feet MLLW at the offshore end of the dock (about a 1 percent slope). Because the dock and trestle would be constructed to a final elevation of +40 feet MLLW with bridge beams spanning the distance between caissons, the total height of the individual caissons would range from 44 to 63 feet (final elevation + water depth + seafloor excavation). The seafloor slope and different caisson heights would be accounted for in future stability analyses described above (PLP 2020-RFI 160).

## Tsunamis

**Predicted Runup Elevations and Probabilities**—Recent tsunami modeling for lower Cook Inlet (ASCE 2017b) predicts a run-up elevation in the Amakdedori area in the range of 26 to 30 feet above mean high water (MHW), or about 39 to 44 feet above MLLW, with potential seismically induced regional subsidence of about 1 foot, for a very large earthquake with a 2,500-year return period (PLP 2019-RFI 112a). These estimates are based on probabilistic modeling of tectonic sources (e.g., from the megathrust offshore of Kodiak Island), and do not include potential local landslide-induced sources. As discussed in Section 3.15, Geohazards and Seismic Conditions, debris avalanches on the flanks of Augustine Volcano are also estimated to be capable of generating local tsunami wave amplitudes in the range of 5 to 60 feet (Waythomas et al. 2006).

The 2,500-year return period event is the “maximum considered tsunami” in the ASCE (2017a) standards, which specify that certain structures be designed so that they can provide essential functions immediately following this event. The probability of this size tsunami occurring over the life of the port is roughly 1 in 35, assuming the port needs to be operational through closure phase 3, for a total of 70 years (20 years of operations, plus 50 years of closure). Older modeling by Crawford (1987) predicts run-up elevations in the Amakdedori area for smaller, more frequent, medium to large earthquakes (100- to 500-year events) of about 19 to 30 feet MLLW. The probability of a landslide-induced tsunami occurring over the same project life may be as high as 1 in 2, based on past frequency of Augustine Volcano debris avalanches reaching the ocean about every 150 to 200 years (Waythomas et al. 2006), although this estimate does not take into account tsunami size or directional origin (debris avalanche location around the island).

**Port Impacts Site-Specific Tsunami Design**—If unmitigated, effects from a large tsunami could include risks to worker safety, equipment, and structures, such as the fuel storage tanks, concentrate containers, caisson dock and trestle, trucks, and cranes. Damage during a tsunami could result from initial wave crushing or buoyancy failures, which can cause tipping or sliding of fuel storage and concentrate containers (Brooker 2011). The cross-sectional area of the caissons supporting the dock would be exposed to the hydrodynamic impact of a tsunami wave, and a critical loading condition would be the very low water level during the “retreat phase” of the tsunami, during which the stabilizing effect of water on the outside of the caissons would be absent or diminished. For more frequent smaller tsunamis, predicted run-up elevations would be below that of the port facilities, and the magnitude and extent of impacts on terminal facilities and related effects on the environment would be expected to be similar to waves from large storm events (see Section 4.16, Surface Water Hydrology).

The elevation of the terminal patio and caisson dock was raised to 40 feet MLLW since the Draft EIS to account for tsunami runup potential (PLP 2019b; 2019-RFI 112a). Prior to the final design phase of the project, a formal site-specific tsunami study would be conducted in accordance with ASCE (2017a) standards to provide site-specific maximum run-up, inundation, and current velocity that would be incorporated into final design. The detailed tsunami analysis would include numerical modeling of wave impacts from both seismic and volcanic sources, such as the effects from debris avalanches on Augustine Island. The final terminal elevation would be revisited in final design based on these analyses (PLP 2019-RFI 112; PLP 2019-RFI 112a).

The port diesel fuel facility would be designed to withstand the largest design event. The concrete containment barrier wall around the fuel tank farm (see Figure 2-32) would be designed to protect against tsunami run-up. The effects of potential spill releases from project facilities are discussed in Section 4.27, Spill Risk. A risk analysis would be undertaken for other port components to determine the associated risk level and associated design event. Structures would be designed to withstand tsunami forces, protect against debris impacts such as container interactions, resist uplift, and ensure that scour does not form that could undermine structures (PLP 2019-RFI 112).

In addition to design mitigation, other measures would be employed to reduce risk to personnel, such as early warning systems, vertical evacuation structures, and operational procedures and training on when to move to higher ground and secure critical equipment (PLP 2019-RFI 112).

**Impacts to Vessels**—Tsunamis can create shipping hazards such as strong currents or areas of sub-tidal rocks exposed by wave drawdown, such as those documented north of the port and offshore of Augustine Island (Intecsea 2019). Some boat damage could result from barge/wharf or barge/ship collisions if loading and lightering activities at the wharf or offshore mooring locations coincide with the arrival of a tsunami wave. However, tsunami warning infrastructure, which typically sends warnings within minutes (NOAA 2018e), may provide enough time to move vessels to avoid these impacts. Advance warning of the potential for local landslide-generated tsunamis from Augustine Volcano is expected to be longer due to tracking of volcanic activity by Alaska Volcano Observatory (AVO).

Impacts to vessels at the two lightering locations would be analyzed during the site-specific tsunami studies to understand the response if a vessel happened to be in place during an event. For the majority of potential events, the vessels would not remain moored. Operational procedures would be in place so that if volcanic activity is predicted or a tsunami warning issued, vessels would cease lightering operations and move to safer locations in deeper water (PLP 2019-RFI 112).

**Summary of Tsunami Impacts**—In relation to NEPA factors described in Section 4.1, Introduction to Environmental Consequences, the likelihood of a large tsunami occurring at the port ranges from low (i.e., 1 in 35) to moderate over the life of the port, depending on the results of future site-specific tsunami analysis that would evaluate both seismic and landslide sources. The intensity of impacts could range from minimal disruption of activities or boat damage, to terminal flooding and damage to infrastructure, although critical infrastructure such as the fuel tank farm would be expected to remain intact with mitigation in final design. Infrastructure damage would be localized in the near vicinity of the port and mooring sites. The duration of impacts could range from hours to months in the event repairs are required.

## Volcanoes

A number of active volcanoes have erupted in the last few decades within about 100 miles of the project area (see Figure 3.15-5). Of particular potential concern is Augustine Volcano, approximately 20 miles east-northeast of the Amakdedori port site. The magnitude of impacts from any of the active volcanoes could include ash clouds transported by wind, and fallout that disrupts construction and operations of project components, depending on prevailing wind direction and plume height. Volcanic ash particles are particularly abrasive, corrosive, and pervasive.

In terms of duration and extent, based on past frequency of eruptions of about 1 in 35 years (Miller et al. 1998), ashfall effects could occur once or twice over the life of the port. Impacts from a volcanic plume could affect both the port facilities and moored ships. The magnitude and extent of direct effects could include damage to equipment, engines, and compressor stations; and disruption of staffing, shipping, and fuel supplies. The duration of effects would be temporary, potentially lasting several days per incident. Ashfall effects on the project would not be expected to result in indirect effects from the facilities on other environmental resources. Typical practices to minimize the effects of an ashfall event would include a vulnerability analysis of facilities and equipment, and hazard planning.

Potential effects from volcanic debris avalanches that flow into Cook Inlet are described above under Tsunamis. The likelihood of these flows reaching the port facilities is considered low.

### 4.15.3.4 Natural Gas Pipeline Corridor

## Earthquakes and Surface Faults

As described above for the transportation corridor, the natural gas pipeline corridor would not cross any known active surface faults (see Figure 3.15-1). Therefore, direct effects on the pipeline from surface fault displacements would not be expected to occur. There is a small possibility that surface displacement could occur on faults previously unrecognized as active, such as splays of the Lake Clark fault (see Figure 3.15-2), causing rupture or other damage to the pipeline. Recommendations are provided in Appendix M1.0, Mitigation Assessment, to conduct special design for fault crossings that may be found to be active in the future.

A major earthquake could cause liquefaction in unfrozen lowlands, stream crossings, and marine areas with fine sandy soils. This condition has the potential to cause buried pipelines to become buoyant; which, if not properly accounted for in design, could lead to pipe flotation and possible damage. The loss of soil shear strength during liquefaction could also lead to permanent ground movements through lateral spreading, flow failure, and settlement. Control measures for liquefaction and buoyancy (e.g., estimation of lateral spreading, use of select compacted backfill, increased cover depth, swamp weights, and post-earthquake inspection) are considered typical state-of-practice for high-liquefaction areas so that design deflection and stress on the pipe would not be exceeded. The use of thicker-walled pipe in marine areas would also help reduce the effects of liquefaction in Cook Inlet and Iliamna Lake.

As described in Chapter 5, Mitigation, additional seismic and liquefaction analyses would be conducted during detailed design to further evaluate the design implications of possible loss of pipeline support from liquefaction (NanaWP and Intecsea 2019a). Therefore, pipe rupture and potential related environmental effects in the event of liquefaction is considered unlikely. If pipe damage were to occur, the extent would be expected to be limited to the immediate vicinity of the liquefaction. The duration of impacts would be short-term, assuming the pipeline could be repaired in a timeframe of days to months.

