3.26 VEGETATION

The affected environment for vegetation includes all vegetation types that may be directly or indirectly impacted during construction and operations under all project alternatives, components, and variants. Vegetation is described in terms of the extent and characteristics of predominant types. Rare or sensitive plant species and all taxa of invasive species are also discussed.

In the Environmental Impact Statement (EIS) analysis area, forests and shrublands cover lowlands and fringe riparian corridors. These often closed-canopy types transition to woodlands and dwarf shrub types over shallow soils at higher elevations. The most exposed alpine sites support dwarf alpine scrub with significant cover of lichen and bare ground. Upland forests and woodlands are dominated by white spruce (*Picea glauca*), Kenai birch (*Betula papyrifera* var. *kenaica*), and balsam poplar (*Populus balsamifera* ssp. *balsamifera*), whereas forested wetlands are most commonly dominated by black spruce (*Picea mariana*) and occasionally black cottonwood (*Populus balsamifera* ssp. *balsamifera*). Upland shrub is most commonly dominated by alder (*Alnus* spp.) with the proportion of willow (*Salix* spp.) increasing with wetter soil conditions. Across peatlands, dwarf black spruce, birch (*Betula nana*), ericaceous shrub (e.g., *Vaccinium* spp., *Empetrum nigurm*) and tussock-forming sedges co-dominate (Three Parameters Plus and HDR 2011a).

The plant species and communities described in this section are primarily based on information provided in Chapter 13 of the Environmental Baseline Document (EBD) (Three Parameters Plus and HDR 2011a), Chapter 38 of the EBD (HDR and Three Parameters Plus 2011a), and the project geographic information system (GIS) database, which reflects changes in the project area since publication of the EBD (HDR 2019i).

The affected environment for vegetation supports analysis for other biological resources addressed in this EIS, including Section 3.23, Wildlife Values, and Section 3.22, Wetlands and Other Waters/Special Aquatic Sites. Vegetation is also an important aspect of social resources (see Section 3.5, Recreation, and Section 3.9, Subsistence).

3.26.1 EIS Analysis Area

The EIS analysis area includes the area potentially affected by direct and indirect impacts from project construction and operations. The analysis area includes all four components (mine site, transportation corridor, ports, and natural gas pipeline) under each project alternative and variants; see Chapter 2, Alternatives, for an explanation and maps of alternatives, variants, and project components. The analysis area for vegetation is the same as wetlands (see Figure 3.22-1 in Section 3.22, Wetlands and Other Waters/Special Aquatic Sites, for a map of the analysis area for wetlands).

Mine Site—The analysis area includes the direct disturbance footprint buffered by 330 feet to account for fugitive dust impacts.

Transportation Corridor and Ports—The analysis area for the transportation corridor and ports includes the direct disturbance footprints buffered by 330 feet to account for fugitive dust impacts. Although the direct disturbance footprints are included for the pile-supported and caisson docks (both of which have concrete decking), lightering areas, and mooring buoys, these features are not buffered, because they are not expected to be sources of fugitive dust.

Natural Gas Pipeline—The pipeline-only natural gas pipeline corridor analysis area includes the sections where the pipeline is not co-located with the transportation corridor. These sections of the natural gas pipeline have a maximum impact width of 91 feet through Iliamna Lake, 102 to 183 feet through Cook Inlet, and 150 feet through overland areas. The overland analysis area

includes the direct disturbance footprints for access roads and material sites, buffered by a 330-foot zone to account for dust impacts.

3.26.2 Analysis Methodology

3.26.2.1 Vegetation

A vegetation classification system is a hierarchical organization of types that differentiates the most generalized types by physiognomy (e.g., forest, shrub, and herbaceous) and more detailed types by diagnostic growth forms and character species (e.g., white spruce closed forest). This section describes the classification system used to describe vegetation in the analysis area, and for the impact analysis described in Section 4.26, Vegetation.

Project vegetation types were developed to provide a standardized way to discuss vegetation and summarize impacts in the analysis area. The 50 detailed project vegetation types identified from field-verified data were combined to 10 broader categories based on structural characteristics, including dominant growth form (forest, shrub, or herbaceous), tree and shrub canopy cover (woodland, open or closed), and average tree and shrub height (dwarf, low, or tall) (Three Parameters Plus and HDR 2011a; HDR and Three Parameters Plus 2011a). Reference guides to the environmental baseline study classification system, including vegetation type definitions and representative photos, are included in Chapter 13 and Chapter 38 of the EBD. A table showing the hierarchical nesting of project vegetation types in vegetation structure types is provided in Appendix K3.26.

Terminology used for the project and structural vegetation types is based on the Alaska Vegetation Classification (Viereck et al. 1992), supplemented by Wibbenmeyer et al. (1982), and modified as necessary to accommodate interpretation of available aerial imagery. Field-verified vegetation mapping covers 100 percent of Alternative 1a, Alternative 1, Alternative 2—North Road and Ferry with Downstream Dams, and Alternative 3—North Road Only. Digital vegetation mapping was completed using GIS with aerial photography at scales between 1:1,200 and 1:1,500.

The 10 vegetation structure types, applied in the characterization of vegetation in this section and in the analysis of direct and indirect impacts in Section 4.26, Vegetation, are summarized below:

- **Open/Closed Forest—**The open or closed forest type has over 10 percent cover of trees and generally includes needleleaf and deciduous forests and woodlands as well as stands of dwarf spruce at treeline or in lowland bogs. Vegetation types in this structure type are Closed White Spruce Forest, Open White Spruce Forest, White Spruce Woodland, Black Spruce Woodland, Closed Broadleaf Forest, Open Broadleaf Forest, Broadleaf Woodland, Closed Mixed Forest, Open Mixed Forest, Mixed Forest Woodland, Dwarf White Spruce Scrub, and Dwarf Black Spruce Scrub.
- **Closed Tall Shrub—**The closed tall shrub type has over 75 percent cover of shrubs with average height greater than 5 feet tall. This type generally includes broadleaf tall shrub communities. Vegetation types in this structure type are Closed Willow Tall Shrub, Closed Alder Tall Shrub, and Closed Alder-Willow Tall Shrub.
- **Open Tall Shrub—**The open tall shrub type has 25 to 75 percent cover of shrubs with average height greater than 5 feet tall. This type generally includes broadleaf tall shrub communities. Vegetation types in this structure type are Open Alder Tall Shrub, Open Alder-Willow Tall Shrub, and Open Willow Tall Shrub.
- **Closed Low Shrub—**The closed low shrub type has over 75 percent cover of shrubs ranging in height from 8 inches to 5 feet. This type generally includes broadleaf low shrub communities. Vegetation types in this structure type are Closed Willow Low Shrub, Closed Alder-Willow Low Shrub, and Closed Alder Low Shrub.

