3.2 SOILS

SYNOPSIS

This section describes current conditions and potential impacts related to four subresources:

- Soils types and disturbance/removal;
- Permafrost degradation and hazards;
- Erosion by water, wind, or thermal process; and
- Soil chemical quality, including effects from contaminated sites and fugitive dust.

Each alternative is examined by major project component: Mine Site; Transportation Corridor; and Pipeline.

EXISTING CONDITIONS SUMMARY

Existing soils conditions are described in Section 3.2.2, Affected Environment. Descriptions of soil type, permafrost conditions, erosion, and soil quality/contaminated sites are provided by project component and facilities.

EXPECTED EFFECTS SUMMARY

Alternative 1 - No Action

There would be no new impacts to Soils under the No Action Alternative.

Alternative 2 - Donlin Gold's Proposed Action

Mine Site: Direct impacts associated with the Mine Site would range from changes in soils that may not be measurable or apparent, to acute or obvious changes in the resource character, although the intensity for most effects would be reduced through reclamation or additional mitigation. Examples of effects at incrementally increasing intensities include: minor thaw settlement; best management practices (BMPs) performing effectively at controlling erosion resulting in measurable increases above baseline; and complete soil removal, or permafrost deformation at toe of the waste rock facility (WRF).

Soil removal would result in the irreversible alteration of a total of roughly 9,000 acres of soil and discontinuous permafrost, representing approximately 130 million tons of permafrost soils experiencing thaw effects. The duration of fugitive dust effects would be such that resources would not be anticipated to return to previous levels, potentially accumulating and persisting over the life of the mine and remaining at similar levels following mine closure; whereas the duration of erosion effects could potentially last for months or years until stabilization is achieved. The extent or scope of soil disturbance, permafrost, and erosion effects would be limited to areas within the mine footprint and Project Area boundaries. Fugitive dust effects could be measurable as far as 10 miles from the mine. In terms of context, impacts to soil and permafrost would affect usual or ordinary resources that are widely distributed in the region, but some effects are governed by regulation.

Transportation Corridor: Net overall effects associated with the Transportation Corridor would vary in intensity, and do not consider any effects associated with off-road vehicle (ORV) usage from mine access road infrastructure based on non-compliance rationale with operational plans. The intensity of impacts would be the same as described above for the Mine Site. Examples of effects at incrementally increasing intensities include: soil compaction, or arsenic in road dust at levels similar to baseline; thermal erosion at Angyaruaq (Jungjuk) Port site stockpile, or contaminated soils at Dutch Harbor requiring removal; and complete soil removal at road cuts, or erosion in certain soil types.

Soil disturbances would result in irreversible alteration of roughly 900 acres of surface soil and associated erosion and permafrost (where present), with an estimated 6.9 million tons of permafrost soils experiencing thaw effects, and would be limited geographically to areas within the footprints of the individual infrastructure components. The duration of erosion effects could range from several months to soil degradation that would not be anticipated to return to previous levels. The extent or scope of dust and contaminated sites effects would be limited to areas within the vicinity of individual facility footprints (e.g., dust on order of $1/10^{th}$ mile from road). The context of soil and permafrost effects would be the same as described above for the Mine Site.

Pipeline: Impacts associated with the Pipeline would range from changes in soils that may not be measurable or apparent, to acute or obvious changes in the resource character, although the intensity for most effects would be reduced through effective design, reclamation, access limitations, or other mitigation. Examples of effects at incrementally increasing intensities include: compaction in winter construction areas; thaw settlement and thermal erosion effectively controlled through pipeline design and BMPs; and complete soil removal at right-of-way (ROW) cuts, isolated ROW erosion incidents during construction, or heavy ORV use near Farewell.

Soil disturbances under Alternative 2 would impact a total of approximately 8,350 to 14,100 acres, depending on the amount of additional ROW space needed in areas of challenging ground conditions. Soil disturbance area under the North Option would be the same as the main route under Alternative 2. The extent of soil disturbance, erosion, and contaminated sites effects would be limited to areas within the footprint or immediate vicinity of the ROW and individual infrastructure components. Indirect ORV erosion effects could range from discrete segments of the ROW potentially extending for miles beyond the ROW if used to access new areas. The extent or scope of permafrost effects would be limited along intermittent ice-rich areas, mostly occurring along the north flank of the Alaska Range. Soils and permafrost would be irreversibly altered in areas of higher intensity effects, although the duration of most effects following reclamation would persist until stabilization criteria are met. An estimated 37 million tons of permafrost soils would experience thaw effects. Effects from contaminated sites (e.g., at Farewell airstrip) would last through construction only. The context of soil and permafrost effects would be the same as described above for the Mine Site and Transportation Corridor.

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

Alternative 3A - LNG Powered Trucks

Net overall effects would be similar to Alternative 2. There would be a small reduction in impacts to Kuskokwim River bank soils at relay points due to less low water travel, a reduction in soil and permafrost disturbance at ports by about 10 to 20 acres, and a slight reduction in fugitive dust from less fuel truck traffic on the mine access road.

Alternative 3B - Diesel Pipeline

Net overall effects would be similar to Alternative 2. Up to an additional 900 to 940 acres of soil would be disturbed, depending on selected option, due to the increased length of ROW and associated facilities. There would be no change in permafrost effects, and erosion effects would occur and be managed at the same levels of intensity as those under Alternative 2. There could be an increase in contaminated soils encountered during construction in the Beluga-Tyonek area and at Puntilla airstrip.

Alternative 4 - Birch Tree Crossing (BTC) Port

Net overall effects for soils and permafrost would be similar to Alternative 2. For the Transportation Corridor, the extent of irreversibly altered soils and permafrost (total removal, buried by fill, thaw settlement) would cover about 40 more miles of road and 39 more acres at the port than the proposed action. An estimated 25 million tons of permafrost soil would experience thaw effects, approximately four times that of Alternative 2. There would be greater potential for repeated fill repairs in localized thermokarst areas along the mine access road, and additional soil compaction and permafrost degradation effects beneath 12 miles of ice road. Direct erosion effects would be managed through BMPs similar to Alternative 2, although erosion at the Birch Tree Crossing (BTC) Port site could be of lower intensity due to reuse of berth construction soils in material site reclamation, and there would be less disturbance of riverbank soils due to fewer relay points along the Kuskokwim River. Similar to Alternative 2, effects from ORV use from mine access road infrastructure are not considered based on non-compliance rational with operational plans.

Alternative 5A - Dry Stack Tailings

Overall effects for soils and permafrost would be similar to Alternative 2. There would be a slightly greater area of soil disturbance (about 85 acres more for the Tailings Storage Facility (TSF) and filter plant) and permafrost removal beneath dams (due to larger combined footprints) than Alternative 2. The total amount of thawed permafrost soils would be approximately 150 million tons under Alternative 5 – Lined Option, and approximately 170 million tons under Alternative 5 – Unlined Option, both representing increases over Alternative 2. There would likely be an increase in erosion effects due to increased surface area (up to 60 percent more) exposed to wind and water erosion, and to the complexity of erosion and sedimentation controls (ESCs) and BMPs at the dry stack. The increase in stockpile surface area (12 percent) is expected to be manageable with BMPs. The intensity and duration of dust deposition impacts would be similar to Alternative 2, although a slightly broader distribution of impacts is possible due to a small increase in the amount of dust for the Mine Site as a whole (6.6 percent).

Alternative 6A - Dalzell Gorge Route

Net overall effects would be similar to Alternative 2. Up to an additional 1,300 acres of soil (about 9 percent more than Alternative 2) would be disturbed for the Pipeline due to the greater area of off-ROW surface disturbance. Alternative 6A has a greater lateral extent of permafrost, particularly unstable permafrost, along the ROW (about 10 miles more), but less modeled vertical thaw settlement than Alternative 2, although differences in the amount of geotechnical data and thaw modeling conducted likely accounts for these apparent differences. The estimated amount of thawed permafrost soil under Alternative 6A would be roughly 12 million tons more than under Alternative 2. Alternative 6A is roughly similar to Alternative 2 with respect to erosion susceptibility.

3.2.1 REGULATORY FRAMEWORK

Various laws and regulations pertain to the soils and soil conditions in the Project Area. A preliminary review of public-record documents available from local, state, and federal agencies was conducted to evaluate baseline conditions related to soil quality and past handling and use of hazardous and non-hazardous materials and petroleum products, which resulted in contaminated properties within, adjacent to, and in relative proximity to project components. The various databases and associated regulatory framework used to perform the preliminary review are described in the subsections below, in addition to regulatory requirements pertaining to soil by applicable agencies.

3.2.1.1 EPA

Databases maintained by the U.S. Environmental Protection Agency (EPA) list information regarding environmental cleanup activities for affected lands under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, and impaired waters designated under the Clean Water Act (CWA). Uncontrolled and abandoned hazardous waste sites that are perceived to be a major threat to both surrounding populations and the environment can be placed on the EPA National Priorities List, commonly referred to as the Superfund list; both non-Superfund and Superfund sites are regulated by CERCLA. The Comprehensive Environmental Response and Liability Information System (CERCLIS) is a database maintained by the EPA as part of the Superfund program, and includes potential and confirmed hazardous wastes sites at which the EPA Superfund program has some involvement. The Superfund database (EPA 2013l) provides available information through November 11, 2013.

The review also included CWA Impaired Water Section 303(d) listings for the proposed Project Area. Although these listings directly apply to water bodies, some can be associated with impaired soil conditions resulting in the release of toxic and other deleterious organic and inorganic substances.