## Unstable Slopes

An unstable bluff roughly 200 feet high exists between the Anchor Point compressor station on Kenai Peninsula and Cook Inlet. As described in Section 3.15, Geohazards and Seismic Conditions, a recent landslide scarp lies within 100 feet of the pipeline route, and bluff retreat rates range as high as 3 feet per year near the town of Kenai. To avoid the bluff, the pipeline would be constructed using horizontal directional drilling (HDD) from the compressor station to the pipeline's emergence point on the Cook Inlet seafloor to the west.

The HDD would begin at an elevation of about 207 feet on the eastern side of Sterling Highway and drop down to an elevation of -12 feet MLLW or deeper[10] in accordance with the Pipeline and Hazardous Materials Safety Administration requirements (PLP 2018-RFI 011). (The exact water depth at which the pipeline would emerge at the seafloor has not been determined, but would be deep enough to avoid navigational hazards [(PLP 2020d]). The downslope elevation of the recent landslide lies about half-way down the vegetated bluff slope (see Figure 3.17-16), which determines how deep the slip surface goes in cross-section view. Based on the typical HDD cross-section in Figure 2-40, there would be about 150 feet of vertical distance between the base of this landslide and the HDD pipeline. Although landslide conditions could vary over time, and the actual HDD location would vary based on the actual angle it follows between entry and exit points, this example illustrates that the HDD methods would likely avoid any existing or future landslides.During the life of the project, the steep bluff at Cook Inlet would likely continue to erode and retreat landward as a result of natural causes. Bluff erosion could become more pronounced in the event of increased precipitation due to climate change; however, even at the high end of historic retreat rates reported at Kenai to the north, the bluff edge is unlikely to reach the HDD entry point hundreds of feet to the east during the project life. With the use of HDD methods, the pipeline is expected to pass well below and landward of the bluff, and avoid the unstable slope hazards (PLP 2018-RFI 011). Therefore, potential impacts on the project and related effects on the environment from this geohazard are expected to be minimal because of this avoidance.

## Coastal and Offshore Hazards

Seabed and lake bottom hazards such as movement of boulders on the seafloor, scour from tides and ice, shoreline sediment drift, uneven bottom conditions, or shifting sand waves can cause damage to submerged pipelines, as has occurred with existing oil and gas infrastructure in other areas of Cook Inlet. The minimum depth of pipeline cover above the 12-foot water depth would range from 3 to 5 feet, which would reduce potential effects from these hazards (NanaWP and Intecsea 2019b). The depth of cover west of the HDD installation location, and below the 12-foot water depth on the sides of Cook Inlet and in Iliamna Lake, would be on the order of 1 to 2 feet, which is also considered sufficient to ensure that the top of the pipeline lies below the mudline and avoids these hazards.

About an 11-mile segment of the pipeline route southeast of Augustine Island would not need to be buried to avoid seafloor hazards. This segment would be between 59 and 70 miles west of the eastern side of Cook Inlet in water depths ranging from 155 to 221 feet, which is well below the depth of ice gouge and ice-rafted boulders. Surveys in this area indicate the presence of fine- to medium-grained sand at the seafloor with no boulder fields, outcropping bedrock, or evidence of surface fault or fold deformation near the seafloor, and few third-party risks such as vessel interaction or anchoring (NanaWP and IntecSea 2019a, b). Although the potential for bottom scour was identified in this area, the heavy wall design of the pipeline is predicted to be stable based on on-bottom stability analysis using standard industry software (NanaWP and Intecsea 2019b; PRCI 2019).

In Iliamna Lake, some areas of the lake bottom with uneven terrain in water depths of 33 to 131 feet would require supporting berms to prevent pipeline damage from unacceptable free spanning (see Figure 2-46). The berms would be constructed of engineered fill and rock derived from onshore material sites. The heavy wall pipe is not anticipated to require anchoring to prevent lateral movement off the berms; although if operations monitoring indicates otherwise, mitigation

[10]An 1,800-foot HDD pipeline would exit at approximately -12 feet MLLW, while a 2,000-foot HDD would exit at approximately -18 to -24 feet MLLW. Current technology can accommodate a 2,000-foot HDD for a 12-inch-diameter pipeline (PLP 2018-RFI 011).

might include placement of concrete saddle weights or similar weighting method (PLP 2020-RFI 164).

As described in Chapter 5, Mitigation, industry best practices for inspection and maintenance, such as pigging and offshore remote surveys, would be used during construction and operations to ensure the integrity of the pipeline in the event of loss of cover or support (NanaWP and Intecsea 2019c).

## Volcanoes

Effects on the pipeline from Augustine Volcano could include flows during an eruption or debris avalanches reaching the pipeline, and areas of shallow bedrock related to past Augustine Volcano flows that could create construction and operations challenges. Ashfall impacts to aboveground pipeline infrastructure such as the compressor station could also occur from any of the active Cook Inlet volcanoes (see Figure 3.15-5). Ashfall effects would be the same as described above under Amakdedori port.

Based on a preliminary study of past debris avalanches from Augustine Volcano, a 7.5-mile standoff distance between Augustine Island and the pipeline was established to avoid this hazard. This would be confirmed in future design to quantify the probability of a debris avalanche reaching the pipeline, considering seabed gradient. As described above under “Tsunamis,” slope failure at Augustine Volcano could also trigger a tsunami, which could affect pipeline construction and infrastructure at the shore crossings (NanaWP and Intecsea 2019a).

Areas of shallow bedrock and adjacent scour have been mapped along the pipeline route southwest of Augustine Volcano. Embedment and pipeline stability may be challenging in these areas, with the potential for pipeline spans or float-up to occur, and/or pipeline walking, buckling, or vibration. Potential mitigations that could be applied include rock dumping to stabilize the pipeline, strakes (fins that reduce vibration), increased wall thickness, improved weld criteria, or coating design. As described in Chapter 5, Mitigation, additional site-specific investigation and engineering analyses would be conducted to support detailed design and mitigation plans (Intecsea 2019; NanaWP and Intecsea 2019a).

## 4.15.4 Alternative 1

### 4.15.4.1 Mine Site

Under Alternative 1, the magnitude, duration, extent, and likelihood of impacts at the mine site would be the same as those described under Alternative 1a. The following section describes impacts for the mine site that would be different under a ferry variant.

## Summer-Only Ferry Operations Variant

Under the Summer-Only Ferry Operations Variant, copper-gold concentrate would be stored in shipping containers at the mine site during the winter at a storage area northeast of the pyritic TSF (see Figure 2-59). Based on the surficial geology map (see Figure 3.13-2), the copper-gold concentrate storage area is primarily underlain by surficial glacial outwash deposits, which generally consist of a mixture of sand- to gravel-sized material. The glacial outwash appears to thin to the northeast, with possible bedrock exposed near the northeastern boundary of the storage area.

During a large earthquake, the potential would exist for the stacked shipping containers to be impacted by differential settlement of the underlying glacial outwash due to being thicker to the southwest than the northeast, potentially resulting in toppling of the containers. The likelihood would depend on the magnitude and duration of the seismic event, height of container stacking, density of foundation materials, and other factors. The impact would likely be mitigated through further investigation and foundation preparation such as compaction of near-surface materials.

### 4.15.4.2 Transportation Corridor

The effects of earthquakes and seiches on the transportation corridor under Alternative 1 would be the same as described above for Alternative 1a.

#### Lake Tsunamis

As discussed above under "Transportation Corridor" for Alternative 1a, it is possible that an earthquake-triggered landslide could occur along coastal areas at the eastern end of the lake and generate a tsunami wave. Such an event would be expected to dissipate to the west as the lake widens away from enclosed bays and islands, and would be slightly less likely to have an effect on the Alternative 1 north ferry terminal further to the west than the Eagle Bay terminal under Alternative 1a, although the likelihood of occurrence is considered low in both cases. Recommendations are provided in Appendix M1.0, Mitigation Assessment, to further evaluate the likelihood of landslide-induced tsunamis originating in the eastern end of the lake to affect the ferry terminals.

#### Unstable Slopes

In terms of potential extent of impacts from unstable slopes, several small areas of unstable slope deposits occur along the Alternative 1 mine access road: about 2 and 6 miles east of the mine site on the northern side of Koktuli Mountain (along the portion of the road corridor common to all alternatives); and near the junction between the mine access and Iliamna spur roads (see Section 3.15, Geohazards and Seismic Conditions) (Detterman and Reed 1973; Hamilton and Klieforth 2010). Over-steepened, potentially unstable slopes could also be created during the development of the geologic material sites. There are slightly fewer areas of steep slope deposits along the Alternative 1 roads as compared to Alternative 1a, because the Alternative 1 mine access road avoids the steep section near Roundhouse Mountain.

The Alternative 1 north ferry terminal location is underlain by surficial deposits consisting of beach and lake terrace sand and gravel, which are not prone to unstable slope conditions (see Figure 3.13-4; Section 3.15, Geohazards and Seismic Conditions; and Figure 2-53 and Figure 2-54). Slope conditions at the south ferry terminal and along the port access road would be the same as described under Alternative 1a.

As described above under Alternative 1a, typical engineering and construction practices such as engineered cuts, benching, and drainage controls would be used to minimize the potential for landslide impacts on the roads, material sites, and disruption of truck haulage. Therefore, if such effects were to infrequently occur, the duration and extent of impacts on the project and related effects on environmental resources would be easily repairable in the short-term, and would be of limited extent in the immediate vicinity of the road footprint.