- **Open Low Shrub—**The open low shrub type has 25 to 75 percent cover of shrubs ranging in height from 8 inches to 5 feet. This type generally includes broadleaf and ericaceous low shrub communities; tussock-forming sedges (*Carex* spp. and cottongrasses (*Eriophorum* spp.) can compose a significant component of communities dominated by ericaceous shrubs. Vegetation types in this structure type are Open Sweetgale-Graminoid Bog, Open Mixed Shrub-Sedge Tussock, Open Dwarf Birch-Ericaceous Shrub Bog, Ericaceous Shrub Bog, Low Ericaceous Shrub Tundra, Open Dwarf Birch Scrub, Shrub Birch-Willow, Open Willow Low Shrub, Open Willow Low Shrub Fen, Open Alder-Willow Low Shrub, and Open Alder Low Shrub.
- **Dwarf Shrub—**The dwarf shrub type has less than 10 percent cover of trees and over 25 percent cover of shrubs less than 8 inches tall. This type generally includes tundra dominated by dwarf ericaceous shrub that may be characterized by an abundance of sedge (*Carex* spp.), lichen, or horsetail (*Equisetum* spp.) species, or a hummocky microtopography. Vegetation types in this structure type are Dwarf Ericaceous Shrub Tundra, Dwarf Ericaceous Shrub Tundra—Hummock, Dwarf Ericaceous Shrub Tundra – Equisetum, Dwarf Ericaceous Shrub Tundra—Carex, and Dwarf Ericaceous Shrub-Lichen Tundra.
- **Dry to Moist Herbaceous—**The dry to moist herbaceous type has less than 10 percent tree cover and less than 25 percent shrub cover. This type generally includes graminoid- and forb-dominated communities occurring as grasslands and sedge; or forb meadows on xeric dunes, beaches, and mesic subalpine to alpine sites. Vegetation types in this structure type are Halophytic Dry Graminoid, Bluejoint Tall Grass, Bluejoint-Herb, and Mesic Herb.
- **Wet Herbaceous—**The wet herbaceous type has less than 10 percent tree cover and less than 25 percent shrub cover. This type generally includes graminoid- and forb-dominated communities occurring as fresh or saltwater marshes, sedge meadows, fens, bogs, and peatlands on hydric sites. Vegetation types in this structure type are Halophytic Graminoid Wet Meadow, Subarctic Sedge-Moss Wet Meadow, Fresh Sedge Marsh, Fresh Herb Marsh, and Aquatic Herbaceous. The Aquatic Herbaceous type includes submerged aquatic vegetation, and represents the special aquatic site—Vegetated Shallows. The occurrence of and impacts to Vegetated Shallows are presented in Section 3.22 and Section 4.22, Wetlands and Other Waters/Special Aquatic Sites.
- **Other—**This type refers to permanently flooded habitat with less than 25 percent vegetation coverage. This type generally includes features such as oceans, lakes, rivers, and streams.

The habitat descriptions provided here are largely based on information provided in Chapter 13 and Chapter 38 of the EBD (Three Parameters Plus and HDR 2011a; HDR and Three Parameters Plus 2011a) and the associated GIS database, which reflects changes in the project since publication of the EBD; the last update to the GIS database was in November 2019. A series of tables (Table 3.26-1 through Table 3.26-10) is presented below to illustrate the proportion of each of these types in the analysis area. Values are rounded to the nearest whole acre, or nearest whole percent; apparent inconsistencies in sums are the result of rounding. The open water type is included in each table depicting vegetation but is not considered part of the affected environment for vegetation; therefore, it is not included in the calculation of impacts to vegetation (Section 4.26, Vegetation).

Rare or sensitive plant species—Confirmed or reported populations of species on the Alaska Center for Conservation Science (ACCS) rare vascular plant species list were reviewed from the online ACCS database (ACCS 2018a).

Invasive plant species—Field studies and the online Alaska Exotic Plant Information Clearinghouse (AKEPIC) database (ACCS 2018b) were reviewed for presence of invasive plant species in the analysis area.

3.26.2.2 Rare or Sensitive Plant Species

Rare or sensitive plant species are those with limited abundance, geographic distribution, and/or habitat. The ACCS curates biological and occurrence data for more than 350 vascular species of conservation concern in Alaska (ACCS 2018a; Nawrocki et al. 2013); no special state-wide protections are afforded species on this list. ACCS assigns a conservation status for a species in the state (i.e., S-rank); these regional ranks are further compiled by NatureServe, the parent organization for the network of Natural Heritage Programs and Data Centers, to assign a global conservation status (i.e., G-rank). These conservation status levels categorize risk, regardless of geographic designation, to the viability of a species on a scale of 1 to 5, where 5 is a species that is secure and not at risk for extirpation because of widespread abundance; whereas 1 indicates a critically imperiled species at very high risk of extirpation because of very few occurrences, declining populations, or extremely limited range and/or habitat. Species with state ranks between 1 and 3 are typically considered species of conservation concern.

The only documented occurrences of rare or sensitive plant species in the project area are for the Chukchi primrose (*Primula tschuktschorum*; S3). Both occurrences are in the North Fork Koktuli watershed: one approximately 2 miles west/southwest of Kaskanek Mountain and 22 miles northwest of Iliamna; and the other 40 miles west of Iliamna. Neither location occurs in the analysis area. Incidental observations of Bering Sea dock (*Rumex beringensis*; S3) were made between Newhalen and the Upper Talarik Creek; however, the voucher material collected was insufficient for taxonomic confirmation.

Ethnobotany—Ethnobotany can be described as the study of the relationship between humans and plants. For Alaska Natives, this relationship connects the knowledge of plants to the moral and spiritual values of local people (Jernigan no date). Plants and plant materials have edible, medicinal, and utilitarian use. More than 80 species of plants are harvested for consumption and use in the analysis area.