3.2.1.2 ADEC

The Alaska Department of Environmental Conservation (ADEC) Contaminated Sites Program has database lists of known contaminated sites and leaking underground storage tanks (LUSTs) throughout Alaska. The database provides information regarding the type of contaminant released to the environment, the type(s) of media (air, water, soil, rock) affected by the contaminant, the Potential Responsible Party for cleaning up the documented release, and the location where the release occurred (ADEC 2013a). Lands within the Contaminated Sites Program are regulated under Title 18 of the Alaska Administrative Code (AAC) Chapters 75 and 78 (18 AAC 78) (ADEC 2012a, 2012b). ADEC oversees regulatory compliance work at contaminated sites, from discovery to site characterization and overall cleanup process (ADEC 2009). The ADEC database has four different rankings of site status: Open (characterization or remediation ongoing), Cleanup Complete (Closed), Open with Institutional Controls, and Cleanup Complete with Institutional Controls. Institutional Controls may include: maintenance of physical or engineering measures to limit an activity that might interfere with cleanup or that might result in exposure to a hazardous substance at the site; restrictive covenants, easements, deed restrictions, or other measures that limit site use or conditions over time, or provide notice of any residual contamination; and, zoning restrictions or land use planning by a local government with land use authority (ADEC 2012a).

Stormwater Pollution Prevention Plans (SWPPPs) are required to mitigate soil erosion during construction and operations as part of the Alaska Pollutant Discharge Elimination System (APDES) permitting program implemented by ADEC. The APDES program manages erosion induced discharge criteria to receiving waters for compliance with Section 402 of the CWA. Concerns include, but are not limited to, dredged soil, mining wastes, rock, sand, dirt, and runoff from construction activities. Permits establish allowable discharge limits and other conditions (monitoring and compliance) to ensure that water quality is protected. Multiple plans addressing various aspects of stormwater pollution discharge from disturbed surfaces (soil) and other Donlin Gold Project components would detail applicable erosion control measures, monitoring, reclamation, and mitigation measures (i.e., best management practices [BMPs]).

3.2.1.3 PHMSA

Permafrost-bearing soils can be susceptible to thermal degradation and ground movement via settlement. Soils most susceptible to these processes are considered thaw unstable soils. Segments of pipeline where the magnitude of differential settlement is anticipated to be greatest will likely occur between transitions to and from thaw unstable soil. For these reasons, strain-based pipeline design and associated permitting for differential ground movement may be required by the U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA). Strain-based pipeline serviceability and safety considerations include pipe diameter and wall thickness, material strength, and load stress-strain under longitudinal plastic deformation (strain greater than 0.5 percent). This pipeline will require safety conditions beyond the requirements of the present gas pipeline code (49 Code of Federal Regulations [CFR] Part 192). The conditions will include design, pipeline materials, construction, and operations and maintenance (O&M) practices to ensure that measures are in place to mitigate strains in areas where strains are anticipated to approach or be above 0.5 percent.

3.2.1.4 OTHER

In addition to ADEC, soil erosion is regulated by several other entities. The Alaska Department of Natural Resources (ADNR) also has applicable regulations regarding certain soil disturbances derived from Donlin Gold Project related activities. These include, but are not limited to various land use permit requirements and reclamation planning. ADNR approval of these permits and plans would be required prior to initiating activities. Plan objectives would address mitigation measures, control features, and reclamation activities compatible with approved land uses.

The Alaska Department of Fish and Game (ADF&G) provides guidelines for stream bank erosion control, and regulates work that may impact fish streams. During Closure and post-Closure, stream banks would be reclaimed to conditions per ADF&G guidelines and ADNR bonding and reclamation requirements.

Details regarding specific regulatory required plans applicable to soil throughout the Donlin Gold Project are presented in Section 3.2.3, Environmental Consequences.

3.2.2 AFFECTED ENVIRONMENT

This section presents a description of soils for the Mine Site (Section 3.2.2.1), Transportation Corridor (Section 3.2.2.2), and Pipeline (Section 3.2.2.3) components of the Donlin Gold Project. The following overview includes information available regarding the types of soil, presence or absence of permafrost, erosion characteristics, soil quality and contaminated sites with regard to each proposed component.

3.2.2.1 MINE SITE

3.2.2.1.1 SOIL TYPES

There are numerous soil studies and literature resources pertinent to the Donlin Gold Project study area. The available information is based on variety of soil classification criteria used to satisfy the practical needs of each study performed. For these reasons, variations in soil descriptions exist amongst the resources available. Soil descriptions derived from geotechnical studies are typically based on the Unified Soil Classification System (USCS) that categorizes mineral and organic soils based on particle-size characteristics and texture, properties that affect their use and physical behavior in construction. The U.S. Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) provides a variety of baseline soil data intended to assist in land resource planning and management, including classifications based on soil taxonomy, drainage, slopes, vegetative growth potential, and suitability for various land uses and development. Soil descriptions based on Donlin Gold Project geotechnical studies are provided in Section 3.1, Geology, in the discussion of Mine Site surficial deposits. NRCS soils descriptions are presented below.

Based on available NRCS data applicable to the Mine Site, two specific soil map units exist within the Mine Site area (NRCS 2008). These are shown on Figure 3.2-1. Each map unit is made up of the major soils components for which it is named, plus one or more minor components that, because of the scale used, were not mapped separately. The map units at the Mine Site and their corresponding major soil types are provided in Appendix F. These consist mostly of silty gravelly soils associated with colluvium, loess, and weathered bedrock on upland slopes; and loamy, gravelly and silty soils associated with the floodplains and stream terraces along Crooked Creek.

Site-specific field taxonomic classification data was collected for approximately half of the Mine Site in support of a Preliminary Jurisdictional Wetlands Determination (3PPI et al. 2012). The study area data set is located north of the pit, and captures the dominant soil types observed. A total of 23 soil types were identified in the Mine Site area, of which three types accounted for approximately three-quarters of total soils documented. These three soil types and the corresponding percent of the mapped area covered by each, are:

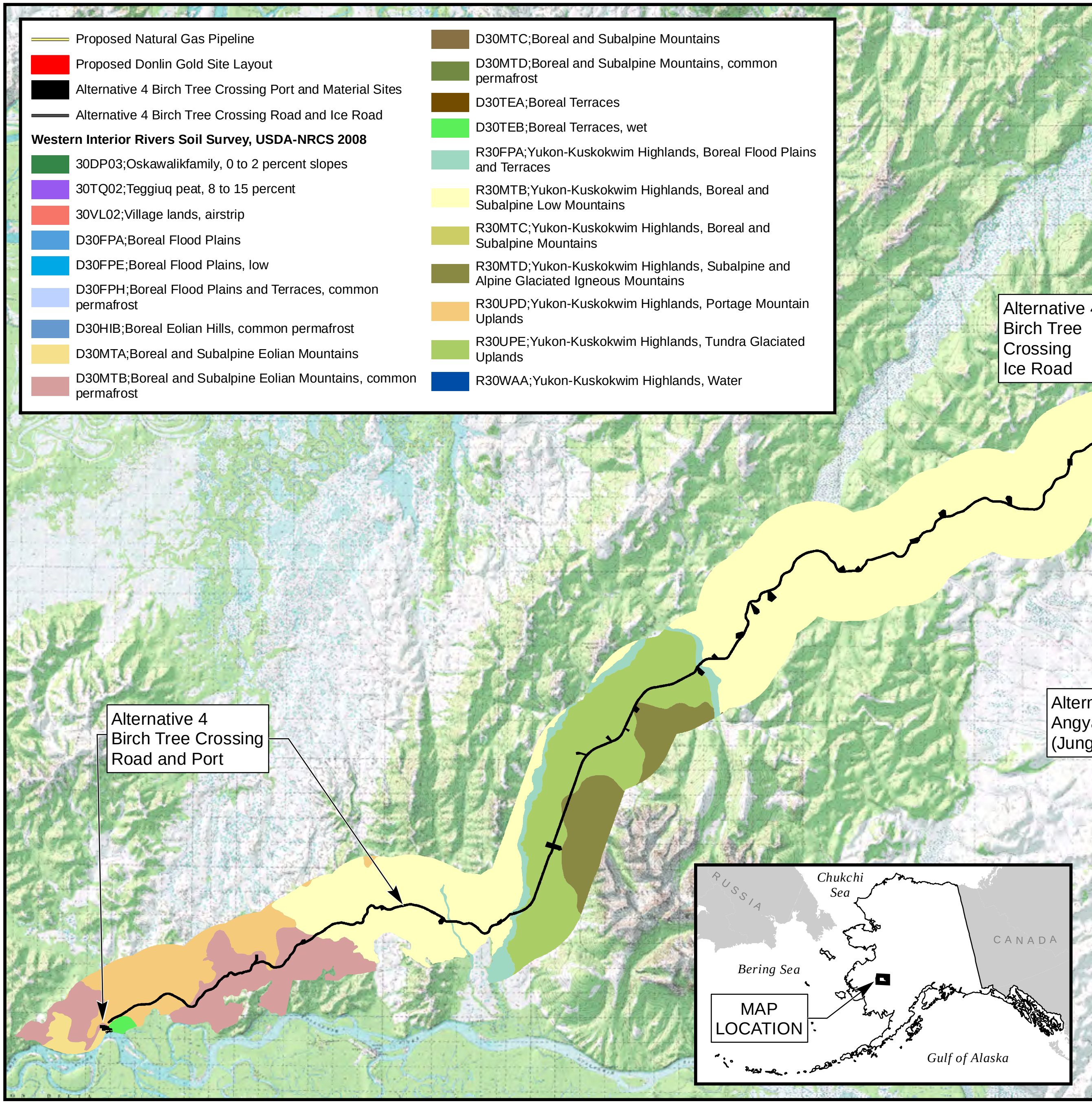
- Hemic Glacistel – 41 percent: Glacistels are typically associated with Boreal Scrub and organic plains.
- Typic or Lithic Dystrocryept – 26 percent: Typic Dystrocryepts are associated with shoulder slopes, saddles, and footslopes or toeslopes. Lithic Dystrocryepts have a lithic or bedrock contact within 20 inches of the soil surface.
- Glacic Historthel – 7 percent: Historthels are typically associated with footslopes with open black spruce forest-shrub and spruce woodlands-shrub.