Based on topography along the Alternative 1 road corridor, avalanches would not be expected to occur during mine operations.

#### Summer-Only Ferry Operations Variant

There would be no difference in the magnitude and extent of geohazard-related impacts under the Summer-Only Ferry Operations Variant. Differences related to lake ice hazards (for year-round versus summer-only ferry operations) are discussed under Section 4.16, Surface Water Hydrology.

## Kokhanok East Ferry Terminal Variant

As described in Section 3.15, Geohazards and Seismic Conditions, the Kokhanok East Ferry Terminal Variant location would be underlain by beach deposits near the shoreline and volcanic bedrock farther upslope. The magnitude and potential for seismic effects and unstable slope impacts would be expected to be similar to those of the south ferry terminal location west of Kokhanok (under Alternative 1a and Alternative 1).

### 4.15.4.3 Amakdedori Port

## Stability of Sheet Pile Dock

The port design for Alternative 1 would be to construct a solid earth-filled causeway leading to a sheet pile dock structure filled with granular material. An assessment of the static and seismic stability of the sheet pile dock design is presented in Appendix K4.15 and summarized below. As described above under Alternative 1a, existing geotechnical information regarding foundation materials for the offshore components at the port is limited, and suggests that subsurface deposits would consist primarily of sand and gravel, with possible buried boulders and shallow bedrock. Additional geotechnical investigation would be conducted as the project design progresses (PLP 2018-RFI 005).

The types of geohazards impacts that could affect the rockfill causeway and sheet pile dock and have the potential to result in adverse impacts to the environment include:

- Damage to the sheet pile wall during installation due to the presence of boulders or shallow bedrock in the nearshore sediment, which could result in release of fill during operations.
- Structural instability and potential failure of the sheet pile wharf as a result of seismic loading, foundation conditions, liquefaction, erosion at the base of the sheet pile, icing increasing gravity load on the sheets, and corrosion requiring regular monitoring of cathodic protection systems.

Like the caisson dock design under Alternative 1a, with additional field investigation and detailed stability analyses, the sheet pile dock could be designed to withstand geohazards impacts and be protective of the environment. In comparison to the caisson design, the sheet pile dock is more likely to be damaged during construction if boulders or shallow bedrock are present in the subsurface. The sheet pile variant is more likely to lead to a release of fill in the event of construction damage or scour around the base of the sheet pile. Depending on foundation conditions, it is possbile that the sheet pile dock could be more susceptible to instability during a major earthquake, although future seismic stability analyses are expected to mitigate these effects under either alternative. There would be less seafloor disturbance (no excavation) required prior to sheet pile dock installation, but its footprint would cover about a five times larger area of the seafloor than the caisson dock (PLP 2019b).

In the event of a tsunami, the sheet pile bulkhead would potentially have more cross-sectional area exposed to hydrodynamic and drawdown forces than the caisson design, depending on wave direction. Wave impacts and flooding of the earthfill causeway during a tsunami would be expected to cause little damage and erosion, because riprap would be used to protect the sides, and would be designed to resist tide buoyancy and storm impacts (PLP 2018-RFI 093).

With additional geotechnical investigation and stability analyses, the sheet pile dock design would be refined to address the potential for failure that could lead to adverse impacts on the environment. In the event of geohazard-related dock damage, the extent of possible fill release to the environment would generally be limited to the close vicinity of the dock footprint. As with the caisson dock, some of the port facilities would be reconfigured at closure to support a smaller operation, with some terminal facilities and port infrastructure being decommissioned (SRK 2019d). Therefore, the duration of geohazards impacts on the dock would be long-term, lasting throughout operations and possibly into post-closure.

## Stability of Pile-Supported Dock Variant

A pile-supported dock is considered as a variant under Alternative 1 to minimize in-water impacts. The pile-supported dock would be constructed on trestle and dock piles (see Figure 2-63). The footprint area of this variant would be smaller than the other designs, about 5 percent of that required for the caisson trestle and dock, and about 1 percent of that required for the sheet pile variant (PLP 2019b).

As with the caisson and sheet pile docks, detailed engineering analysis has not been completed in support of initial design. Due to the potential for shallow bedrock at Amakdedori, the piles would likely require socketing into bedrock. They may also be more susceptible to marine and icing conditions compared to other dock designs, and would likely require more maintenance, repair, and possible replacement during the project life (PLP 2019b).

The stability of a pile-supported dock is typically a function of structural design details and pile-soil interaction. The current state-of-practice is to use bending in the pile to resist lateral loads (e.g., wind, seismic, vessel impacts, and mooring loads), which may control pile embedment depths. Static stability analysis is typically conducted to determine the ability of the dock to accommodate and control maximum displacements from these loads, as well as global stability issues such as liquefaction. The survivability of a pile-supported structure in a large earthquake is generally considered better than bulkhead-type structures, which do not perform well in major earthquakes, and are difficult to repair. Sections of the existing Port of Alaska pile-supported dock in Anchorage survived the 1964 earthquake, but experienced some damage during the November 2018 Anchorage earthquake, due partly to operating well past its original 35-year design life. The dock experienced spiral weld failure near mudline and cracking of vertical seams during the 2018 earthquake, but no global failure. However, the dock may be at risk of progressive collapse in a future earthquake due to its age, corrosion, and 2018 earthquake damage (Brehmer 2019).

In terms of magnitude of impacts, the pile-supported dock would likely experience more construction difficulties due to shallow bedrock or boulders in the subsurface than the caisson or sheet pile dock designs; have metal corrosion concerns like the sheet pile dock; and ice-related impacts that could be worse due to exposure of the piles to the elements (PLP 2018-RFI 071, PLP 2019b). As with the caisson and sheet pile designs, additional geotechnical investigation and stability analysis would be performed during final design, and the results would provide a better understanding of dock behavior in response to geohazards, and how much shallow bedrock would hinder pile installation.

Based on the conceptual level of design and experience with similar structures, given appropriate maintenance attention, the likelihood of stability issues would be generally considered low with the pile-supported dock, and survivability in a major earthquake generally greater than the sheet pile dock. Unlike the sheet pile dock, the pile-supported dock would not have the potential to release fill into the marine environment as a result of geohazard-related events. In the event of potential geohazard-related impacts to the pile-supported dock, the duration of effects would range from temporary (e.g., ice loads that would be repairable) to long-term, requiring weeks or months to repair, and the extent would likely be limited to the footprint of the structure.

**Summer-Only Ferry Operations Variant**

This variant would require increased storage capacity for concentrate containers at the port during the non-summer season. Therefore, in the event of a tsunami, there could be an increased risk of container damage or movement, or debris impacts involving containers. Like Alternative 1a, the terminal would be designed to withstand tsunami forces and protect against debris impacts (PLP 2019-RFI 112).

There would be no difference in other geohazard-related impacts under this variant for this component.

### 4.15.4.4 Natural Gas Pipeline Corridor

Geohazard-related impacts for the pipeline component under Alternative 1 would have similar effects to those described for Alternative 1a.

**Kokhanok East Ferry Terminal Variant**

There would be no difference in geohazard-related impacts under this variant for this component.

## 4.15.5 Alternative 2—North Road and Ferry with Downstream Dams

### 4.15.5.1 Mine Site—Downstream Embankment

The bulk TSF main embankment under Alternative 2 would be constructed using downstream raises (see Figure 2-64 through Figure 2-66), as compared to the buttressed-centerline design under the other alternatives (PLP 2020d; PLP 2018-RFI 075). Under Alternative 2, the overall downstream slope would be 2.6H:1V, which would be the same as the buttressed-centerline-constructed embankment under the other alternatives. The upstream slope of the main embankment under Alternative 2 would be 2H:1V, versus the upstream slope under the other alternatives that would be a serrated near-vertical upstream face at the dam crest for the upper 280 feet, and partially rest on tailings (see Figure 2-8).

**Preliminary Static Stability Analyses**—As described in Appendix K4.15, the preliminary static stability analysis for the downstream-constructed main embankment calculated an FoS value on the order of 1.9 to 2.0 under static loading conditions, similar to that of the buttressed-centerline design (see Table K4.15-6), thereby offering minimal additional stability or resilience over the design in the other alternatives. A schematic section of the main embankment at its ultimate height with the predicted potential slip surface is shown in Figure 2-66.

As with the FoS values for the modified centerline embankment, the downstream embankment FoS values are considered adequate for the current conceptual levels of design, for determining low probabilities of instability, and for comparing downstream and centerline embankments. Acceptably reliable FoS values for preliminary and detailed design and final construction package purposes would be refined, based on additional geotechnical investigation of tailings and embankment fill characteristics, during the advanced preliminary and detailed stages of the designs.

The bulk TSF main embankment under Alternative 2 would be raised approximately 25 feet higher (embankment height approximately 570 feet) than the design in the other alternatives to provide equivalent bulk TSF storage capacity. The embankment fill would increase from 78 million cubic yards ($yd^3$) to 124 million $yd^3$, and the impoundment footprint area would increase by 119 acres (PLP 2018-RFI 075a). This would result in increased impacts on other resources such as material sites, substrate, and wetlands (see Section 4.13, Geology; Section 4.18, Water and Sediment

Quality; and Section 4.22, Wetlands and Other Waters/Special Aquatic Sites), but would not change the global stability of the embankment.