Edible Plants (Jernigan no date, Viereck 1995):

- several species of berries:
    - alpine bearberry (*Arctostaphylos alpina)*
    - Lapland cornel (*Cornus suecica)*
    - black crowberry (*Empetrum nigrum*)
    - red current (*Ribes triste*)
    - arctic raspberry (*Rubus arcticus*)
    - cloudberry (*Rubus chamaemorus*)
    - salmonberry (*Rubus spectabilis*)
    - small cranberry (*Vaccinium oxycoccos*)
    - bog blueberry (*Vaccinium uliginosum*)
    - lingonberry (*Vaccinium vitis-idaea*)
    - squashberry (*Viburnum edule*)
- alpine sweetvetch (*Hedysarum alpinum*)
- wild chives (*Allium schoenoprasum*)
- ferns (any producing a fiddlehead):

    - common ladyfern (*Athyrium filix-femina*)
    - spreading woodfern (*Dryopteris expansa*)
- wild celery, also known as:
    - cow parsnip (*Heracleum maximum*)
    - seacoast angelica (*Angelica lucida*)
- prickly rose (*Rosa acicularis*)

Medicinal Plants (Garibaldi 1999):

- Tilesius' wormwood (*Artemisia tilesii*)
- boreal yarrow (*Achillea millefolium* var. *borealis*)
- arctic sweet coltsfoot (*Petasites frigidus*)
- fireweed (*Chamerion angustifolium*)
- disc mayweed (*Matricaria discoidea*)
- American red raspberry (*Rubus idaeus*)
- arctic dock (*Rumex arcticus*)
- alpine mountainsorrel (*Oxyria digyna*)

A variety of trees and shrubs are used for smoking fish (*Alnus* ssp.*, Betula nana*), basket making *(B. papyrifera* var. *kenaica* bark)*,* boat building, sealant, and trap making (*Picea* spp. wood, resin, and roots, respectively) (Jernigan no date). See Section 3.9, Subsistence, for additional discussion on the importance of subsistence resources.

3.26.2.3 Invasive Species

Non-native species are those that are present in a given area due to the accidental or intentional introduction by humans. Not all non-native species are equally harmful. Invasive species are a subset of non-native species that have the biological capacity to establish, reproduce, and spread throughout natural communities. Executive Order 13112—Invasive Species, further defines invasive species as those whose introduction does or is likely to harm the economy, environment, or human health.

Globally, invasive species can have severe impacts on local biodiversity, community structure and function, and natural resources, with consequences to the greater ecosystem, economy, and human health (Cameron et al. 2016; Duncan et al. 2004; Molnar et al. 2008). Documented impacts of invasive species in Alaska include loss of biodiversity (Buckelew et al. 2011; Roon et al. 2016) and habitat degradation (O'Hare et al. 2006; Schrader and Hennon 2005) with projected consequences for the economy (Schwoerer 2017) and human health. Measures implemented to control invasive species, such as application of herbicides, can also affect native species (Rinella et al. 2009).

This section discusses all taxa of invasive species that occur in the analysis area, or may be introduced to the analysis area by project-related activities. Taxa considered are terrestrial plants and vertebrates, freshwater aquatic plants, and marine species. Invasive freshwater animal species are not addressed, because they have not been documented as occurring in the analysis area, nor have they been identified as candidate species of concern in this region of Alaska.

Regulatory Authority—The US Army Corps of Engineers (USACE) authority on invasive species includes Executive Order 13751—Safeguarding the Nation from the Impacts of Invasive Species (amendment to Executive Order 13112), which directs agencies to take steps to eradicate and control invasive species. Authority also falls under the National Invasive Species Act (NISA) of

1996, which amended the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990. The USACE is one of the federal members of the Aquatic Nuisance Species (ANS) Task Force, which was established by the 1990 act. Members are charged with preventing the introduction and spread of ANS and monitoring and controlling ANS. The NISA furthered ANS activities by calling for ballast water regulations; the US Coast Guard issued ballast water regulations pursuant to NISA in 2012. Applicable regulations are also listed in Appendix E.

Vectors—Vectors of dispersal may be categorized as passive and active. Actively dispersed species are capable of movement under their own power, whereas the passive dispersal of species is mediated by animals (including humans), wind, or water. Generalist species that produce abundant propagules or offspring and are capable of long-range dispersal are often the most invasive. For this reason, integrated pest management resources often focus limited resources on highly invasive species and their most probable pathways of introduction. The most probable pathways of introduction recognized for the project are: via contaminated material and equipment; via hull fouling and ballast water contamination of marine vessels; and via accidental transport of invasive terrestrial vertebrates as stowaways on boats and freshwater plants on float planes.

Terrestrial Plants—Field studies conducted in the analysis area did not provide any recorded instances of invasive plant species. A search of the AKEPIC online database for invasive plant species occurrences in Alaska shows lambsquarters (*Chenopodium album*) documented in the analysis area at the Diamond Point port. Lambsquarters is evaluated as very weakly invasive by the Invasive Ranking System for Alaska (Carlson et al. 2008); this record dates from pre-1950, and it is unknown if the population still exists (ACCS 2018b).

Reed canarygrass (*Phalaris arundinacea*), orange hawkweed (*Hieracium aurantiacum*), common dandelion (*Taraxacum officinale*), and common plantain (*Plantago major*) are documented along the road system within a mile of the analysis area on the Kenai Peninsula (ACCS 2018b). Reed canarygrass and orange hawkweed are evaluated to be extremely invasive and highly invasive, respectively; common dandelion and plantain are considered modestly and weakly invasive, respectively (Carlson et al. 2008).

Additional invasive species are documented from Port Alsworth on Lake Clark and the village of Igiugig at the outlet of Iliamna Lake. While well outside of the analysis area, these communities have navigable connections to project waters and therefore represent potential source locations for invasive plants.

The most invasive species documented from Port Alsworth are foxtail barley *(Hordeum jubatum*) and smooth brome (*Bromus inermis*); both are evaluated as moderately invasive. Additional species reported from Port Alsworth, listed in decreasing order of potential invasiveness, are: white clover (*Trifolium repens*), common dandelion (*Taraxacum officinale*), timothy (*Phleum pratense*), common sheep sorrel (*Rumex acetosella*), redroot pigweed (*Amaranthus retroflexus*), prostrate knotweed (*Polygonum aviculare*), common plantain (*Plantago major*), common chickweed (*Stellaria media*), shepherd's purse (*Capsella bursa-pastoris*), lambsquarters (*Chenopodium album*), and pineapple weed (*Matricaria discoidea*). These additional species are evaluated as modestly to very weakly invasive (Carlson et al. 2008).

The most invasive species documented from Igiugig was oxeye daisy (*Leucanthemum vulgare*), evaluated to be moderately invasive. Additional species from Igiugig, listed in decreasing order of potential invasiveness, are: creeping buttercup (*Ranunculus repens*), Kentucky bluegrass (*Poa pratensis*), fall dandelion (*Leontodon autumnalis*), common sheep sorrel (*Rumex acetosella*), common chickweed (*Stellaria media*), and pineapple weed (*Matricaria discoidea*). These additional species are evaluated as modestly to very weakly invasive (Carlson et al. 2008).