3.2.2.1.2 PERMAFROST

Permafrost is soil or rock that is at or below the freezing temperature of water for two or more years. Regionally, the Mine Site is located in an area characterized by discontinuous, moderately thick to thin permafrost in fine-grained soils, and isolated masses in coarse-grained soils (Ferrians 1965, 1994).

The approximate distribution of permafrost in the Mine Site area was compiled by Donlin Gold, LLC based on recorded field observations in test pits and boreholes (BGC 2006, 2009a, 2011d) (Figure 3.2-2). Slope angle and aspect strongly influence solar radiation exposure, and therefore, permafrost distribution. For this reason, permafrost is more prevalent on north and east facing slopes. Permafrost also tends to be more prevalent in lower topographic features such as valley bottoms, drainages and toeslopes. In the Mine Site area, vegetation tends to decrease with increasing elevation, reducing surface insulation. Consequently, these higher elevations tend to have thinner permafrost. Ice-rich permafrost is generally limited to overburden soils, and is often associated with the presence of peat and its insulating properties. High-ice-content soils and soils exhibiting ice segregation are generally associated with silt-bearing materials, although visible ice crystals can also exist in frozen gravelly materials (BGC 2006). Thin, discontinuous ice lenses, where present and measured in surficial deposits, range from 0.4 to 2 inches thick (BGC 2009a).

An average seasonal frost depth of 6.6 feet exists in the Mine Site, but can vary from approximately 1.5 feet to 14 feet. Where present, a mean permafrost depth of approximately 19 feet was determined for the area, with reported depths ranging from approximately 7.5 feet to 105 feet near Anaconda Creek (BGC 2006). Although permafrost is generally limited to overburden soils, it occasionally extends into bedrock. Investigation at roughly one-quarter of the subsurface exploration sites encountered conditions where permafrost extended to the soil-bedrock interface. At approximately two-thirds of these locations, permafrost was limited to overburden materials, and in the remaining one-third, extended to depths of 6.6 to 10 feet into the weathered bedrock.



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SOIL TYPES AT MINE SITE AND MINE ACCESS ROADS

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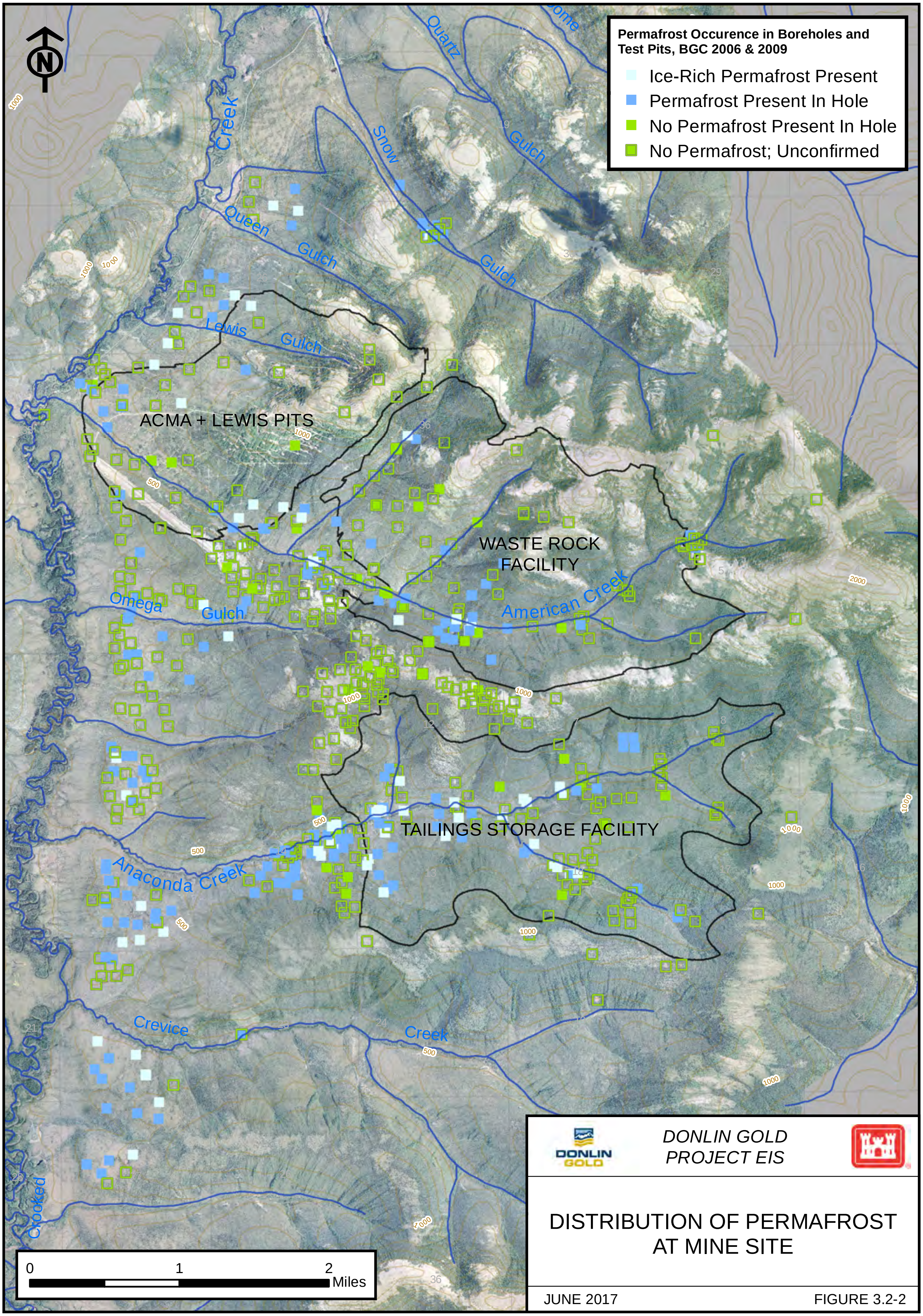
FIGURE 3.2-1



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DISTRIBUTION OF PERMAFROST AT MINE SITE

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FIGURE 3.2-2

3.2.2.1.3 EROSION

Discontinuous permafrost, windy conditions, and unconsolidated overburden materials at the Mine Site create the potential for thermal, wind, and hydraulic erosion.

Thermal erosion of ice-rich permafrost soils can lead to ground subsidence, slope instability and drainage alteration. Removal or disturbance of any overlying organic mat and vegetative materials can accelerate permafrost degradation rates. Developed thermokarst topography associated with permafrost instability is present along Crooked Creek and the lower benches of the Project Area, and along the Crooked Creek floodplain from Donlin Creek to below Crevice Creek. Thermokarst is also present along interfluve areas between gulches or drainages on lower benches (BGC 2005).

Wind erosion is the process of wind blowing away soil, silt, fine sand, or vegetation that is light enough to become airborne and deposited at a different location. The rate of soil displacement depends on weather conditions (wind velocity, precipitation, and temperature) as well as soil type and slope. Deforestation, excavation, and road construction increase the rate of wind erosion. These actions also impact drainage patterns and soil compaction, leading to exposure of mineral soil and a potential increase in hydraulic erosion. Wind erosion reduces the capacity of the soil to store nutrients and water, thus making the environment drier and affecting the porosity and permeability of the soils.

Two measures of soil susceptibility to wind erosion are used to describe soils present throughout the Project Area based on review of available NRCS information. One measure includes NRCS "hazard of erosion" descriptions ranging from none (i.e., n/a) to, slight, moderate, and severe as shown in Appendix F. Another measure includes published wind erodibility group (WEG) values listed in applicable tables where no hazard of erosion description is available. The WEG is assigned to groupings of soils that have similar properties affecting their resistance to soil blowing in cultivated areas, which is similar to wind erosion susceptibility and dust potential following surface alteration. The WEG is based on properties of the soil surface layer and ranges from 1 through 8. Lower numbers are generally associated with greater susceptibility to erosion. For example, non-cohesive homogeneous sands susceptible to wind erosion could have a WEG value of 1, whereas bedrock, frozen soils, or saturated soils (e.g., muskegs) could have a WEG value of 8.

Hydraulic erosion is the removal and transport of soils by rainfall and flowing water. Specific conditions affecting hydraulic erosion vulnerability include inherent soil properties (cohesion), slope and flow velocities, and vegetative cover. Silt and sand soil types are generally more susceptible to various types of erosion than gravels and coarser material. Slope length and grade substantially influence soil erosion rates (Warren et al. 1989). Removal of protective surface organics also accelerates erosion processes in underlying non-cohesive soils.

Three NRCS measures are used to describe soil susceptibility to hydraulic erosion via runoff for different soil types. These include erosion hazard descriptions (e.g., n/a, slight, moderate, and severe), K-factor value, and T-factor value. Hazard of erosion descriptions are preferentially used in applicable tables for soil components where available (e.g., Appendix F). In the absence of hazard of erosion descriptions, K- and T-factor values are provided in applicable tables. K-factor is a relative index of soil susceptibility to particle detachment (erosion) and transport due to runoff. T-factor is a soil loss tolerance index used to describe soil sensitivity (productivity) to erosional losses.