**Preliminary Seismic Stability Analyses**—Preliminary pseudo-static (seismic) and post-liquefaction stability analyses were completed for the downstream alternative using the same methods and input parameters described above for the bulk TSF buttressed-centerline embankment (under Alternative 1a, "Seismic Stability Analyses") and in Appendix K4.15. The results of the pseudo-static analysis shown in Table K4.15-11 predict negligible displacement (less than 0.3 foot) of the Alternative 2 embankment in a downstream direction under all earthquake scenarios. In comparison, the results for buttressed-centerline construction (Alternative 1a) are slightly higher (by 0.04 foot) for the two MCEs with the highest ground shaking predictions (deep intraslab and background earthquakes), although displacement estimates are minimal in either case, and would not affect the integrity of the structure. This difference would not be measurable under field conditions and indicates effectively no detectable difference in stability between the two designs (PLP 2020-RFI 071d).

The post-liquefaction stability analysis evaluated the stability of the Alternative 2 embankment in a downstream direction in the event the tailings liquefy in an earthquake. The results (Table 4.15-2 and Table K4.15-11) showed that, like the downstream cases evaluated for the buttressed-centerline dam, tailings liquefaction does not affect the global stability of the embankment, and the FoS remains well above the target of 1.2.

Uncertainties regarding the pseudo-static and post-liquefaction analyses would be similar to those described in Appendix K4.15, and above for the modified-centerline embankment (under Alternative 1a, "Seismic Stability Analyses"). In particular, uncertainties regarding whether tailings would segregate and provide a coarser deposit close to the embankment, resulting in a lower phreatic surface near the embankment, could also affect the stability of the downstream dam. Like the modified-centerline embankment, should Alternative 2 move forward into a further preliminary-level design phase, additional geotechnical evaluation and numerical modeling would still need to be conducted to further evaluate the seismic stability of the embankment, which would reduce these uncertainties.

Data compiled in the late 1900s on global dam failures by several agencies, including the US Environmental Protection Agency, US Committee of Large Dams, and United Nations Environment Program, show that dams built by downstream or centerline construction methods are safer than dams built by upstream construction methods, especially under seismic shaking (ICOLD 2001). Subsequent updated studies by Rico et al. (2007a) and Azam and Li (2010) confirmed these findings. Centerline construction was not cited in Mount Polley TSF failure investigative reports (Morgenstern et al. 2015; Hoffman 2015) as being a causative factor in the failure.

**Post-Closure**—Like the buttressed-centerline embankment, the downstream-constructed embankment under Alternative 2 would be designed to withstand an earthquake with a return period up to 10,000 years. The preliminary static, pseudo-static, and post-liquefaction stability analyses completed for the downstream alternative are based on end-of-operations conditions when the pond, tailings, and phreatic surfaces would be at their maximum or highest condition. Given that the tailings would continue to consolidate, runoff from the closure cover would be promoted, infiltration restricted, and the phreatic surface expected to drop over time; the results of these analyses would be protective of conditions following closure. Also like the buttressed-centerline alternative, stability and seepage analyses specific to closure conditions would be conducted during detailed closure design and would be updated as required under State permitting throughout the latter stages of operations.

## Summer-Only Ferry Operations Variant

There would be no difference in geohazard-related impacts under this variant for this component.

### 4.15.5.2 Transportation Corridor

## Mine and Port Access Roads

**Earthquakes**—The access roads under Alternative 2 would not cross any known active faults (see Figure 2-64, Figure 2-68, Figure 2-69, and Figure 3.15-1). The location and possible activity of Lake Clark fault splays and Bruin Bay fault that cross the Alternative 2 roads are described under Alternative 1a.

Wide, low-gradient stream crossings or estuaries along the Alternative 2 road, such as at the Pile and Iliamna river crossings or the road along Iliamna Bay, may be subject to liquefaction. The magnitude, duration, and extent of potential impacts on most of the road route related to liquefaction would be similar to those described for Alternative 1a. However, liquefaction or other ground failure effects on bridges across these rivers and the road embankment along Iliamna Bay are more likely to occur than at river crossings with incised bedrock or gravel substrates, such as at the Newhalen and Gibraltar river crossings under Alternative 1a.

Potential tsunami-related impacts in Iliamna Bay would be expected to be less severe than at the Amakdedori port site because Iliamna Bay is more protected and shallower than Amakdedori. However, more transportation infrastructure could be exposed to tsunamis under Alternative 2 with the access road from Williamsport to Diamond Point, lying adjacent to Iliamna Bay.

**Unstable Slopes**—Several areas of unstable solifluction, colluvium, and landslide deposits have been mapped along the mine access road west of Newhalen River, in the area northwest of Eagle Bay on the flanks of Roadhouse Mountain, along the lakefront south of Knutson Mountain, and at the head of Lonesome Bay. Steep alluvial fan and talus deposits also occur in incised valleys crossed by the eastern portion of the route east of Pile Bay (see Section 3.15, Geohazards and Seismic Conditions) (Detterman and Reed 1973; Hamilton and Klieforth 2010). As described in Appendix K3.1, Introduction to Affected Environment, TEK indicates that the steep slopes and valleys between Pile Bay and Williamsport are well known for landslide and avalanche risks (INL 2019). Rockslides and rockfall hazards could occur in this area where exposed bedrock and road cuts would be likely. Rockfall is evident along the steep coastal slopes between Williamsport and Diamond Point; therefore, unstable slopes and rockfall hazards would also be expected along this waterfront section of the road.

As noted above, landslides can be earthquake-triggered; could become more frequent with increased precipitation due to climate change; and could create related erosion and sedimentation effects downstream. Given the numerous steep unstable slopes at the eastern end of the lake, these types of related effects are more likely to occur under Alternative 2 than under Alternative 1a or Alternative 1.

Typical engineering and construction practices, such as engineered cuts, benching, drainage controls, and road maintenance, would be used to manage unstable slopes and reduce the potential for landslide impacts during construction, and disruption of truck haulage. Several locations along the existing Williamsport-Pile Bay Road would be rerouted under this alternative to avoid steep slopes, including approximately the eastern third of this area, and a short road segment close to Pile Bay. Unstable slopes could also lead to an increase in the likelihood of spills (Section 4.27, Spill Risk, provides an analysis of spill impacts from a truck spill scenario). The likelihood of such effects occurring would be expected to be greater for Alternative 2 as compared to Alternative 1a or Alternative 1, because there would be more areas of unstable slopes associated with the transportation corridors under Alternative 2. However, in terms of duration and extent, with appropriate designed engineering controls in place during construction and operations, impacts on the project and related effects on environmental resources would be repairable over the short-term, and limited to the immediate vicinity of the road footprint.

The potential exists for avalanches to occur along portions of the road alignment between Williamsport and Pile Bay. The occurrence of avalanches and landslides could become more frequent over time if climate change causes increased precipitation as rain or snow. Avalanches are expected to be managed using relevant best management practices (BMPs) such as hazard mapping, forecasting, and blasting if necessary. Recommendations are provided in Appendix M1.0, Mitigation Assessment, to also consider the use of snow sheds along this portion of the road, which could protect against both avalanches and rockfall. In terms of duration and extent, if avalanches were to occur, they would temporarily impact a local portion of the road until the snow could be removed.

## Eagle Bay to Pile Bay Ferry

The magnitude, duration, and extent of potential impacts on the ferry terminals related to ground shaking and the potential for tsunamis in Iliamna Lake would be similar to those described above under Alternative 1a for the Eagle Bay ferry terminal. Although the potential for seiche occurrence is considered unlikely (AECOM 2018j), the eastern end of the lake has steeper slopes and is narrower and deeper than the area of Alternative 1a or Alternative 1; factors that can increase the likelihood of an earthquake-triggered landslide-induced tsunami occurring from either a subaerial or submerged source and impacting shore-based infrastructure. Recommendations are provided in Appendix M1.0, Mitigation Assessment, to further evaluate the likelihood of landslide-induced tsunamis originating in the eastern end of the lake to affect the ferry terminals.

## Summer-Only Ferry Operations Variant

Under the Summer-Only Ferry Operations Variant, road traffic would be concentrated during the 6-month transportation season, which would include rainy months. Because heavy rain is often a trigger for slope failure, the potential for these impacts on road traffic and spill potential could be slightly greater under this variant, but would be balanced by fewer avalanche impacts due to lack of winter season traffic. Lake ice hazards are discussed under Section 4.16, Surface Water Hydrology.

There would be less potential for impacts to the ferry to occur from landslide-induced tsunamis under this variant than Alternative 2 due to less ferry traffic.

## Newhalen River North Crossing Variant

There would be no difference in geohazard-related impacts under this variant for this component compared to the Newhalen River south crossing.

### 4.15.5.3 Diamond Point Port

The Diamond Point port facility would use the same design concept as the Amakdedori port sheet pile dock under Alternative 1 (see Figure 2-71 and Figure 2-72), although with a footprint about four times bigger than the sheet pile dock at Amakdedori (PLP 2018-RFI 071).