Freshwater Aquatic Plants—Waterweed (*Elodea* spp.)[1] is the first invasive freshwater aquatic plant documented in Alaska. Waterweed is not known to occur in the analysis area or project watersheds (evaluated at the Hydrologic Unit Code 10 level). Since its discovery in Chena Slough in 2009, infestations have been documented in Fairbanks, Anchorage, Matanuska-Susitna and Kenai Peninsula waterbodies, including the world's busiest floatplane base, Lake Hood (AKEPIC 2018b). Waterweed is evaluated as highly invasive (Carlson et al. 2008); an emergency quarantine was placed against the transport and trade of this plant into and across Alaska in 2014 (SOA 2014).

Plant Pathogens—Plant pathogens include a wide variety of insects and diseases that are often grouped by the part of the plant they attack; for example, leaves (defoliators) or bark (bark beetles). Although pathogen infestation is a natural condition for many plants, introduced plant pathogens are particularly damaging because the target vegetation, which did not co-evolve with the pest, is not equipped with genetic resistance; some of the introduced pathogens cause mortality of the plant; and pathogens are highly mobile organisms whose dispersal is not limited to transportation corridors (USDA 2008).

Birch are preferentially defoliated by birch leaf rollers (*Epinotia solandriana, Caloptilia alnivorella,* and *C. strictella*) and the birch leafminers (*Fenusa pumila*, *Heterarthrus nemoratus* and *Profenusa thomsoni*). Some of these species are native, but climatic conditions may favor outbreaks in some years. Leaf-rolling larvae skeletonize leaves, causing them to curl, brown, and drop prematurely; branch dieback and tree mortality sometimes occurs. The larvae of leaf-mining sawflies eat the chlorophyll, which disrupts a tree's ability to conduct photosynthesis; however, mortality has yet to be observed in Alaska, likely because the majority of damage occurs late in the summer after most tree growth has occurred (USDA 2019).

Marine Species—Marine vessels can introduce nonnative marine species by the discharge of ballast water sourced from other regions or by the inadvertent transport of fouling organisms, which can survive on submerged or wet vessel surfaces such as hulls, anchors, propellers, and sea chests (i.e., biofouling). Although invasive marine species have not been documented in the analysis area, two species are of management concern: European green crab (*Carcinus maenas*), and the carpet sea squirt (*Didemnum vexillum*). An assessment of invasion risk of non-native marine species to the Bering Sea ranked these species as posing the second and fourth highest risk for invasion, respectively (Reimer et al. 2017). The species evaluated as the first and third most invasive are the Pacific oyster (*Crassostrea gigas*) and the Mediterranean mussel (*Mytilus galloprovincialis*). These mollusks are capable of long-distance dispersal and severe habitat modification; however, they are considered a lesser threat to aquatic resources in the analysis area, because climate projections indicate no suitable habitat for reproduction in Bristol Bay and presumably Cook Inlet waters (Reimer et al. 2017).

In Alaska, three species of non-native colonial tunicates, also known as sea squirts, have been documented. Of these species, the population of carpet sea squirt first detected in 2010 and established in Whiting Harbor, Sitka, is of highest concern. Carpet sea squirt is a marine invertebrate filter-feeder capable of rapid and smothering growth over a wide range of marine habitats, including natural substrata, along exposed outer coasts, and at depths up to 266 feet. Carpet sea squirt can be moved between locations as biofouling on vessel hulls, as contaminant in ballast water, and infested aquatic farm gear or infrastructure. Transfers of shellfish stock or equipment may also play a role in spread (Cohen et al. 2011; Bullard et al. 2007; Lambert 2009).

European green crab (*Carcinus maenas*) is found in rocky intertidal and estuarine areas. Green crabs tolerate a wide range of water temperatures and salinities and prey on a wide variety of

[1] Waterweed includes both Canadian waterweed (*Elodea canadensis*) and Nuttall's waterweed (*E. nuttallii*) as these species form fertile hybrids and can be difficult to differentiate by either phenotype or genotype.

marine organisms including commercially important bivalves, gastropods, decapods, and fish (Klassen and Locke 2007). This species has not been documented in Alaska, but is experiencing a range expansion north along the coast of British Columbia. Of greatest concern to Alaska is the potential for larvae to travel north in ocean currents. Human-mediated pathways of dispersal include the aquarium and live food trades, aquaculture, and biofouling[2] of vessel hulls and ballast water (Therriault et al. 2008).

Terrestrial Vertebrate Species—Invasive terrestrial vertebrates are not known from the analysis area; however, the Norway Rat (*Rattus norvegicus*) is identified as a key species for eradication, especially on island ecosystems where migratory and resident bird populations flourish, in part due to low predator pressure. The Norway rat is currently documented from 10 Aleutian Islands and many population centers in Alaska. The Norway rat can breed year-round under favorable conditions; gestation periods are short (21 days) and litter size can reach 14. Rats are omnivores and very opportunistic predators.

Impacts from invasive species are discussed in Section 4.26, Vegetation. Additional information on invasive species trends in the western Alaska region are discussed below under Climate Change.

3.26.3 Alternative 1a

The Alternative 1a analysis area totals 20,092 acres, 18,907 acres (94 percent) of which are vegetated. The extent of the analysis area includes the direct and indirect footprints for all project components; no variants are considered under this alternative. A summary of vegetation types by project component is provided below.

3.26.3.1 Mine Site

Under Alternative 1a, the mine site analysis area is characterized by the dwarf shrub type, representing 56 percent of the area. The dwarf shrub type is dominated by ericaceous shrub and often includes a high component of lichen. Other shrub types collectively comprise 29 percent of mine site (Table 3.26-1). Forested types are not present due to the exposure and elevation of the mine site. Human-caused vegetation disturbance in the area is minimal, and appears to be limited to mineral exploration, all-terrain vehicle (ATV) trails, and campsites (Three Parameters Plus and HDR 2011a).

Table 3.26-1: Alternative 1a—Mine Site Analysis Area Vegetation Types

Vegetation Type	Acres	Percent Area
Dry to Moist Herbaceous	430	4
Wet Herbaceous	605	5
Dwarf Shrub	6,434	56
Open Low Shrub	1,730	15
Open Tall Shrub	381	3
Closed Low Shrub	184	2
Closed Tall Shrub	1,072	9
Other	482	4
Open Water	156	1
Mine Site Analysis Area	**11,472**	**100**

Source: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

[2] The undesirable accumulation of microorganisms, plants, algae and animals on submerged structures (especially ships' hulls).