Erosion factor K_w (K) indicates the erodibility of the whole soil. K-factors are grouped into 14 class values ranging from 0.02 to 0.69, where greater values are representative of increased erodibility. Values of K greater than 0.4 generally tend to produce higher rates of runoff and erosion (IWR 2002). With the exception of organic soils, NRCS assigns a K_w value for each soil horizon present at depth within the soil component, often resulting in multiple K_w values. The $K_{w(max)}$ value referenced in applicable tables represents the highest K_w value in soils extending to 18 inches below ground surface. This approach allows for a comparison of the erodibility of shallow surface soils most likely to be impacted by project-related disturbances, and is considered conservative since the greatest K_w value may not be representative of dominant soil horizons in the 18-inch interval evaluated.

Alternatively, the soil loss tolerance factor (T-factor) is used to describe soil sensitivity to erosional losses. The T-factor is defined as the maximum amount of annual erosion in tons per acre at which the quality of the soil can be maintained for plant growth; these values are commonly used as objectives for conservation planning purposes. T-factors range from one to five tons per acre soil loss (annual); are assigned to soils without respect to land use or cover; and represent a goal for maximum sustainable soil loss. Greater T-factor values correspond with soils that can tolerate more soil loss and maintain vegetation productivity. Higher values generally indicate deeper, more erosion-resistant soils; and lower values indicate thinner, more erosion-susceptible soils.

Erosion descriptions listed in Appendix F for soil map units in the Mine Site area range from slight to severe for water-caused erosion, assuming that the organic mat has been removed (NRCS 2008). The hazard of erosion for the least prevalent soil map unit, located along Crooked Creek (R30FPA), is slight. The most prevalent soil map unit in the upland part of the Mine Site (R30MTC) ranges from moderate to severe, with gravelly colluvial slopes exhibiting the highest susceptibility to water erosion. Wind erosion susceptibility, a measure of potential for airborne dust if soil is disturbed, ranges from slight to moderate for Mine Site soil types.

3.2.2.1.4 SOIL QUALITY/CONTAMINATED SITES

Review of the CWA Impaired Water Section 303(d) listings indicated that no such waterbody listings are present within the Mine Site project boundaries. Review of the CERCLIS database indicated that no known federally funded Superfund sites are present within the Mine Site project boundaries. Review of the ADEC Contaminated Sites database indicates no identified contaminated sites in the Mine Site area.

Elevated background concentrations of certain elements or compounds in soils at the Mine Site could result in adverse concentrations in vegetation or water that could potentially be derived from stripped overburden and fugitive dust associated with Mine Site activities. A summary of baseline concentrations and summary statistics of inorganic compounds in soils in the vicinity of the Mine Site are listed in Table 3.2-1. The distribution of baseline sample locations is shown in Figure 3.2-3.

While not currently applicable to the Mine Site, ADEC soil cleanup levels, which are administered through the State's Contaminated Sites Program, are listed in Table 3.2-1 for comparison purposes to provide a framework for understanding existing conditions. One element, arsenic, is naturally elevated in baseline soils for all statistics compared to ADEC levels. The arithmetic mean is notably higher for this constituent than the geomean, indicating that the distribution of data is skewed and the arithmetic mean is sensitive to concentrations at the higher end of the distribution. In other words, there are a small number of high concentrations compared to the bulk of concentrations centered around the geomean value, which cause the arithmetic mean to be higher.

High arsenic levels in soils from natural mineralized and volcanic sources are common in Alaska (e.g., Gough et al. 1988), and are present near the Mine Site as it is a component of the ore deposit (Section 3.7, Water Quality). Individual arsenic sample results are listed by watershed in Appendix F (Table F-5a). The highest concentrations are present in watersheds within and north of the Mine Site (Queen, Ruby, Snow, Dome, Quartz, and Ophir), and appear to follow a halo-type trend around intrusive rocks and associated bedrock mineralization shown on Figure 3.1-3. Constituents exceeding the ADEC levels in both baseline soils and predicted fugitive dust are further evaluated in Section 3.2.3.2.4.

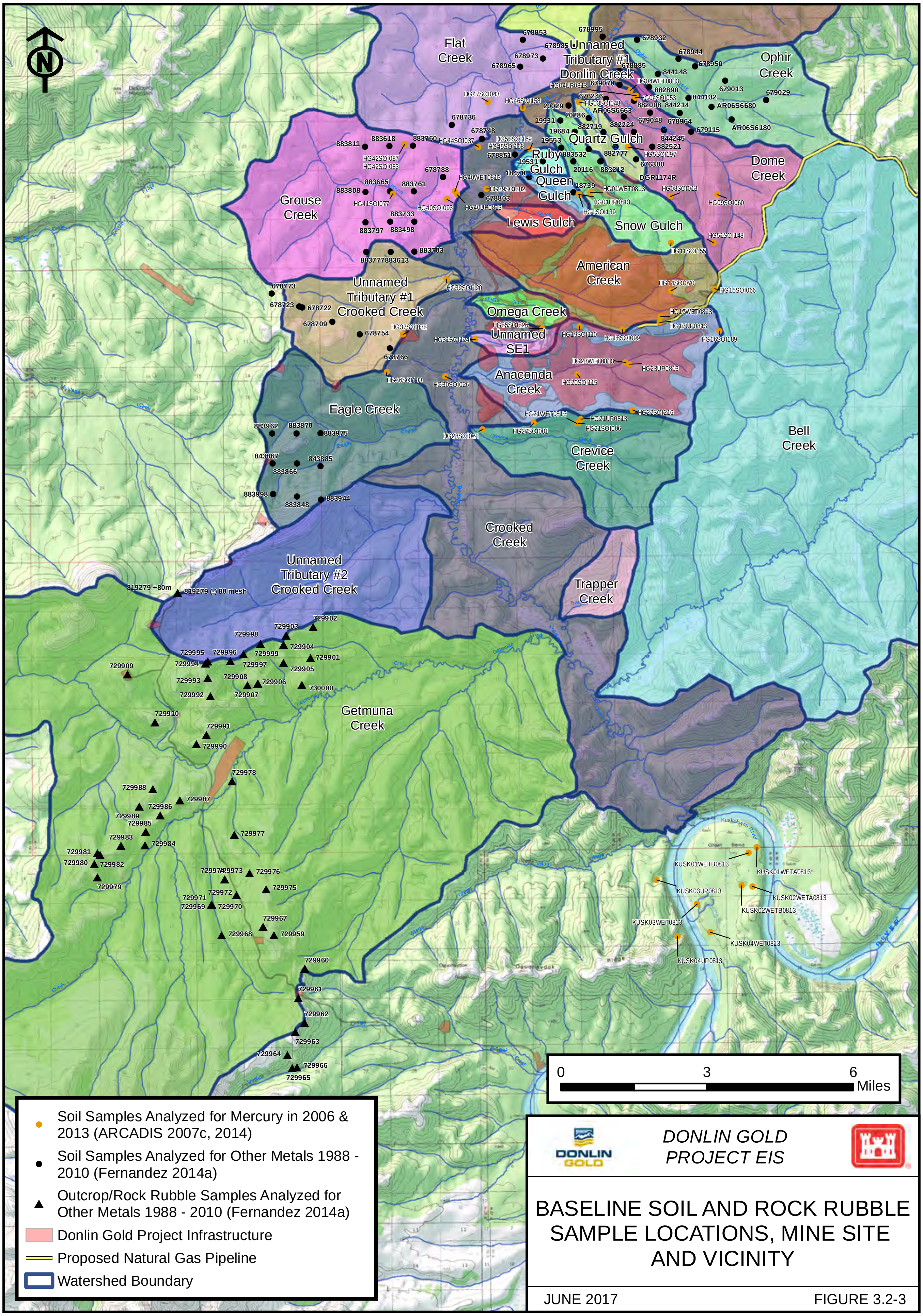
Table 3.2-1: Concentrations of Inorganics in Baseline Soils, Mine Site and Vicinity

Analyte[1]	Mean[2] (ppm)	Standard Deviation[2] (ppm)	95% UCL[2] (ppm)	Geometric Mean[3] (ppm)	ADEC Soil Cleanup Level[4] (ppm)
Antimony	5.35	11.1	11.1	2.08	41
Arsenic	78.8	177	169	23.9	8.8
Barium	480	294	640	380	20,000
Beryllium	0.963	0.504	1.07	0.66	200
Cadmium	0.245	0.195	0.289	0.23	92
Cobalt	13.5	4.7	14.5	12.7	-
Chromium	58.1	27.8	63.9	52.7	100,000[5]
Copper	33.9	36.9	54.1	26.3	4,100
Lead	12.9	6.1	14.0	12.0	400
Manganese	525	195	567	491	-
Mercury	0.212	0.342	0.415	0.123	30/10[6]
Nickel	33.9	18.4	37.7	31.1	2,000
Selenium	2.07	0.72	2.27	1.94	510
Silver	0.369	1.05	0.909	0.17	510
Thallium	0.535	0.203	0.592	1.36	1.0
Uranium	2.41	0.61	2.59	3.23	-
Vanadium	80.7	36.4	88.3	72.5	510
Zinc	91.7	27.7	97.4	88.7	30,000

Notes:
1 Baseline data sources: For all metals except mercury, data from Fernandez (2014a: Donlin Soil Samples 20140825.xlsx); n = 64 to 73. For mercury, data from ARCADIS (2007c, 2014); n = 54. Rubble/outcrop data not included.
2 For arithmetic mean, standard deviation, and 95% UCL, datasets with non-detects estimated by the Kaplan-Meier (KM) method.
3 Geomean estimated using 1/2 the detection limit for non-detects.
4 18 AAC 75: Method Two, Under 40-inch Zone, Human Health (ADEC 2017b).
5 Total chromium concentrations were compared to chromium III guidelines since chromium VI rarely occurs naturally and the majority of total chromium in baseline soils is expected to be in the most stable form, chromium III (ATSDR 2012).
6 Mercury guidelines are shown as mercuric chloride/methylmercury.