## Earthquakes

As discussed in Appendix K4.15, ground shaking potential in the Diamond Point area is slightly greater than at Amakdedori, based on probabilistic seismic hazard predictions that evaluate the potential for earthquakes from all sources (see Table K4.15-14), but is lower than Amakdedori for an earthquake generated specifically on the Bruin Bay fault (see Table K4.15-15). The likelihood of liquefaction effects on dock stability may be higher under this alternative due to the presence of finer-grained sediments in Iliamna Bay as compared to Amakdedori. The Bruin Bay Fault extends along the western shore of Cook Inlet near both the Amakdedori and Diamond Point port sites. Although there is no evidence for Holocene offset at the surface, this fault is associated with several small to moderate earthquakes up to M7.3 in 1943 (Stevens and Craw 2003).

## Stability of Sheet Pile Dock

The sheet pile dock at Diamond Point would have the same potential to result in adverse impacts to the environment during construction and operations as discussed above for the Alternative 1 sheet pile dock at Amakdedori, and in Appendix K4.15.

The magnitude of potential impacts for the Alternative 2 sheet pile dock could be greater than the Alternative 1 sheet pile dock due to the larger footprint and fill volume required for the Alternative 2 dock, and possible higher likelihood of boulders in the subsurface with related risk of short embedment or sheet pile damage. In addition, there could be added complexity to foundation condition effects, dock stability, and construction issues near the northwestern corner of the dock, where a 350-foot-long section of the dock would be installed immediately adjacent to the dredged turning basin (see Figure 2-71), resulting in a 10-foot elevation change at the seafloor on either side of the dock and along the southern dock face to the east at the edge of the dredged area. Foundation conditions could be different on either side of the dock in this area or along the dock face, and construction in this area may require varying sheet pile heights or embedment depths.

As described in Section 4.18, Water and Sediment Quality, substrate conditions are generally finer-grained in Iliamna Bay than in Kamishak Bay. Because dock fill would partly consist of dredged material, in the event that potential geohazard-related impacts cause a release of fill to the marine environment, the extent of redeposition could be greater than under Alternative 1, and could range widely depending on season, tides, and wave conditions (e.g., from the close vicinity of the dock structure to the mouth of Iliamna Bay).

As with Amakdedori port, some of the Diamond Point port facilities may be reconfigured at closure to support a smaller operation with some terminal facilities being decommissioned (SRK 2019d), although it is possible that the Diamond Point port would be operated after mine closure by another entity (see Chapter 2, Alternatives). Therefore, the duration of potential geohazards-related impacts would be long-term, and the extent would generally be limited to the close vicinity of the dock footprint. With additional geotechnical investigation and stability analyses, the sheet pile dock design would be refined to address the potential for failure that could lead to adverse impacts on the environment (PLP 2018-RFI 005).

## Stability of Pile-Supported Dock Variant

The Pile-Supported Dock Variant for the Diamond Point port would have potential geohazard-related impacts similar in magnitude, duration, and extent as the Pile-Supported Dock Variant at the Amakdedori port under Alternative 1. The offshore foundation conditions would likely be different than the Amakdedori site but are also likely to include buried boulders and/or areas of shallow bedrock, which could affect the constructability and overall performance of the pile-supported system. If this variant is chosen, field conditions would be further investigated in support of final design.

## Unstable Slopes

As described above for the Alternative 2 transportation corridor, steep unstable slopes, rockfall, and avalanche hazards would be expected along the Diamond Point-Williamsport waterfront section of the road leading to Diamond Point port, and could also be present along the slopes above the port terminal and dredge material storage areas where steep alluvial fan deposits have been mapped (see Figure 2-64) (Detterman and Reed 1973). The potential for slope instability could be exacerbated in the event of increased precipitation due to climate change.

Typical engineering and construction practices such as foundation improvements, benching, and drainage controls, are expected to be employed during port design to manage unstable slopes and reduce the potential for impacts on the terminal and material storage areas. The material storage areas would be constructed with berms on their downslope sides, which are expected to prevent downslope movement or erosion effects from the storage areas.

## Tsunamis

The magnitude, duration, extent, and potential for tsunami impacts at the Diamond Point port site would be similar or slightly less than those at the Amakdedori port site under Alternative 1a and Alternative 1. The predicted run-up elevation for the 2,500-year event is slightly less for Diamond Point (36 to 39 feet MLLW) than at Amakdedori (39 to 44 feet MLLW) (see Section 3.15, Geohazards and Seismic Conditions). The potential for landslide-generated tsunamis from Augustine Volcano affecting the port site and lightering locations would be considered similar to Amakdedori, because historic events have occurred radially around Augustine Volcano (see Figure 3.15-5). However, the potential for local landslide-generated events originating from the slopes of Cottonwood, Iliamna, or Iniskin bays could be greater under Alternative 2 than at Amakdedori due to the presence of steep slopes and narrower bodies of water in this area. The engineering analyses and mitigation in final design that would occur at Amakdedori based on ASCE (2017a) industry standards (PLP 2018-RFI 112; PLP 2018-RFI 112a) would be the same for Diamond Point, assuming the additional infrastructure at this port site (dredge material storage area and roads) would be included in the site-specific tsunami analysis.

## Volcanoes

The Diamond Point port location would be approximately the same distance from volcanoes in the area, including Augustine Volcano, as the Amakdedori port under Alternative 1a and Alternative 1. Therefore, the likelihood of impacts occurring would be similar, with the magnitude, duration, and extent of impacts dependent on the severity of an ash cloud and the wind direction at the time of an eruption. In winter, the magnitude, duration, and extent of potential impacts from Augustine Volcano on the Alternative 2 port site could be greater than at Amakdedori due to dominant northwesterly winds in this area (Knight Piésold 2018g).

### 4.15.5.4 Natural Gas Pipeline Corridor

Referring to Figure 2-73, natural gas pipeline construction under Alternative 2 would follow a different corridor route west of Cook Inlet, and would therefore encounter different geology and related potential geohazards than Alternative 1a and Alternative 1 (see Section 3.13, Geology and Section 3.15, Geohazards and Seismic Conditions).

## Earthquakes and Surface Faults

In western Cook Inlet, the Alternative 2 pipeline would be routed to Ursus Cove to avoid known rocks and boulders at the mouth of Iliamna Bay (PLP 2018-RFI 063). At about 3 miles before making landfall, the pipeline would cross a mapped fault trace of the potentially active Bruin Bay fault (see Figure 3.15-1). Additional field investigation prior to final design (e.g., an offshore geophysical survey or onshore fault study at Ursus Head where the fault is mapped as having an upland component), would be needed to identify whether the fault is active and whether potential displacement mitigation in design would be necessary, if this alternative were to be selected.

As described above under the Alternative 2 transportation corridor, the potential for liquefaction effects along the Alternative 2 pipeline route may be higher in some areas where the route crosses wide alluvial or estuarine deposits, such as the Pile Bay and Iliamna river crossings, along the Diamond Point-Williamsport section of road, and between Ursus Cove and Cottonwood Bay. The type of impacts on the pipeline in the event of liquefaction are described above under Alternative 1a.

**Unstable Slopes**

Steep unstable slopes are a known hazard to pipeline integrity, and have been known to cause operation interruptions and ruptures in other mountainous areas of the world (e.g., the Andes, Eastern Europe, and Sakhalin Island) (Lee et al. 2016). Unstable slopes mapped between Ursus Cove and Pile Bay, and for the Alternative 2 route west of Eagle Bay, are discussed above under the Alternative 2 transportation corridor. The pipeline segment between Pile Bay and Eagle Bay crosses areas of exposed steep bedrock with the potential for rock instability, and alluvial fan and talus deposits, which could be unstable on steeper slopes. The corridor would avoid mapped landslide deposits on the flanks of Knutson and Roadhouse mountains.

Typical engineering and construction practices such as engineered cuts, rock stabilization, benching, and drainage controls would likely be used at these locations to reduce the potential for rockslide and landslide impacts to the pipeline. Additional measures, such as long-term slope monitoring and inspections, may be necessary in select areas. With these controls, the likelihood of slope failures occurring during construction and operations that would affect pipeline integrity would be expected to be minimal. In terms of duration and extent, related effects on environmental resources would also be expected to be minimal, repairable in the short-term, and limited to the immediate vicinity of the pipeline right-of-way (ROW).

**Coastal Hazards**

The depth of the pipeline as it approaches Ursus Cove from Cook Inlet, as well as the underwater crossing of the bay to Diamond Point, would be sufficient to ensure that the top of the pipeline lies below the mudline. The minimum depth of cover above the 12-foot water depth would be 3 feet, which would be expected to reduce potential effects from coastal hazards, such as shoreline drift, ice gouge, or ice-rafting of surface boulders.

## 4.15.6 Alternative 3—North Road Only

Under Alternative 3 and its variants, the magnitude, duration, extent, and likelihood of impacts at the mine site (including concentrate pumphouse) would be the same as those for Alternative 1a. The impacts from the natural gas pipeline corridor would be the same as those described under Alternative 2. The following section describes impacts for the transportation corridor and port that would be different under Alternative 3 and its variants.