3.26.3.2 Transportation Corridor

Under Alternative 1a, the transportation corridor includes the 35 miles of the mine access road from the mine site to the Eagle Bay ferry terminal, with a connection to the existing Iliamna/ Newhalen road system, a 28-mile crossing of Iliamna Lake to the south ferry terminal, and a 37-mile port access road between the south ferry terminal and Amakdedori port. It also includes the 1-mile Kokhanok spur road connecting the transportation corridor to the community of Kokhanok and the 0.4-mile explosives storage spur road connecting the mine site access road to a storage pad near the mine site. The transportation corridor includes the segments of the natural gas pipeline that are co-located with access roads. This alternative includes a southern crossing of the Newhalen River.

The transportation corridor analysis area is characterized by the dwarf shrub type, representing 41 percent of the area; other shrub types collectively compose 27 percent. The open/closed forest vegetation type is subdominant, representing 23 percent of the area (Table 3.26-2). Human-caused vegetation disturbance in the area is minimal, and appears to be limited to ATV trails, roads, and building pads near the village of Iliamna, Kokhanok Airport, and the shore of Iliamna Lake (Three Parameters Plus and HDR 2011a).

Table 3.26-2: Alternative 1a—Transportation Corridor Analysis Area Vegetation Types

Vegetation Type	Acres	Percent Area
Dry to Moist Herbaceous	105	1
Wet Herbaceous	152	2
Dwarf Shrub	3,063	41
Open Low Shrub	603	8
Open Tall Shrub	755	10
Closed Low Shrub	34	<1
Closed Tall Shrub	690	9
Open/Closed Forest	1,746	23
Other	112	1
Open Water	233	3
Transportation Corridor Analysis Area	**7,494**	**100**

Source: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

3.26.3.3 Amakdedori Port

The Amakdedori port site includes shore-based facilities at the port and an offshore area for the marine facility with caisson dock design. The Amakdedori port analysis area is dominated by the dwarf shrub type, representing 59 percent of the area. The “other” vegetation type (i.e., partially vegetated or barren land) is subdominant, representing 9 percent. Because the Amakdedori port analysis area extends into Cook Inlet, the area is composed of 10 percent open water (Table 3.26-3). No human-caused vegetation disturbance is reported at Amakdedori.

Table 3.26-3: Alternative 1a—Amakdedori Port Analysis Area Vegetation Types

Vegetation Type	Acres	Percent Area
Dry to Moist Herbaceous	10	9
Wet Herbaceous	1	1
Dwarf Shrub	70	59
Open Low Shrub	1	1
Open Tall Shrub	2	2
Closed Low Shrub	1	1
Closed Tall Shrub	5	4
Other	17	14
Open Water	12	10
Amakdedori Port Analysis Area	**118**	**100**

Source: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

3.26.3.4 Natural Gas Pipeline Corridor

Under Alternative 1a, the 192-mile natural gas pipeline corridor from the Kenai Peninsula to the mine site includes five main segments: 1) Cook Inlet crossing to the Amakdedori port, 2) along the port access road to Iliamna Lake, 3) across Iliamna Lake to Newhalen, 4) overland to connect with the mine access road east of the Newhalen River Crossing, and 5) along the mine access road to the mine site.

Segments of the natural gas pipeline corridor that are co-located with access roads are included in the transportation corridor analysis area. Pipeline-only segments of the natural gas pipeline (i.e., those that are not co-located with road corridors) are addressed here and include: the 1-mile Kenai Peninsula tie-in, the 104-mile Cook Inlet crossing, the 34-mile Iliamna Lake crossing, and the 35-mile alignment from the north ferry terminal to the mine site. The natural gas pipeline corridor is predominantly composed of open water, which represents 78 percent of the analysis area. Open/closed forest comprises 9 percent of the analysis area, and dwarf and open low shrub vegetation each contribute an additional 5 percent (Table 3.26-4).

Table 3.26-4: Alternative 1a—Natural Gas Pipeline Corridor Analysis Area Vegetation Types

Vegetation Type	Acres	Percent Area
Dry to Moist Herbaceous	5	1
Wet Herbaceous	2	<1
Dwarf Shrub	54	5
Open Low Shrub	46	5
Open Tall Shrub	10	1
Closed Low Shrub	2	<1
Closed Tall Shrub	8	1
Open/Closed Forest	89	9
Other	6	1
Open Water	785	78
Natural Gas Pipeline Corridor Analysis Area	**1,007**	**100**

Source: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

3.26.4 Alternative 1

The Alternative 1 analysis area totals 21,395 acres, 20,123 acres (94 percent) of which are vegetated. The extent of the analysis area includes the direct and indirect footprints for all project components, as well as the Summer-Only Ferry Operations, Kokhanok East Ferry Terminal, and Pile-Supported Dock variants. A summary of vegetation types by project component and applicable variants is provided below.

3.26.4.1 Mine Site

The Alternative 1 base case and Alternative 1a have the same direct disturbance footprint at the mine site; however, consideration of the Summer-Only Ferry Operations Variant under Alternative 1 increases the affected area for vegetation by 19 acres. Similar to Alternative 1a, the mine site analysis area under Alternative 1 is characterized by the dwarf shrub type, representing 56 percent of the area, with other shrub types collectively comprising 29 percent (Table 3.26-5).

Table 3.26-5: Alternative 1—Mine Site Analysis Area Vegetation Types

Vegetation Type	Acres	Percent Area
Dry to Moist Herbaceous	432	4
Wet Herbaceous	605	5
Dwarf Shrub	6,449	56
Open Low Shrub	1,730	15
Open Tall Shrub	381	3
Closed Low Shrub	184	2
Closed Tall Shrub	1,072	9
Other	482	4
Open Water	156	1
Mine Site Analysis Area	**11,491**	**100**

Source: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Summer-Only Ferry Operations Variant

Under this variant, increased storage capacity for concentrate containers would be needed at the mine site to facilitate year-round processing operations. The addition of a container storage yard and relocation of a sewage tank pad to accommodate the storage yard increases the affected environment for vegetation at the mine site under Alternative 1. This increase is included in the mine site analysis area presented in Table 3.26-5.

3.26.4.2 Transportation Corridor

Under Alternative 1, the transportation corridor includes the 28-mile mine access road, from the mine site to the north ferry terminal on Iliamna Lake, a 19-mile ferry crossing of Iliamna Lake to the south ferry terminal west of Kokhanok, and the port access road considered under Alternative 1a. Separate spur roads included under Alternative 1 are the 9-mile Iliamna spur road from the mine access road to the existing road system supporting the communities of Iliamna and Newhalen, and the Kokhanok spur road and explosives storage spur road described under Alternative 1a.