Shaded cells = Baseline concentrations exceed ADEC soil cleanup levels.

Abbreviations:
- Not available
N number of samples
95% UCL 95 percent upper confidence limit on the mean
ADEC Alaska Department of Environmental Conservation



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BASELINE SOIL AND ROCK RUBBLE SAMPLE LOCATIONS, MINE SITE AND VICINITY

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FIGURE 3.2-3

Another element, thallium, is elevated in baseline soils for only the geometric mean. This is likely due to statistical methods used in incorporating non-detect results into the data set. A number of individual thallium results were non-detect using relatively high detection limits (10 ppm) compared to the ADEC level, and non-detect results were included in the geometric mean result using half the detection limit (or 5 ppm). The Kaplan-Meier method used for incorporating non-detects into arithmetic means and upper confidence limits (UCL) in Table 3.2-1 is based on EPA guidance (Singh and Singh 2013), and is specifically formulated to handle environmental sample sets skewed with non-detect results.

Hydrocarbons and cyanide, which are typically associated with mine activity, and therefore could be constituents of concern, are not known to be present in natural soils and vegetation at the Mine Site. No baseline data have been collected for these constituents in soils, because there have been no reported or suspected adverse soil conditions from hydrocarbons or cyanide from past and current project developments that would warrant sampling for these constituents (Weglinski 2015f).

3.2.2.2 TRANSPORTATION CORRIDOR

3.2.2.2.1 SOIL TYPES

Surficial deposits and geotechnical investigations conducted by Donlin Gold along the proposed Angyaruaq (Jungjuk) and BTC Port site alternatives are described in Section 3.1, Geology. NRCS soil types for these areas and other transportation components are summarized below.

<u>Angyaruaq (Jungjuk) and Birch Tree Crossing Mine Access Roads and Port Sites</u>

Based on available NRCS data, a total of five soil map units coincide with the Angyaruaq (Jungjuk) mine access road and six with the BTC mine access road (NRCS 2008). The distribution of these units is shown on Figure 3.2-1, and their corresponding soil types are provided in Appendix F. The identified units are representative of reconnaissance and detailed reconnaissance level mapping (3PPI et al. 2012).

The first 20 miles of road corridor leading from the proposed Mine Site, where the Angyaruaq (Jungjuk) and BTC mine access roads follow the same route, pass through soil unit R30MTB, which consists of loamy and gravelly soils associated with colluvium, loess, and weathered bedrock on upland slopes. The south half of the Angyaruaq (Jungjuk) mine access road is dominated by the same silty gravelly colluvial soil unit (R30MTC) present at the Mine Site. Soil types at the Angyaruaq (Jungjuk) Port site include silty and loamy soils associated with eolian slopes (loess) and floodplains adjacent to the Kuskokwim River. The western half of the potential BTC mine access road route is dominated by glaciated upland soils (R30UPE) along the northwest flank of the Russian Mountains; coarse-loamy eolian deposits (D30MTB) in boreal and subalpine mountains; and silty to coarse-loamy cryoturbate soils (R30UPD) in uplands at the potential BTC mine access road terminus.

<u>Crooked Creek Winter Road</u>

A single-season winter ice road, under Alternative 4, would be developed from the Mine Site to the vicinity of Crooked Creek Village. The temporary ice road would support simultaneous construction of the BTC mine access road from opposing ends. A total of six soil types are present along the proposed winter road alignment, of which one is common to the Angyaruaq (Jungjuk) and BTC mine access road alternatives, and two are shared with the Angyaruaq (Jungjuk) mine access road alternative (Figure 3.2-1). The three soil types exclusive to the temporary ice road alignment are limited to loamy alluvium deposits (D30FPA and 30DP03) and organic materials over silty eolian deposits (30TQ02). These soil types are found on relatively low angle slopes, and represent only a slight percentage of the total soils encountered along the alignment. These three soil types are limited to within 1 mile of the ice road terminus near the Village of Crooked Creek.

Bethel Port Site and Floodplain

Bethel area soil is typically composed of alluvial floodplain deposits of the Kuskokwim River consisting of silt, sand, and gravel interlayered with organic peat and wood (Dorava and Hogan 1995). The uplands bordering the Kuskokwim floodplain are generally underlain by fluvial sand and silt deposits (Hinton and Girdner 1967, 1975). The soil map unit associated with the Bethel area and Kuskokwim River floodplain, which also applies to both upstream port site alternatives, is Histic Pergelic Cryaquepts-Typic Cryofluvents, loamy nearly level association (USDA-SCS 1979). This unit and its principal components (Appendix F) include both poorly drained soils with permafrost on lower portions of the floodplain, and well drained soils on natural levees along existing and former river channels with deeper permafrost. Any actions that would occur at Dutch Harbor or the Port of Bethel at the Bethel Yard Dock are not part of the proposed action, and are considered connected actions (see Section 1.2.1, Connected Actions, in Chapter 1, Project Introduction and Purpose and Need).

Dutch Harbor

Surface materials in the Dutch Harbor area generally consist of glacial sediment and till, often overlain with soil containing ash and lapilli layers of volcanic tephra (Lemke and Vanderpool 1995). The soil horizon is often shallow, and can vary from 1.5 feet to 5 feet thick. The soil map unit (IA2) detailed in Appendix F is representative of soils present in lowlands and coastal margins where existing Dutch Harbor port facilities are situated (USDA-SCS 1979). Volcanic bedrock at the Delta Western fuel farm on Amaknak Island lies at depths as shallow as 1 to 6.5 feet (ADEC 2013b). Any actions that would occur at Dutch Harbor or the Port of Bethel at the Bethel Yard Dock are not part of the proposed action, and are considered connected actions (see Section 1.2.1, Connected Actions, in Chapter 1, Project Introduction and Purpose and Need).

3.2.2.2.2 PERMAFROST

Angyaruaq (Jungjuk) Road and Port Site

The northern half of the Angyaruaq (Jungjuk) mine access road alignment contains intermittent permafrost in boggy soils along the Crooked Creek floodplain near the Mine Site (Recon 2007a, 2011a). Frozen colluvial silt over weathered broken bedrock, both with occasional visible ice, is also present along slopes ascending to Juninggulra Mountain ridge lines (Recon 2007a).

Permafrost is generally absent along most of the southern half of the Angyaruaq (Jungjuk) mine access road alignment. Where present, permafrost is generally associated with fine-grained materials and silt-bearing sand and gravel mixtures. There are few occurrences of permafrost north of the North Fork Getmuna Creek, and the Getmuna Creek drainage itself contains no evidence of permafrost (Recon 2011a).

Near the southern end of the Angyaruaq (Jungjuk) mine access road, discontinuous permafrost is prevalent in low sloping, silt-bearing soils in the lower Jungjuk Creek area within 0.6 miles of the port site. Documented permafrost thicknesses in this area vary from near ground surface to 20 feet below ground surface. Visible ice volume estimates range from 1 to 50 percent (Recon 2011a).

Discontinuous permafrost at the Angyaruaq (Jungjuk) Port site exists from near surface to depths greater than 35 feet (DMA 2007b; Recon 2007b). Visible ice volume estimates range from 10 to 40 percent. Fine-grained soils with moderate ice content in this area can be extremely unstable during thaw degradation conditions (Recon 2011a).

Birch Tree Crossing Road and Port Site

Discontinuous permafrost was encountered along the BTC route alternative during a mid-summer geotechnical subsurface investigation program performed in 2007 (DMA 2007a). A total of 92 test borings were completed along the alignment from Crooked Creek to mile 73.8 near the potential BTC Port site. Permafrost conditions exist or have the potential to exist at approximately 60 of the 92 boring locations (65 percent). The 60 boring locations encountered frozen soil at depths greater than an assumed active layer thickness of approximately 6 to 7 feet, or had frozen soil conditions at the maximum borehole depth if less than 7 feet. Of borings advanced to depths of 10 feet or greater, approximately 45 borings exhibited frozen soil conditions at or deeper than 10 feet. Frozen soil conditions along the alignment varied from near ground surface to depths greater than 40 feet. Approximately 32 of the soil boring locations were either ice-free, or exhibited seasonal ice conditions associated with the active layer.

Similar to the Angyaruaq (Jungjuk) mine access road alignment, discontinuous permafrost is present along the Crooked Creek floodplain and flats, before the alignment ascends into upland slopes and ridge tops, that are generally thawed, to approximately 10.5 miles from the Mine Site. Intermittent permafrost conditions resume over ridge saddles, crests, and side slopes to approximately 15.5 miles from the Mine Site. Permafrost generally becomes more prevalent under similar terrain to the Iditarod River floodplain crossing, located approximately 33.5 miles from the Mine Site. The segment from Iditarod River floodplain crossing to Cala Poco Creek (at 40 miles) traverses segments of prevalent thermokarst terrain inundated with thick organic mat soil horizons and ice-rich, fine-grained soils.

Intermittent, discontinuous permafrost proceeds beyond the proposed Owhat River crossing, through generally flat or gradual sloping terrain that includes multiple creek floodplains, muskegs, varying degrees of thermokarst, and outwash plains. Clean sand and gravel mixtures, such as those present in the Owhat River floodplain, are often free of frozen soil conditions. Where preset, permafrost conditions vary from ice-rich, silt-bearing materials to thawed colluvium and alluvium. The presence of white massive ice was observed in silt materials in one boring located approximately 50.5 miles from the Mine Site near the route's Owhat River crossing.