### 4.15.6.1 Transportation Corridor

**All Road Routes, Mine Site to Port**

Geohazards-related impacts resulting from construction and operation of the Alternative 3 north access road from Diamond Point to the mine site would be generally the same as the combination of road and natural gas pipeline corridors described under Alternative 2. However, the likelihood of slope stability issues occurring along the all-road route would be higher between Eagle Bay and Pile Bay than under Alternative 2, due to the wider road ROW (compared to the Alternative 2 pipeline-only in this area), and greater need for engineering controls (such as wider cut-and-fills) to mitigate potential slope impacts. There would also be a slightly higher likelihood of spills due to the longer road route through steep terrain (Section 4.27, Spill Risk provides an analysis of spill impacts from a truck spill scenario), and greater potential for avalanche impacts to occur that would be preventable using relevant BMPs described above for Alternative 2.

Typical engineering controls and BMPs described above would reduce the likelihood of slope failures and avalanches occurring along the all-road route. In terms of duration and extent, related effects on environmental resources would be expected to be repairable over the short-term (days or weeks), and limited in extent to the immediate vicinity of the access road ROW footprint. Recommendations are provided in Appendix M1.0, Mitigation Assessment, to also consider the use of snow sheds along the road to protect against avalanches.

The likelihood of a potential landslide-induced tsunami in Iliamna Lake impacting Alternative 3 shore-based infrastructure would be less than other alternatives because there would be no ferry terminals, but there could be effects on the road where it is close to shore along the eastern part of the lake. Recommendations are provided in Appendix M1.0, Mitigation Assessment, to further evaluate the likelihood of landslide-induced tsunami originating in the eastern end of the lake to affect the transportation route.

## Concentrate Pipeline Variant

Because the concentrate pipeline would be installed in the same trench as the natural gas pipeline, the magnitude, duration, extent, and likelihood of impacts from geohazards, such as unstable slopes, would be similar to the Alternative 2 natural gas pipeline corridor and Alternative 3 all-road route. There would be a slightly higher likelihood of minor spills due to the additional potential contaminant source from the concentrate pipeline along steep terrain, which would be partially mitigated through leak detection systems (Section 4.27, Spill Risk, provides analysis of spill impacts from a concentrate spill scenario).

### 4.15.6.2 Port North of Diamond Point

Geohazard-related impacts would generally have a similar magnitude, duration, extent, and likelihood as those described for Alternative 2, except for the effects described below for the shore-based port facilities, caisson dock, and concentrate storage.

## Port Facilities

**Unstable Slopes—**The shore-based port facilities under Alternative 3 would be located several miles north of the Alternative 2 port location in a narrow strip of surficial deposits backed by steep cliffs. Rockslides and rockfall are more likely to occur here than at the Alternative 2 port, conditions which would be exacerbated during a major earthquake. Cut slopes into bedrock would be necessary during construction to accommodate the port facilities (see Figure 2-81). Typical rock slope design and maintenance techniques such as benching and drainage controls would be incorporated into final design and operations to mitigate this impact.

**Tsunamis—**The magnitude, duration, extent, and potential for tsunami impacts at the Alternative 3 port facilities site would be similar or greater than those at the Amakdedori port site and the Alternative 2 Dimond Point port site. The predicted run-up elevation for the 2,500-year event is greater at the Alternative 3 port site (45 to 47 feet MLLW) than at the Alternative 2 port site (36 to 39 MLLW) and at Amakdedori (39 to 44 feet MLLW) (see Section 3.15, Geohazards and Seismic Conditions). The potential for landslide-generated tsunamis affecting the port site would be similar to Alternative 2. The engineering analyses and mitigation in final design that would occur at Amakdedori based on ASCE (2017a) industry standards (PLP 2018-RFI 112; PLP 2018-RFI 112a) are expected to be the same under Alternative 3.

## Caisson Dock

The dock under Alternative 3 would be constructed in a similar manner as described for the caisson dock under Alternative 1a at Amakdedori, with similar-sized individual caisson footprints and separations between caissons, which would support a concrete deck. The Diamond Point causeway is shorter than at Amakdedori and would require fewer 60-foot by 60-foot caissons, but more of the larger 60-foot by 120-foot caissons than at Amakdedori.

**Foundation Conditions and Dock Stability**—The causeway under Alternative 3 would be constructed in shallower water than at Amakdedori or at Diamond Point under Alternative 2, extending from shore to about -4 feet MLLW. The Alternative 3 dock caissons would be placed in water depths of -18 feet MLLW, along the sides of a turning basin dredged into native seabed materials ranging from -3 to -6 feet MLLW.

As described in Section 3.15, Geohazards and Seismic Conditions, foundation conditions for the caissons under Alternative 3 would likely include mostly silt with less than 30 percent sand and gravel and occasional boulders. Bedrock is not expected to be present to a depth of more than 100 feet (PLP 2020d). Any boulders encountered in the dredge basin and channel would be removed and used in shore-based construction or placed in the dredge stockpile. Prior to installing the caissons under Alternative 3, the seafloor would be prepared by excavating approximately 5 feet of sediment below the turning basin to create a level, compact surface; this would be a 2- to 3-foot deeper foundation excavation than at Amakdedori, likely due to the presence of finer deposits in Iliamna Bay. The caissons would be backfilled with coarse material separated from the dredged sediments plus additional coarse material from onshore quarries, sized to achieve proper compaction to avoid settlement.

The finer-grained seafloor material at Diamond Point, possible presence of buried boulders in the subsurface, and 12- to 15-foot elevation change between the northwest and southeast sides of the caissons present potentially more complex geotechnical conditions for stability analysis and founding the caissons than at Amakdedori, although conditions would be similar to those described for the Alternative 2 sheet pile dock. It is expected that additional geotechnical investigation would be conducted as the project design advances to confirm foundation conditions, and that these conditions would be at least partly mitigated by the deeper foundation excavation and caisson placement. The types of geotechnical investigations and stability analyses conducted for the dock under Alternative 3 are expected to be similar to those described under Alternative 1a and in PLP 2020-RFI 160. As with Alternative 1a, ground improvement work would be considered during the design process if necessary, based on the additional investigation and analyses (PLP 2020-RFI 160).

**Earthquakes—**Ground-shaking potential and the likelihood of active surface fault displacement under Alternative 3 would be similar to that described under Alternative 2. There could be a higher risk of liquefaction effects on the caisson dock under Alternative 3 than described for the caisson dock at Amakdedori (under Alternative 1a), due to the finer-grained seabed material in Iliamna Bay. Liquefaction assessment would be completed in the early stages of design to determine which modeling methodologies are required for lateral spreading in a seismic event. Dredge slopes of 4H:1V are proposed to address sediment stability and the potential for seismic-induced slumping on the sides of the turning basin (PLP 2020d). If more detailed slope stability analysis is required, FLAC software may be used to estimate the soil movements and overall performance of the structure, and ground improvements may be considered during the design development process (PLP 2020-RFI 160).

**Tsunamis—**Impacts to the caisson dock under Alternative 3 would be similar to those described under the Alternative 1a caisson dock. In the event of a tsunami, the caisson dock would potentially have less cross-sectional area exposed to hydrodynamic and drawdown forces, and possibly be less susceptible to damage in a tsunami, than the sheet pile design under Alternative 2.

**Other Impacts**—Erosion potential at the base of the caissons due to tidal currents would be similar to that described for the caisson dock under Alternative 1a. Seafloor sediment at the Alternative 3 dock is more likely to build up on the dredged basin side of the caissons than erode, due to tidal currents and the 12- to 15-foot elevation change between the native seabed and dredge basin. Maintenance dredging would be conducted on a periodic basis to keep the channel and basin open as required for vessel draft.

The likelihood of impacts from the release of fill material in the event of shearing or cracking of the caisson columns would be similar to those described for the caisson dock under Alternative 1a. Unlike Amakdedori, however, any released material would likely be coarser than the surrounding seabed sediment and would be derived from a combination of subsea and onshore sources.

#### Concentrate Pipeline Variant

Due to the presence of steep bedrock cliffs adjacent to the footprint of the concentrate storage facility, the potential for unstable slopes and rockfall would exist during construction and operation. If this variant were selected, the final design would typically include a geotechnical investigation to confirm foundation and slope conditions to ensure the facility construction and operation would mitigate unstable slopes.

As noted above under Alternative 3 "Port Facilities," impacts from a tsunami at this location would be similar to or greater than at the Amakdedori port and the Diamond Point port site under Alternative 2 due to a higher predicted runup elevation. If a tsunami were to occur, it would have a higher potential to result in a contaminant release to the marine environment under this variant, because this variant includes bulk storage of concentrate and the others do not. Section 4.27, Spill Risk, provides analysis of spill impacts from a concentrate spill scenario. The duration of impacts could range from hours to months in the event repairs would be required. As described in Chapter 5, Mitigation, practices that would minimize these effects would include site-specific tsunami analysis and design, incorporation of flooding into design (e.g., tie-downs), emergency action planning with tsunami escape routes, or consideration of design changes to facility armoring and elevation.