The transportation corridor analysis area is dominated by the dwarf shrub vegetation type, which represents 45 percent of the area. Other shrub types collectively contribute an additional 30 percent with the open/closed forest vegetation type subdominant at 17 percent (Table 3.26-6).

Table 3.26-6: Alternative 1—Transportation Corridor Analysis Area Vegetation Types

Vegetation Type	Acres	Percent Area
Dry to Moist Herbaceous	127	1
Wet Herbaceous	175	2
Dwarf Shrub	3,958	45
Open Low Shrub	642	7
Open Tall Shrub	930	11
Closed Low Shrub	57	1
Closed Tall Shrub	946	11
Open/Closed Forest	1,527	17
Other	198	2
Open Water	260	3
Transportation Corridor Analysis Area	**8,820**	**100**

Source: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Kokhanok East Ferry Terminal Variant

This variant considers an alternate south ferry terminal site east of the Village of Kokhanok. Under this variant a crossing of the Gibraltar River would not be required and the number of stream crossings would be reduced. The Kokhanok East Ferry Terminal Variant includes a 20-mile crossing of Iliamna Lake and a 27-mile port access road from the Kokhanok east ferry terminal to Amakdedori port. Spur roads included under this variant are the 5-mile Kokhanok spur road connecting the port access road to the community of Kokhanok, as well as the Iliamna spur road and explosives storage spur road described under Alternative 1a. Inclusion of this variant in addition to the Alternative 1 base case for the transportation corridor increases the affected environment for vegetation by 1,325 acres relative to Alternative 1a. This increased footprint is included in the Alternative 1 transportation corridor analysis area presented in Table 3.26-6.

3.26.4.3 Amakdedori Port

Alternative 1 would incorporate an earthen fill causeway and sheet pile dock design, which increases the open water portion of the analysis area to 28 percent compared to Alternative 1a. The same as Alternative 1a, the vegetation of the Amakdedori port analysis area is dominated by the dwarf shrub type, representing 48 percent of the area, with the “other” vegetation type (i.e., partially vegetated or barren land) subdominant at 9 percent (Table 3.26-7).

Table 3.26-7: Alternative 1—Amakdedori Port Analysis Area Vegetation Types

Vegetation Type	Acres	Percent Area
Dry to Moist Herbaceous	12	6
Wet Herbaceous	2	1
Dwarf Shrub	89	48
Open Low Shrub	1	1
Open Tall Shrub	3	2
Closed Low Shrub	3	2
Closed Tall Shrub	6	3
Open Water	52	28
Other	17	9
Amakdedori Port Analysis Area	**185**	**100**

Source: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Summer-Only Ferry Operations Variant

To support the year-round transport of concentrate from Amakdedori, concentrate transported to the port site during the ferry's operating months would be stored in an expanded container storage yard. Expansion of this storage yard would increase the affected environment for vegetation; this increase is included in the Amakdedori port analysis area presented in Table 3.26-7.

Pile-Supported Dock Variant

Adoption of a pile-supported dock design under Alternative 1 would reduce the in-water footprint of the marine facility, but would have no change on the affected environment for vegetation.

3.26.4.4 Natural Gas Pipeline Corridor

Under Alternative 1 the 188-mile natural gas pipeline corridor from the Kenai Peninsula to the mine site includes four main segments: 1) Cook Inlet crossing to the Amakdedori port; 2) along the port access road to the south ferry terminal; 3) across Iliamna Lake to the north ferry terminal; and 4) along the mine access road to the mine site.

Segments of the natural gas pipeline corridor co-located with access roads are included in the transportation corridor analysis area. Pipeline-only segments of the natural gas pipeline are addressed here, and include: the 1-mile Kenai Peninsula tie-in, the 104-mile Cook Inlet crossing, the 19-mile Iliamna Lake crossing, and the 28-mile north ferry terminal to the mine site.

The natural gas pipeline corridor analysis area is predominantly open water, comprising 89 percent of the analysis area. Collectively, shrub vegetation types are subdominant along the transportation corridor, representing approximately 6 percent of the area (Table 3.26-8).

Table 3.26-8: Alternative 1—Natural Gas Pipeline Corridor Analysis Area Vegetation Types

Vegetation Type	Acres	Percent Area
Dry to Moist Herbaceous	6	1
Wet Herbaceous	2	<1
Dwarf Shrub	39	4
Open Low Shrub	7	1
Open Tall Shrub	3	<1
Closed Low Shrub	4	<1
Closed Tall Shrub	7	1
Open/Closed Forest	20	2
Other	8	1
Open Water	805	89
Natural Gas Pipeline Analysis Area	**900**	**100**

Source: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Kokhanok East Ferry Terminal Variant

Under the Kokhanok East Ferry Terminal Variant, 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 leaves the shoreline to tie into the route from the Kokhanok west ferry terminal site. Construction of this variant would not change the area of the affected environment for vegetation.

3.26.5 Alternative 2—North Road and Ferry with Downstream Dams

The Alternative 2 analysis area totals 20,049 acres, 18,860 acres (94 percent) of which are vegetated. The extent of the analysis area includes the direct and indirect footprints for all project components, as well as the Summer-Only Ferry Operations, Newhalen River North Crossing, and Pile-Supported Dock variants. A summary of vegetation types by project component and applicable variants is provided below.

3.26.5.1 Mine Site

Alternative 2 incorporates an alternative downstream dam construction method for the bulk tailings storage facility and the Summer-Only Ferry Operations Variant, both of which increase the footprint of direct disturbance, and thus the affected area for vegetation at the mine site, by 115 acres relative to Alternative 1a. Similar to Alternative 1a, the mine site analysis area under Alternative 2 is characterized by the dwarf shrub type, representing 56 percent of the area, with other shrub types collectively composing 29 percent (Table 3.26-9).

Table 3.26-9: Alternative 2—Mine Site Analysis Area Vegetation Types

Vegetation Type	Acres	Percent Area
Dry to Moist Herbaceous	448	4
Wet Herbaceous	606	5
Dwarf Shrub	6,503	56
Open Low Shrub	1,737	15
Open Tall Shrub	380	3
Closed Low Shrub	184	2
Closed Tall Shrub	1,072	9
Other	502	4
Open Water	156	1
Mine Site Analysis Area	**11,587**	**100**

Source: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Summer-Only Ferry Operations Variant

Under this variant, greater storage capacity for concentrate containers would be needed at the mine site to facilitate year-round processing operations. The addition of a container storage yard and relocation of a sewage tank pad to accommodate the storage yard increases the affected environment for vegetation at the mine site under Alternative 2; this increase is included in the mine site analysis area, presented in Table 3.26-9.