Permafrost becomes substantially more intermittent along road segments between 55 and 69 miles from the Mine Site. Ice-free borings are most common along this segment of the potential BTC mine access road alignment. Subsurface conditions indicative of permafrost again become more prevalent near the end of the alternative route terminus at approximately 73.8 miles from the Mine Site.

Crooked Creek Winter Road

Although permafrost occurrence and distribution along the Crooked Creek Winter Road alignment has not been studied in detail, occurrence and distribution similar to documented conditions at the Mine Site, and the Jungjuk mine access road alignment and Port site, are anticipated. Common conditions shared between these investigated areas include, but are not limited to: soil types; terrain; and topography. The temporary nature and intended purpose of the ice road is to minimize surficial disturbances.

Permafrost is most likely to be prevalent at the southern terminus of the potential Crooked Creek winter road based on similar conditions and investigations performed at the Angyaruaq (Jungjuk) Port site. This includes fine-grained soils with moderate ice content, consistent with Tegguiq peat (30TQ02), and Oskawalik family (30DP03) soils. Permafrost is anticipated to extend from near surface to depths of 35 feet or greater.

Prevalent discontinuous permafrost likely exists in the low sloping topography dominated by fine-grained soils that extend north from the potential Crooked Creek terminus. Permafrost would be likely to become less prevalent and more intermittent as the landscape transitions northward to toeslopes of adjacent upland terrain, and coarser material mixtures. Furthermore, permafrost occurrence would be expected in lower valley bottoms and toeslopes of drainages, depending on soil types and slope aspects. An example would be soil type D30FPA, which is a coarse loamy alluvium associated with floodplains.

Bethel

Bethel is located near the southern extent of the discontinuous permafrost zone (Ferrians 1965, 1994). The Bethel Port site (a connected action) is located on the side of the Kuskokwim River, where silt and sandy silt in upland deposits contain abundant permafrost (Wilson et al. 2013), and permafrost there has been documented to depths ranging from approximately 375 to 600 feet (Dorava and Hogan 1995). The depth to the top of permafrost in undisturbed areas around Bethel typically ranges from 1 to 4 feet below the surface; however, permafrost is absent altogether in localized areas (“thaw bulbs”) close to the Kuskokwim River (Bethel Planning Department 1983). At the Bethel Fuel Sales’ tank-farm facility located approximately 30 feet above the west bank of the Kuskokwim River shoreline, the top of permafrost ranges from 3 feet to over 50 feet below ground surface, and the active layer ranges from approximately 3 to 6 feet in depth (Busey et al. 2000). A thaw bulb is present beneath the Kuskokwim River and on the east side of the river, but is unlikely to extend inland of the west cut bank side of the river (Waller 1957; Dorava and Hogan 1995). Any actions that would occur at Dutch Harbor or the Port of Bethel at the Bethel Yard Dock are not part of the proposed action, and are considered connected actions (see Section 1.2.1, Connected Actions, in Chapter 1, Project Introduction and Purpose and Need).

Dutch Harbor

Unalaska (Dutch Harbor) is located in an area that is generally considered free of permafrost (Ferrians 1965, 1994). Any actions that would occur at Dutch Harbor or the Port of Bethel at the

Bethel Yard Dock are not part of the proposed action, and are considered connected actions (see Section 1.2.1, Connected Actions, in Chapter 1, Project Introduction and Purpose and Need).

3.2.2.2.3 EROSION

Various geologic processes that cause erosion are described in Section 3.2.2.1.3. Factors contributing to accelerated erosion can include, but are not limited to human or animal activities or major natural events such as wildfires (NRCS 2008). Erosion mechanisms typical of road construction activities include hydraulic and thermal erosion. Soil susceptibility to erosion associated with each part of the Transportation Corridor components is described below.

Angyaruaq (Jungjuk) Mine Access Road and Port Site

Available NRCS erosion descriptions for soil map units along the Angyaruaq (Jungjuk) mine access road alignment range from slight to severe for water-induced erosion, assuming the organic mat has been removed (NRCS 2008) (Appendix F). Soil types with severe ratings for water erosion are associated with colluvium and loess on slopes. Hydraulic erosion potential would be variable along the Angyaruaq (Jungjuk) mine access road, as slopes of varying grades and aspects are present, as well as multiple minor stream crossings (Recon 2011a). Wind erosion hazards for soils of the Angyaruaq (Jungjuk) mine access road range from slight to severe, the latter of which are associated with loess soils and silty floodplains.

Pronounced thermal erosion would be most likely to occur in the low sloping, silt-bearing soils near the Angyaruaq (Jungjuk) Port site, where discontinuous ice-rich permafrost is most prevalent. Up to 3 feet of settlement can be expected based on observed, naturally occurring thaw degradation processes (Recon 2011a). As noted below, however, the potential for thermal erosion along the Angyaruaq (Jungjuk) mine access road is lower than along the BTC mine access road, as thermokarst terrain is not present along the Angyaruaq (Jungjuk) mine access road corridor.

Birch Tree Creek Road and Port Site

The potential for hydraulic erosion along the first 20 miles of the BTC mine access road alignment would be the same as that of the coincident Angyaruaq (Jungjuk) mine access road alignment in this area. Available NRCS water erosion descriptions for soil map units along the BTC mine access road alignment range from slight to severe, assuming removal of the organic mat (NRCS 2008) (Appendix F). Soil types with severe ratings for water erosion are associated with colluvium, coarse loamy materials, and loess on slopes. Wind erosion hazards for BTC mine access road soils range from slight to severe, the latter of which is associated with loess soils, loamy eolian deposits, and silty floodplains.

The potential for thermal erosion exists along multiple segments of the potential BTC mine access road alignment based on the presence of frozen silt-bearing soil conditions. Hummocky terrain associated with naturally occurring thermokarst conditions is present along numerous segments of the potential BTC mine access road alignment. These conditions often coincide with ice-rich fine-grained soils overlain by an appreciable organic-rich cover (DMA 2007a). Removal or disturbance of any overlying organic mat and vegetative materials can increase permafrost degradation rates and secondary effects associated with hydraulic erosion or accelerated erosion mechanisms (e.g., construction).

Crooked Creek Winter Road

Available NRCS erosion descriptions for soil map units along the potential Crooked Creek Winter Road alignment range from slight to severe for water-induced erosion (NRCS 2008) (Appendix F). Soil types with severe ratings for water erosion are associated with colluvium and loess on higher gradient slopes. NRCS (2008) water erosion ratings generally assume that the organic mat has been removed. Soils most susceptible to thermal erosion are most likely to occur in the low sloping, silt-bearing soils near the Crooked Creek Village ice road terminus where discontinuous ice-rich permafrost is likely to be most prevalent.

Bethel

No water or wind erosion classifications have been established for Bethel soil types in the literature (USDA-SCS 1979 or Hinton and Girdner 1975). Overall, soils in the Bethel area and the Kuskokwim floodplain range from poorly drained organic material over permafrost or loamy materials, to well drained stratified sand, silt, and loamy mixtures (Appendix F). The Susitna soil series in the Bethel area exists on nearly level topography, and dominant gradients are generally less than one-half percent. The soils are well drained to moderately well drained (Hinton and Girdner 1967). The silty material is highly susceptible to frost action and the permafrost table is generally near the surface. Disturbance or removal of the insulative organic materials can facilitate thaw, which is often followed by subsidence and thermal erosion. Based on the dominant fine-grained composition of these soils, susceptibility to water and wind erosion is likely, dependent on localized physical conditions such as vegetation and/or disturbance, slope aspects, and soil cohesion characteristics. Any actions that would occur at Dutch Harbor or the Port of Bethel at the Bethel Yard Dock are not part of the proposed action, and are considered connected actions (see Section 1.2.1, Connected Actions, in Chapter 1, Project Introduction and Purpose and Need).

Dutch Harbor

No water or wind erosion classifications have been established for Dutch Harbor soil types in the literature (USDA-SCS 1979). Surface materials in the Dutch Harbor area generally consist of unconsolidated materials that overlie shallow bedrock interface ranging in depth from 1.5 to 5 feet. The materials generally consist of glacial sediment and materials of volcanic origin (Lemke and Vanderpool 1995). Unstable and potentially unstable unconsolidated material slopes are limited to tills and undifferentiated materials over bedrock. These surface materials can be susceptible to soil failure and subsequent erosion processes during periods of heavy rainfall, where failure is attributed to the presence of till materials at depth (ADNR 1986). Since the Dutch Harbor area is located outside the geographic distribution of discontinuous permafrost, thermal erosion processes are assumed to be non-existent (Ferrians 1965). Any actions that would occur at Dutch Harbor or the Port of Bethel at the Bethel Yard Dock are not part of the proposed action, and are considered connected actions (see Section 1.2.1, Connected Actions, in Chapter 1, Project Introduction and Purpose and Need).

3.2.2.2.4 SOIL QUALITY/CONTAMINATED SITES

Review of the federal CWA Impaired Water Section 303(d) listings indicated that no known impacted watersheds are present within the localities of the project's Transportation Corridor components. Review of the CERCLIS database indicated that neither are any known federally funded Superfund sites present within the Transportation Corridor areas.

Review of the ADEC Contaminated Sites database indicated a total of 126 contaminated sites in the project's transportation areas, in several communities along the Kuskokwim River corridor and in Dutch Harbor on Unalaska Island. Of these, about 50 are located within about ¼ mile of possible tank farm / port locations on the Kuskokwim River and in Dutch Harbor. Figure 3.2-4 and Figure 3.2-5 present the locations of the nearby sites, and their names and locations relative to the project, as well as cleanup status are listed in Appendix F.