### 4.15.6.3 Natural Gas Pipeline Corridor

Geohazard-related impacts would have a similar magnitude, duration, extent, and likelihood as those described for Alternative 2. The offshore portion of the Alternative 3 pipeline is about 1 mile longer than that of Alternative 2, and thus, would be slightly more likely to encounter coastal hazards such as boulders on mudflats or liquefaction effects.

## 4.15.7 Cumulative Effects

Seismic and other geologic hazards (geohazards) range from slope instability in the immediate vicinity of the project footprint to earthquakes and volcanoes in the region that could affect project facilities from long distances (see Section 4.27, Spill Risk, for a discussion of risk of dam failure). The cumulative effects analysis area for geohazards encompasses the footprint of the Pebble Project, including alternatives and variants, the expanded mine footprint (including road, pipeline, and port facilities), and any other reasonably foreseeable future actions (RFFAs) in the vicinity of the project that would result in potential synergistic and interactive effects. In this area, a nexus may exist between the project and other RFFAs that could contribute cumulatively to geologic hazards-related impacts. Section 4.1, Introduction to Environmental Consequences, details the comprehensive set of past, present, and RFFAs considered for evaluation as applicable. Several the actions would be considered to have no potential of contributing to cumulative geologic hazard effects in the analysis area. These include activities that may occur in the analysis area, but are unlikely to result in any appreciable cumulative effect with regard to geohazards, or actions outside of the geologic hazards cumulative effects analysis area.

### 4.15.7.1 Past and Present Actions

Past and present actions in the analysis area would not be expected to contribute cumulatively to geologic hazards. Although past or current actions in the analysis area have included some minor earthworks, the effects are minor both in magnitude and extent, and are not expected to be a significant factor in increased geologic hazards. Similarly, although there have been past volcanic and earthquake events in the region, they have not contributed to any increased geologic hazard risk in current conditions.

### 4.15.7.2 Reasonably Foreseeable Future Actions

RFFAs in the analysis area that would involve earthworks resulting in possible geohazards-related impacts and that could contribute cumulatively to geohazards include the Pebble Project expansion scenario; mining exploration activities for Pebble South and Groundhog mineral prospects; onshore and offshore oil and gas development; and Lake and Peninsula transportation and infrastructure projects such as road improvements and continued development of the Diamond Point Rock Quarry.

The No Action Alternative would not contribute to cumulative geologic hazard effects.

Collectively, the project alternatives with RFFA contribution to increased geohazards are summarized in Table 4.15-4.

**Table 4.15-4: Contribution to Cumulative Effects from Geohazards**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Pebble Project Expansion Scenario | **Mine Site:** The mine site footprint would have a larger open pit and new facilities to store tailings and waste rock, which would contribute to cumulative effects on and from geohazards through removal of overburden and bedrock, and construction of potentially unstable embankments, stockpiles, and pit walls. The expansion scenario and associated infrastructure would be similar for all alternatives.<br>New facilities requiring consideration of static and seismic stability in design would include a southern bulk TSF with flow-through embankment containing an additional 4.6 billion tons of tails; a southern PAG TSF containing 0.6 billion tons of additional pyritic tails; northern and southern WRFs containing an additional 17 billion tons of NAG and PAG waste rock; and water/seepage collection ponds downgradient from these storage facilities (see Table 4.1-2) (PLP 2018-RFI 062). If the potential for expansion is foreseen before closure of the original pyritic TSF, filling the open pit would be reconsidered and the original pyritic TSF would likely remain in its currently planned form. If expansion occurred after closure and transfer of the original pyritic TSF materials to the pit, tailings removal from the pit and transport/placement techniques used at other mine closures could be considered (e.g., Tundra Mine in Northwest Territories, Centralia Mine in Washington).<br>The new TSFs and southern WRF would be sited in geomorphically constricted valleys between exposed bedrock ridges south of the TSFs and pit that drain towards the SFK. The northern WRF would be sited in a broader area of glacial deposits draining towards UTC with an exposed bedrock ridge on the northern side. Based on geologic maps of the area (see Figure 3.13-1 through Figure 3.13-4 in Section 3.13, Geology; and Figure 3.17-1 in Section 3.17, | **Mine Site:** Identical to Alternative 1a.<br>**Other Facilities:** Similar to Alternative 1a, except that the portion of the mine access road from about 10 miles west of the Newhalen River to the Eagle Bay area would not already be in place, and would be constructed along with the rest of the north access road from Eagle Bay area to the new Iniskin Bay port.<br>**Magnitude:** Cumulative impacts from geohazards would be similar to that of the Alternative 1a.<br>**Duration/Extent:** The duration and extent of cumulative impacts from geohazards would be similar to those of Alternative 1a.<br>**Contribution:** The contribution to cumulative effects would be similar to that of Alternative 1a. | **Mine Site:** Similar to the Alternative 1a.<br>**Other Facilities:** The north access road would be extended east from the Eagle Bay ferry terminal to the Iniskin Peninsula. Concentrate and diesel pipelines would be constructed along the north road alignment, all of which would be extended to a new deepwater port site at Iniskin Bay. There would be increased unstable slopes along the Eagle Bay-to-Pile Bay segment, and both unstable slopes and potential liquefaction effects along the extended Williamsport-to-Iniskin Bay segment and deepwater port, due to the presence of steep talus deposits and wide alluvial/estuarine valleys in this area (see Figure 3.13-4 in Section 4.13, Geology).<br>**Magnitude:** Cumulative geohazard impacts from mine expansion would be less than that of the Alternative 1a overall, given that a portion of the north road and all of the gas pipeline would already be | **Mine Site:** Identical to the Alternative 1a.<br>**Other Facilities:** Overall expansion would use the existing north access road; concentrate and diesel pipelines would be constructed along the existing road alignment, all of which would be extended to a new deepwater port site at Iniskin Bay. Like Alternative 2, there could be increased unstable slopes and liquefiable areas along the new pipeline/road segment between Williamsport and Iniskin Bay.<br>**Magnitude:** Cumulative geohazard impacts from mine expansion would be less than that of the other alternatives overall, given that the north access road and gas pipeline would already be constructed. However, there would be more critical facilities concentrated in areas of unstable slopes and liquefiable ground, increasing the likelihood of disruptions to transportation/pipeline |

**Table 4.15-4: Contribution to Cumulative Effects from Geohazards**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | Groundwater Hydrology), foundation conditions at the new embankments and WRFs would likely be similar to those of the proposed facilities; i.e., fractured and faulted Cretaceous granodiorite and younger volcanics overlain by mostly glacial moraine deposits with minor areas of colluvium and solifluction deposits. Like the proposed embankments, the new TSF embankments would likely be founded on bedrock. There could be increased stability concerns for the WRFs and embankments of smaller ponds if founded on potentially unsuitable overburden, which would be addressed during detailed design under ADNR permitting. The new facilities may be closer to potentially active traces of the Lake Clark fault (see Figure 3.15-2 in Section 3.15, Geohazards), particularly in the case of the northern WRF, and would require additional seismic hazard analysis and possibly additional surface fault investigations.<br>The magnitude of potential geohazard-related impacts would be higher than that of the project, due to added stability risk and potential cumulative effects on the SFK and UTC drainages from the new TSFs, WRFs, and larger pit that would be required in the Pebble Project expansion scenario. There would be about 60 years of additional design life for certain structures (e.g., pyritic TSF, main WMP, and port) that would need to remain beyond their original design life to wait for the pit to be available for backfill, which would require additional consideration in stability analyses, engineering reviews, and potential structural mitigations as operations and closure design advances.<br>**Other Facilities:** A north access road and concentrate and diesel pipelines would be constructed under all alternatives with the Pebble Project expansion scenario, extending along the Alternative 3 road alignment from the Eagle Bay area | | constructed, and the south access road would not be needed. However, there would be more critical facilities (e.g., roads and pipelines) concentrated in areas of unstable slopes and liquefiable ground, increasing the likelihood of disruptions to transportation/pipeline systems and spill risk during earthquakes.<br>**Duration/Extent:** Cumulative impacts from geohazards would be similar in duration to the other alternatives, although affecting a smaller area and fewer watersheds than Alternative 1a and Alternative 1.<br>**Contribution:** The contribution to cumulative impacts would be similar to the other alternatives, although affecting a smaller area and fewer watersheds than Alternative 1a and Alternative 1. | systems and spill risk during earthquakes.<br>**Duration/Extent:** The duration of cumulative impacts from geohazards would be similar to that of the other alternatives, although affecting a smaller area and fewer watersheds.<br>**Contribution:** The contribution to cumulative impacts would be similar to the other alternatives, although affecting a smaller area and fewer watersheds. |