3.26.5.2 Transportation Corridor

The transportation corridor includes 35 miles of the mine access road from the mine site to the Eagle Bay ferry terminal on the north shore of Iliamna Lake; a 29-mile crossing of the lake to the Pile Bay ferry terminal; and an 18-mile port access road connecting the Pile Bay terminal to the Diamond Point port. This alternative includes a southern crossing of the Newhalen River.

The transportation corridor analysis area is characterized by the open/closed forest type, which represents 39 percent of the area. The dwarf shrub type is subdominant at 24 percent, with other shrub types collectively representing 27 percent (Table 3.26-10).

Table 3.26-10: Alternative 2—Transportation Corridor Analysis Area Vegetation Types

Vegetation Type	Acres	Percent Area
Dry to Moist Herbaceous	150	3
Wet Herbaceous	83	1
Dwarf Shrub	1,371	24
Open Low Shrub	513	9
Open Tall Shrub	268	5
Closed Low Shrub	41	1
Closed Tall Shrub	667	12
Open/Closed Forest	2,278	39
Open Water	177	3
Other	240	4
Transportation Corridor Analysis Area	**5,788**	**100**

Source: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Summer-Only Ferry Operations Variant

To support the year-round transport of concentrate from Diamond Point, concentrate transported to the port site during the ferry's operating months would be stored in an expanded container storage yard. Because space is limited at the Diamond Point port site, this storage yard would be located in the Alternative 2 transportation corridor. This increase is included in the transportation corridor analysis area presented in Table 3.26-10.

Newhalen River North Variant

This variant includes an alternative crossing of the Newhalen River that lies to the north of the crossing location proposed for Alternative 1a. Inclusion of this variant would increase the affected environment for vegetation. This increase is included in the transportation corridor analysis area presented in Table 3.26-10.

3.26.5.3 Diamond Point Port

Alternative 2 proposes a dock with an earthen fill causeway and sheet pile jetty design placed at Diamond Point at the junction of Cottonwood and Iliamna bays. The closed and open tall shrub vegetation types are subdominant at Diamond Point port, collectively representing 33 percent of the area; the dry to moist herbaceous type is subdominant at 11 percent. Because the Diamond Point port analysis area extends into Cook Inlet, 50 percent of the analysis area is open water (Table 3.26-11). The Williamsport terminus of the Williamsport-Pile Bay Road is at the head of Iliamna Bay; otherwise, vegetation in the area is relatively undistributed.

Table 3.26-11: Alternative 2—Diamond Point Port Analysis Area Vegetation Types

Vegetation Type	Acres	Percent Area
Dry to Moist Herbaceous	27	11
Wet Herbaceous	1	1
Open Tall Shrub	33	13
Closed Tall Shrub	50	20
Other	15	6
Open Water	128	50
Diamond Point Port Analysis Area	**255**	**100**

Source: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Pile-Supported Dock Variant

Adoption of a pile-supported dock design under Alternative 2 would reduce the in-water footprint of the marine facility, but would create no change on the affected environment for vegetation.

3.26.5.4 Natural Gas Pipeline Corridor

Under Alternative 3, the 164-mile natural gas pipeline corridor from the Kenai Peninsula to the mine site includes three main segments: 1) Cook Inlet crossing coming ashore at Ursus Cove; 2) north to Diamond Point port; and 3) overland to the mine site, following along the port and mine access roads with a pipeline-only segment between.

Segments of the natural gas pipeline corridor co-located with access roads are included in the transportation corridor analysis area. Pipeline-only segments of the natural gas pipeline are addressed here and include: the mine access road cut-off to Eagle Bay, the port access road cut-off to Pile Bay; Diamond Point port to Ursus Cove; and the 78-mile section from Ursus Cove across Cook Inlet to the Kenai Peninsula. The area also encompasses construction access roads to the natural gas pipeline corridor on the northern side of Iliamna Lake.

The natural gas pipeline corridor analysis area is dominated by the open/closed forest vegetation type, representing approximately 60 percent of the area; open water represents an additional 28 percent of the area (Table 3.26-12).

Table 3.26-12: Alternative 2—Natural Gas Pipeline Analysis Area Vegetation Types

Vegetation Type	Acres	Percent Area
Dry to Moist Herbaceous	33	1
Wet Herbaceous	15	1
Dwarf Shrub	41	2
Open Low Shrub	52	2
Open Tall Shrub	60	2
Closed Low Shrub	3	<1
Closed Tall Shrub	81	3
Open/Closed Forest	1,452	60
Other	17	1
Open Water	666	28
Natural Gas Pipeline Analysis Area	**2,419**	**100**

Source: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

3.26.6 Alternative 3—North Road Only

The Alternative 3 analysis area totals 21,219 acres, 20,077 acres (95 percent) of which are vegetated. The extent of the analysis area includes the direct and indirect footprints for all project components and the Concentrate Pipeline Variant. A summary of vegetation types by project component is provided below.

3.26.6.1 Mine Site

Alternative 3 incorporates the Concentrate Pipeline Variant, which increases the direct footprint of disturbance by 1 acre; however, because expansion the direct disturbance footprint occurs within the area of potential dust deposition, the affected area for vegetation at the mine site is not increased relative to Alternative 1a. Similar to Alternative 1a, the mine site analysis area under Alternative 3 is characterized by the dwarf shrub type, representing 56 percent of the area, with other shrub types collectively composing 29 percent (Table 3.26-13).

Table 3.26-13: Alternative 3—Mine Site Analysis Area Vegetation Types

Vegetation Type	Acres	Percent Area
Dry to Moist Herbaceous	430	4
Wet Herbaceous	605	5
Dwarf Shrub	6,434	56
Open Low Shrub	1,730	15
Open Tall Shrub	381	3
Closed Low Shrub	184	2
Closed Tall Shrub	1,072	9
Other	482	4
Open Water	156	1
Mine Site Analysis Area	**11,472**	**100**

Source: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Concentrate Pipeline Variant

This variant would cause an increase to the size of the mine site by 1 acre associated with an electric pump station. This increased size is included in the analysis area for the mine site presented in Table 3.26-13.

3.26.6.2 Transportation Corridor

Under Alternative 3, the transportation corridor includes the 82-mile north access road from the mine site to the Diamond Point port on Cook Inlet. This alternative includes a slight realignment around Knutson Bay on Iliamna Lake and a southern crossing of the Newhalen River.