Kuskokwim River Corridor

In the Bethel area, 38 known release sites were identified. Of these, 13 are located either within the Bethel Port site or within ¼-mile of the port site or Kuskokwim River (Figure 3.2-4). Of the sites, 6 are conditionally closed, 2 are conditionally closed with institutional controls, and 5 remain in an open status. One site is located within the Bethel port site boundaries. Listed as Bethel Fuel Sales (ADEC Hazard ID# 2127), this site experienced a petroleum release to the ground surface near a fill tank. Soils were excavated and land farmed on site, and ADEC issued a Cleanup Complete status for the site.

Several sites about ½-mile northeast of the Bethel Port site are within ¼-mile of the river. These sites, shown on Appendix F, are cross-gradient to the proposed port site. Three additional sites associated with underground storage tanks (USTs) or fuel spills at the Bethel Hospital, were identified slightly further than ¼-mile northwest of, and hydraulically upgradient from, potential Bethel Port site locations. However, given the presence of permafrost in the area, the low gradient topography, and distance from the project site, these locations do not appear to be major potential sources of impairment to the Project Area. All other ADEC sites for the Bethel area are greater than 1 mile from the Project Area or are hydraulically cross-gradient or downgradient from the Project Area, and do not appear to pose a risk of substantial environmental impairment. Any actions that would occur at Dutch Harbor or the Port of Bethel at the Bethel Yard Dock are not part of the proposed action, and are considered connected actions (see Section 1.2.1, Connected Actions, in Chapter 1, Project Introduction and Purpose and Need).

Other communities that have contaminated sites located within ¼ mile of the Kuskokwim River include Napakiak, Napaskiak, Kwethluk, Akiachak, Akiak, Tuluksak, Lower Kalskag, and Aniak. A total of 24 contaminated sites in these communities are within ¼ mile of the Kuskokwim River, and are listed in Appendix F. Of these, nine are conditionally closed, one is conditionally closed with institutional controls, and 14 remain open. The source of contamination at most of the sites is primarily attributed to petroleum hydrocarbon releases. Release sources include, but are not limited to: fuel farms; above-ground storage tanks (ASTs) and USTs; and fueling systems. Fuel-impacted soil and / or groundwater conditions exist at many of the open sites. Other minor contaminants include metals and pesticides.

Two sites were listed in the CERCLIS database for the Aniak area within a ¼-mile of the river Transportation Corridor. One of the sites, listed as USDOI BLM Kolmakof Mine, is located on the Kuskokwim River about 20 miles upstream of Aniak, and formerly produced mercury from cinnabar. It is a federal facility and is not listed on the National Priorities List. The other site, listed as White Alice Communication-School Facility, was transferred from the Air Force to the State of Alaska and is not listed on the National Priorities List.

The Red Devil Mine located approximately 30 miles upstream of Crooked Creek (e.g., Figures 3.7-4 and 3.7-12 in Section 3.7, Water Quality) is listed in the CERCLIS database. The site is an abandoned mercury mine predominantly impaired with elevated concentrations of mercury, antimony, arsenic, and organic compounds. Impairments associated with this site pose no environmental concern to soils within localities of the project's Transportation Corridor components. Potential waterbody influences; however, are presented in Section 3.7, Water Quality.

A database search for the Dutch Harbor area produced 71 known contaminated sites. Search criteria were limited to the main Dutch Harbor area and did not include all sites on Unalaska Island. Currently, the Project-specific tank farm expansion site has not been chosen. However, existing tank farms and docks at Dutch Harbor, Rocky Point, and the west side of Iliuliuk Bay (Figure 3.2-5) were assumed to be likely candidates for the purposes of this analysis, as they handle ongoing fuel shipments in the area (Oasis Environmental and Kinnetic Laboratories 2006). Thus, distance and direction estimates are provided in Appendix F relative to these locations.

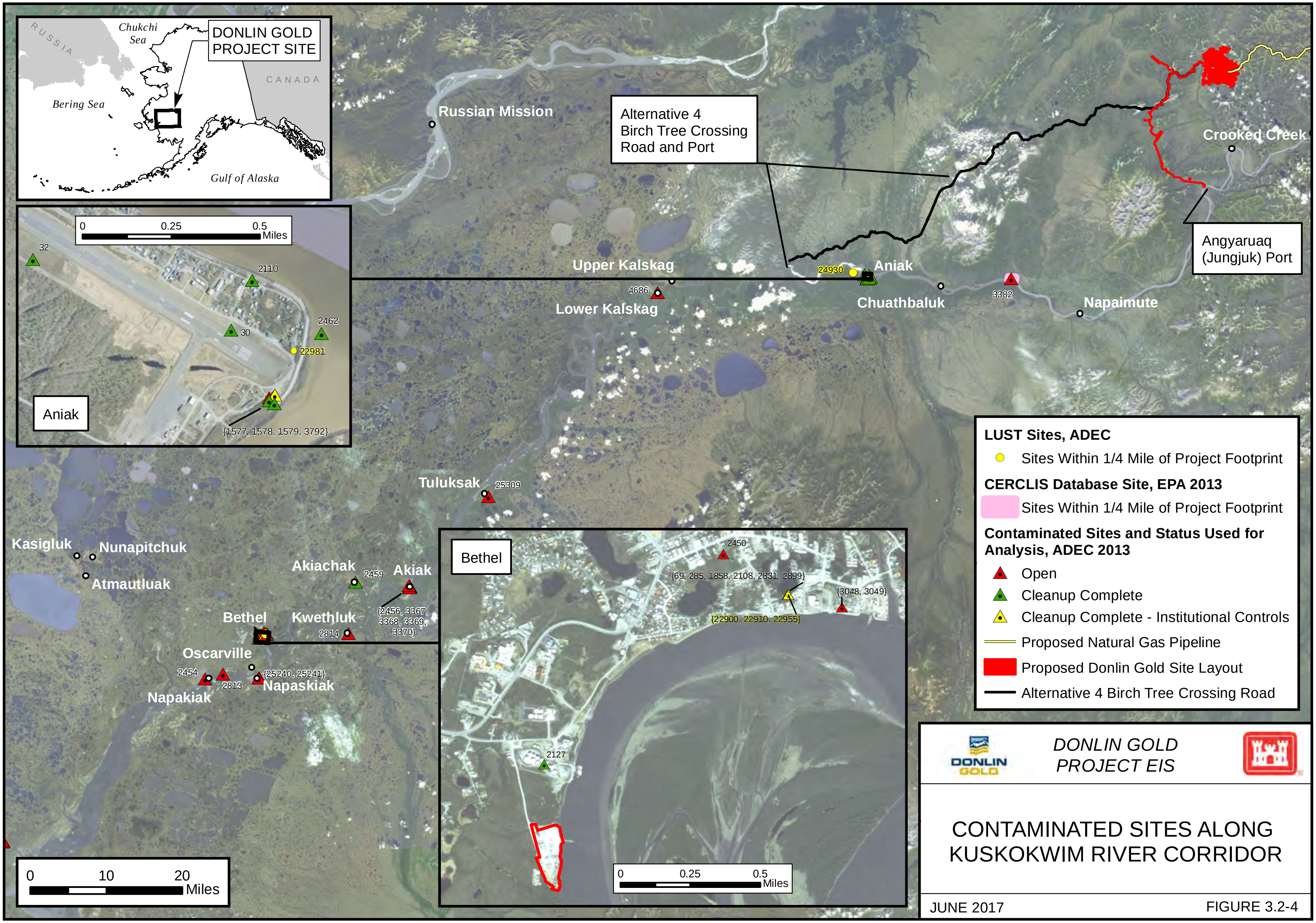
Of the 71 total ADEC sites listed for Dutch Harbor, 17 are located within about ¼ mile of existing tank farms and docks (Figure 3.2-5 and Appendix F). Two of these are listed as cleanup complete, one as Cleanup Complete with Institutional Controls, and the rest as currently open. One site was listed on the CERCLA Database search for the Dutch Harbor area. Referred to as the Dutch Harbor Sediment Site, this site contains contaminated sediments related to numerous historic petroleum spills in and near the harbor related to fuel shipping and handling. It is not a federal facility and is not listed on the National Priorities List.

3.2.2.3 PIPELINE

3.2.2.3.1 SOIL TYPES

Surficial deposits and geotechnical investigations conducted by Donlin Gold along the Pipeline route are described in Section 3.1, Geology. Additional soil details have been compiled for the project corridor in the Pipeline Plan of Development (SRK 2013b) based on terrain mapping and geotechnical analyses as summarized in Section 3.1, Geology. These additional soil details are summarized in tabular format in Appendix F. NRCS soil types associated with the Pipeline are described below.

The NRCS (1998) Soil Survey of the Yentna Area, Alaska is the most current and detailed regional-level soils mapping resource available for the eastern segment of the Pipeline alignment. Soil survey information is available from the terminus of the diesel Pipeline alternative at Tyonek to milepost (MP) 0, and from MP 0 to approximately MP 78 of the eastern Pipeline segment. The Pipeline corridor crosses about 30 different soil map units in the Yentna survey area. Map units are presented on Figure 3.2-6 and soil descriptions in Appendix F.