**Table 4.15-4: Contribution to Cumulative Effects from Geohazards**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | to the Pile Bay terminus of the Williamsport-Pile Bay Road, then to a new deepwater port site at Iniskin Bay. The potential for geohazard impacts along the transportation corridor, ports, and pipeline would increase under the Pebble Project expansion scenario, because both the north and south access corridors and two ports would be used under all alternatives. This would add the effects of unstable slopes along the north access road to those of Alternative 1a. In addition, the development of the second port at Iniskin Bay (under all alternatives) would increase the likelihood of impacts from dock instability, volcanic ashfall, and tsunamis. In the case of tsunamis, the likelihood of a large tsunami of tectonic origin with a 2,500-year return period occurring would increase due to the longer life of the project, with the probability of occurrence at either port roughly 1 in 17, assuming the ports would be functioning for approximately 148 years total (98 years of operations, plus 50 years of closure activities). The likelihood of a landslide-induced tsunami from an Augustine volcanic debris slide could be higher, depending on the results of site-specific tsunami analysis, which would be conducted in final design (see Chapter 5, Mitigation).<br>**Magnitude:** The Pebble Project expansion scenario would impact a footprint approximately four times larger than Alternative 1a, much of which would include new facilities with potential stability impacts such as TSF embankments, WRFs, and pit walls.<br>**Duration/Extent:** The duration and extent of cumulative impacts to geohazards would vary from temporary (e.g., slope instability during construction) to long-term (e.g., instability from additional earthworks and mine facilities during operations) to permanent (e.g., regional risk to expanded bulk TSFs from earthquakes or volcanoes). The extent of | | | |

**Table 4.15-4: Contribution to Cumulative Effects from Geohazards**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | cumulative effects would be in the immediate vicinity of Pebble Project expansion scenario and along the additional transportation segments and port site.<br>**Contribution:** The removal and storage of overburden, rock, and tails, and the extension of the road and pipeline system into steep terrain contributes to the cumulative effects of geohazards such as slope instability. However, these areas are relatively undeveloped, and effects would be limited to the close vicinity of the project footprint, which is a relatively small area in the affected watersheds. | | | |
| Other Mineral Exploration Projects | **Magnitude:** Mining exploration activities, including additional borehole drilling, road and pad construction, and development of temporary camp facilities, would contribute a small amount of slope instability at discrete locations, depending on landowner permitting and restoration requirements. Mineral exploration at the Pebble South and Groundhog prospects could have a minor cumulative effect on geologic hazards, depending on the extent of infrastructure development that was to occur. Under any pre-development exploration scenario, effects on geologic hazards would be expected to be temporary and minor, and limited to potential cumulative effects on infrastructure shared with the Pebble Project.<br>**Duration/Extent:** Exploration activities typically occur at a discrete location for one season, although a multi-year program could expand the geographic area affected in a specific mineral prospect. Table 4.1-1 in Section 4.1, Introduction to Environmental Consequences, identifies seven mineral prospects in the EIS analysis area where exploratory drilling is anticipated (four of which are in relatively close proximity to the Pebble Project). | Impacts would be similar to those for Alternative 1a. | Impacts would be similar to those for Alternative 1a. | Impacts would be similar to those for Alternative 1a. |

**Table 4.15-4: Contribution to Cumulative Effects from Geohazards**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | **Contribution:** Exploration activities could contribute to cumulative effects of slope instability, although the areal extent of disturbance would be a relatively small portion of the Kvichak/Nushagak watersheds. Assuming compliance with permit requirements, contributions to slope instability would be minimal. | | | |
| Oil and Gas Exploration and Development | **Magnitude:** Oil and gas exploration activities in LPB and lower Cook Inlet federal lease areas could involve geophysical exploration; and in limited cases, exploratory drilling (see Table 4.1-1 and Figure 4.1-1 in Section 4.1, Introduction to Environmental Consequences). Onshore geophysical exploration would involve temporary overland activities, with permit conditions that avoid or minimize soil disturbance. Should it occur, onshore exploratory drilling would involve the construction of temporary pads and support facilities, with permit conditions to minimize disturbance to geohazards and restore drill sites after exploration activities have ceased.<br>Offshore exploration activities that occur in the area of the pipeline could increase natural or man-made hazards to the Pebble pipeline or existing fiber-optic cables (Intecsea 2019; NanaWP and Intecsea 2019a), such as scour/erosion or anchor damage with increased boat traffic.<br>**Duration/Extent:** Geophysical exploration and exploratory drilling are typically single-season temporary activities. The 2013 Bristol Bay Plan Amendment shows 13 oil and gas wells drilled on the western Alaska Peninsula, and a cluster of three wells near Iniskin Bay. Historic and active offshore leases in lower Cook Inlet overlap the Pebble natural gas pipeline route in the center and eastern side of the inlet. It is possible that additional geophysical testing and exploratory drilling could occur in the EIS | Impacts would be similar to those for Alternative 1a. | Impacts would be similar to those for Alternative 1a. | Impacts would be similar to those for Alternative 1a. |

**Table 4.15-4: Contribution to Cumulative Effects from Geohazards**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | analysis area; however, based on historic activity, this is not expected to be intensive.<br>**Contribution:** Onshore oil and gas exploration activities would be required to minimize surface disturbance, and could occur in the analysis area, but distant from the Pebble Project. Offshore activities would be required by the Bureau of Safety and Environmental Enforcement to have mitigation plans in place for avoidance of damage to existing infrastructure (NanaWP and Intecsea 2019a). The project would have minimal contribution to cumulative effects from these activities. | | | |
| Road Improvement and Community Development Projects | **Magnitude:** Road improvement projects and continued use of Diamond Point Rock Quarry could have limited impacts on geologic hazards, and contribute to cumulative effects in the overall analysis area, but there would be no cumulative effects on infrastructure shared with the project. LPB and State of Alaska transportation, infrastructure, and energy projects that include possible upgrades to the Williamsport-Pile Bay Road could cause potential reduction in geohazards in the analysis area, but would not have combined effects with the transportation corridor under Alternative 1a. Likewise, the Diamond Point Rock Quarry could have an effect on geologic hazards such as slope instability and rockfall, although these would be expected to be limited to the immediate area around the quarry site, and not have any combined effects with Pebble infrastructure.<br>**Duration/Extent:** Disturbance from road construction would typically occur over a single construction season. Contributions for quarrying activities at Diamond Point would be long-term, for the life of quarry operations. Geographic extent would be | Impacts would be similar to those for Alternative 1a, but less than those for Alternative 2 and Alternative 3, due to lack of effects on infrastructure shared with the Pebble Project. | **Magnitude:** LPB and State of Alaska transportation, infrastructure, and energy projects include possible upgrades to the Williamsport-Pile Bay Road, which is the same alignment that would be used under Alternative 2. If selected, the net magnitude and geographic extent of unstable slope effects may be relatively low, because the mine access road would already be rerouted or upgraded for maintaining slopes. If the road were to be further widened as part of a transportation improvement project, there would likely be additional impacts.<br>The footprint of the Diamond Point rock quarry overlaps | Impacts would be the same as those for Alternative 2. |

**Table 4.15-4: Contribution to Cumulative Effects from Geohazards**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| | limited to the vicinity of the Williamsport-Pile Bay Road, communities, and Diamond Point.<br>**Contribution:** Road construction and quarry use could have effects on slope stability in the analysis area, but would be removed from the project, which would have minimal contribution to cumulative effects. | | with the Diamond Point port footprint in Alternative 2; therefore, there could be a relatively minor net increase in geohazard impacts, such as unstable slopes on shore-based infrastructure or dock stability effects on the marine environment.<br>**Duration/Extent:** These effects are expected to be temporary and repairable, and minor in extent, limited to the immediate areas around the quarry site and roads. The estimated area that would be affected at Diamond Point is approximately 140 acres (ADNR 2014a).<br>**Contribution:** Road construction and quarry use could have cumulative effects on slope stability in areas of project infrastructure overlap. The Pebble Project under Alternative 2 is expected to have minimal contribution to cumulative effects. | |

**Table 4.15-4: Contribution to Cumulative Effects from Geohazards**

| Reasonably Foreseeable Future Actions | Alternative 1a | Alternative 1 and Variants | Alternative 2 and Variants | Alternative 3 and Variant |
|---|---|---|---|---|
| Summary of Project contribution to Cumulative Effects | Primary factors contributing to cumulative geohazards effects include:<br>• Increased potential for stability impacts under Pebble Project expansion scenario from new embankments, storage areas, and pit walls, and extension of roads and pipelines into unstable terrain.<br>• Minor effects from the Pebble Project combined with mineral and oil/gas exploration projects, road improvements, and continued quarry development.<br>Overall, the contribution of Alternative 1a to cumulative geohazards effects, when taking other past, present, and RFFAs into account, would be minor in terms of magnitude, duration, and extent, given industry design standards and permit requirements to mitigate hazards to man-made facilities at the Pebble Project expansion scenario, protection of slope stability along roads, and mitigation plans for avoidance of offshore hazards. | Impacts would be similar to those for Alternative 1a. | Impacts would be similar to those for Alternative 1a and Alternative 1, although less area/watersheds would be affected by mine expansion, and more critical facilities would be concentrated in areas of unstable terrain.<br>Minor effects from Alternative 2 combined with road improvement projects and Diamond Point Rock Quarry. | Impacts would be similar to those for Alternative 2. |

Notes:
TSF = Tailings Storage Facility
WMP = Water Management Pond
WRF = waste rock facilities
NAG = non-acid generation
SFK = South Fork Koktuli
UTC = Upper Talarik Creek
PAG = potentially acid-generating
ADNR = Alaska Department of Natural Resources
LPB = Lake and Peninsula Borough
RFFAs = Reasonably Foreseeable Future Actions