The transportation corridor analysis area is dominated by the open/closed forest vegetation type, which represents 57 percent of the area. The dwarf shrub type is subdominant in the transportation corridor, representing approximately 16 percent of the area; other shrub types collectively cover 19 percent (Table 3.26-14).

Table 3.26-14: Alternative 3—Transportation Corridor Analysis Area Vegetation Types

Vegetation Type	Acres	Percent Area
Dry to Moist Herbaceous	159	2
Wet Herbaceous	112	1
Dwarf Shrub	1,360	16
Open Low Shrub	577	7
Open Tall Shrub	276	3
Closed Low Shrub	41	<1
Closed Tall Shrub	776	9
Open/Closed Forest	5,027	57
Other	172	2
Open Water	256	3
Transportation Corridor Analysis Area	**8,757**	**100**

Source: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Concentrate Pipeline Variant

This variant would slightly increase the road corridor width due to the co-location of the concentrate pipeline and the optional return water pipeline in a single trench with the natural gas pipeline at the toe of the road corridor embankment. Construction of the concentrate pipeline would increase the average width of the road corridor by less than 10 percent; construction of the concentrate and water return pipelines would increase the average width of the road corridor by less than 3 feet under typical construction and relative to Alternative 3. The length would be the same as the 82-mile overland portion of the natural gas pipeline. An intermediate booster station would be sited along the road alignment. This estimated increase in footprint is included in the analysis area presented in Table 3.26-14.

3.26.6.3 Port

Alternative 3 proposes a caisson dock design at a port location north of Diamond Point on Iliamna Bay. The closed and open tall shrub vegetation types are subdominant at the port, collectively representing 40 percent of the area. Because the port analysis area extends into Iliamna Bay, 58 percent of the analysis area is open water (Table 3.26-15).

Table 3.26-15: Alternative 3—Port Analysis Area Vegetation Types

Vegetation Type	Acres	Percent Area
Dwarf Shrub	<1	<1
Open Low Shrub	<1	<1
Open Tall Shrub	13	8
Closed Tall Shrub	51	32
Other	3	2
Open Water	92	58
Port Analysis Area	**160**	**100**

Source: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Concentrate Pipeline Variant

Construction of the Concentrate Pipeline Variant would not change the area of the affected environment for vegetation in the Diamond Point port analysis area.

3.26.6.4 Natural Gas Pipeline Corridor

The natural gas pipeline corridor under Alternative 3 follows the same general route from the Kenai Peninsula to the mine site as that for Alternative 2; however, due to greater co-location of the natural gas pipeline with the road corridor, much of the alignment is within the analysis area for the Alternative 3 transportation corridor. Pipeline-only segments of the natural gas pipeline are addressed here and include: the 8-mile segment from the port to Ursus Cove; and the 78-mile section from Ursus Cove across Cook Inlet to the Kenai Peninsula.

The natural gas pipeline corridor analysis area is predominantly open water, representing 77 percent of the area. Collectively, shrub vegetation types are subdominant along the natural gas pipeline corridor, representing approximately 17 percent of the area (Table 3.26-16).

Table 3.26-16: Alternative 3—Natural Gas Pipeline Corridor Analysis Area Vegetation Types

Vegetation Type	Acres	Percent Area
Dry to Moist Herbaceous	31	4
Wet Herbaceous	<1	<1
Dwarf Shrub	27	3
Open Low Shrub	25	3
Open Tall Shrub	51	6
Closed Low Shrub	3	<1
Closed Tall Shrub	44	5
Open/Closed Forest	3	<1
Other	7	1
Open Water	638	77
Natural Gas Pipeline Analysis Area	**830**	**100**

Source: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

3.26.7 Climate Change

Climate change is currently affecting vegetation in the analysis area and throughout Alaska. Observed and predicted effects include changes in plant phenology (Wolken et al. 2011), changes in vegetation community composition from impacts to hydrology, and changes in fire regimes (Calef et al. 2015). Climate models predict that the Bristol Bay region will experience rapid ecological change during the next 100 years. Computer models for climate change consider future "cliomes," areas where temperature and precipitation reflect certain assemblages of wildlife and vegetation. Bristol Bay's current cliome, "boreal forest with coastal influence and intermixed grass and tundra," is expected to shift north, and largely disappear by 2090 (ANTHC 2018). It may be replaced by "prairie and grasslands," a cliome that does not currently occur in Alaska and is characteristic of southeastern Alberta in Canada (SNAP and EWHALE 2012).

Invasive species risk analysis for the Bering Sea cites new patterns vessel traffic, ballast water exchange, and rising ocean temperatures as the factors likely to increase the rate of introductions

and render habitat more suitable for the establishment of non-native marine species (Reimer et al. 2017). Habitat suitability modeling identifies suitable year-round habitat for between 33 and 35 non-native species under the current climate with between 37 to 60 percent of Bering Sea Shelf habitat to become more suitable under mid-century climate conditions (Reimer et al. 2017).

Bristol Bay residents (ANTHC 2018) report changes in vegetation trends due to warmer and wetter conditions, including rapid tree growth and range expansion; new coastal wetlands; and spread of invasive plant species. An inventory of invasive plants conducted in 18 communities in western Alaska between 2012 and 2014 showed a total of 20 invasive plant species found, including the highly invasive rugosa rose (*Rosa rugosa*), found in Chignik Lagoon (Robinette 2015). In addition to documenting the presence of invasive plants, community members were asked about their observations and concerns about vegetation changes near their communities. The most frequently identified concern was linked to increased shrubs, particularly alder, and the potential changes to berry harvest areas. Similar to the Robinette (2015) study, residents in the vicinity of the analysis area report replacement of the tundra and shrub vegetation types by alder and willow shrub over the last decades. In 2013, Nondalton residents reported additional outbreaks of spruce bark beetle and aphids on the Nushagak River (ANTHC 2018).

Higher temperatures are predicted to increase the spread of invasive plant species. Modeled current and future range for 16 invasive plant species with a high to extremely high invasion potential, show. The scenarios modeled showed all 16 species to have current potential ranges in Alaska (Bella 2009). Notably, these predicted ranges exceed the current known species occurrences, indicating that the species are not yet filling their current predicted potential range. Future predicted scenarios show potential invasion ranges in Alaska for all species included. Although only nine of these invasive species are currently found in Alaska and none of the species modeled have been documented in the analysis area, suitable habitat was identified in the same ecoregion as the project for all the evaluated species.