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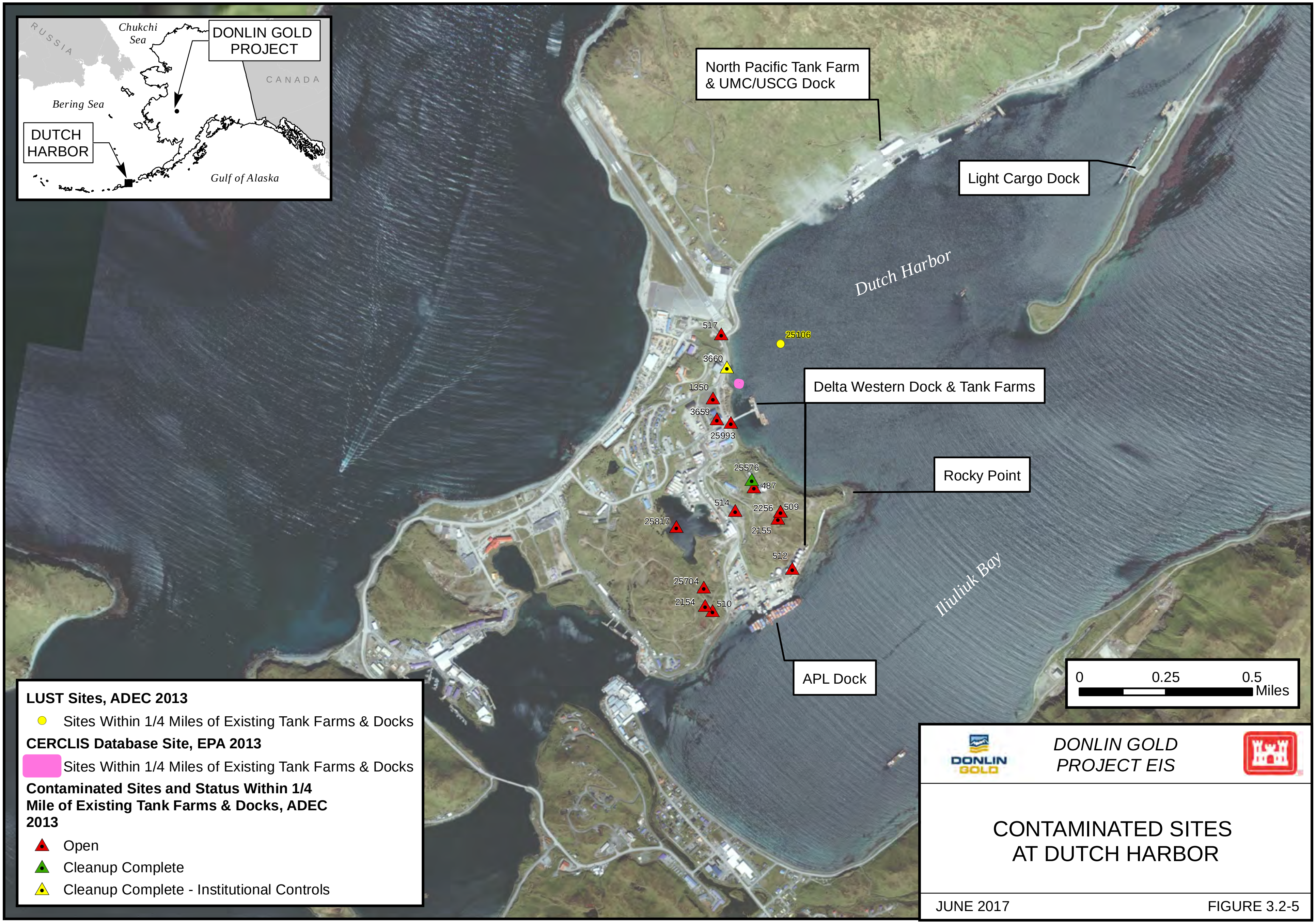
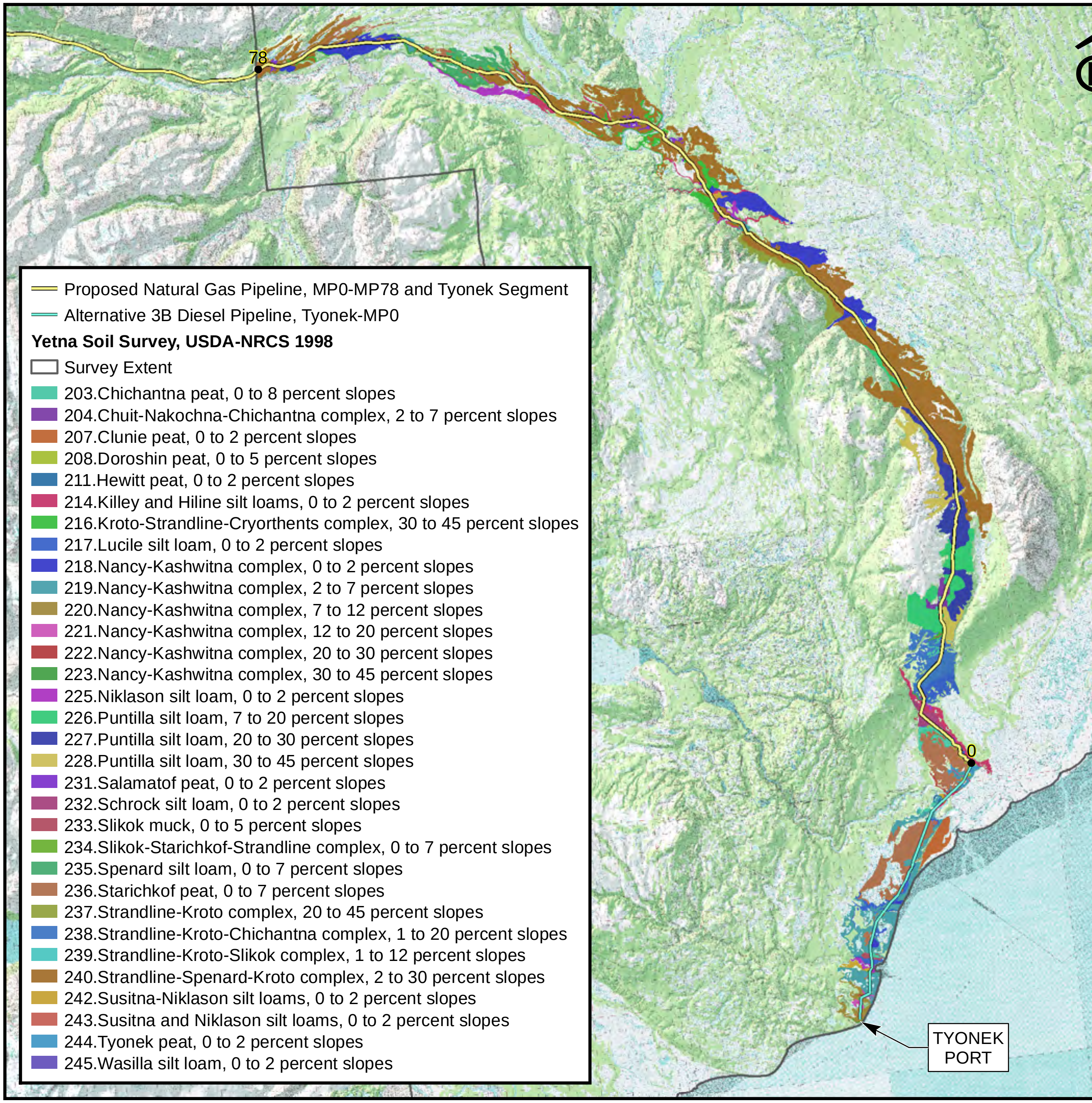
CONTAMINATED SITES ALONG KUSKOKWIM RIVER CORRIDOR

JUNE 2017

FIGURE 3.2-4



DONLIN GOLD PROJECT
DUTCH HARBOR
RUSSIA
Chukchi Sea
CANADA
Bering Sea
Gulf of Alaska
North Pacific Tank Farm & UMC/USCG Dock
Light Cargo Dock
Dutch Harbor
Delta Western Dock & Tank Farms
Rocky Point
Iliuliuk Bay
APL Dock
517
25106
3660
1350
3659
25993
25576
487
514
2256
509
25817
2155
512
25704
2154
510
0 0.25 0.5 Miles
LUST Sites, ADEC 2013
Sites Within 1/4 Miles of Existing Tank Farms & Docks
CERCLIS Database Site, EPA 2013
Sites Within 1/4 Miles of Existing Tank Farms & Docks
Contaminated Sites and Status Within 1/4 Mile of Existing Tank Farms & Docks, ADEC 2013
Open
Cleanup Complete
Cleanup Complete - Institutional Controls
DONLIN GOLD
DONLIN GOLD PROJECT EIS
CONTAMINATED SITES AT DUTCH HARBOR
JUNE 2017
FIGURE 3.2-5



DONLIN GOLD
DONLIN GOLD PROJECT EIS

SOIL TYPES ALONG EASTERN PIPELINE SEGMENT

JUNE 2017 FIGURE 3.2-6

Available soil survey coverage in the central portion of the Pipeline corridor is primarily limited to general-level soils information provided in the State Soil Geographic Database (STATSGO) for Alaska that is based on mapping conducted by the USDA Soil Conservation Service (SCS) in 1979 and revised in 2011 (USDA-SCS 1979, USDA 2011). This source incorporates information from major and current public-domain resource datasets for Alaska. About 20 soil map units from the STATSGO survey have been identified in the central segment of the Pipeline corridor. Map units are presented on Figure 3.2-7 and soil descriptions in Appendix F.

The most comprehensive and current regional soils mapping resource for the western end of the Pipeline corridor is the NRCS (2008) Soil Survey of the Western Interior Rivers Area, Alaska. The area of coverage extends from approximately MP 270 to the western route terminus at the Mine Site. Soil survey information applicable to this segment is considered reconnaissance level or detailed reconnaissance level mapping. Two soil map units from this survey have been identified along the Pipeline corridor (Figure 3.2-8). These are the same as those described for the Mine Site in Section 3.2.2.1.1.

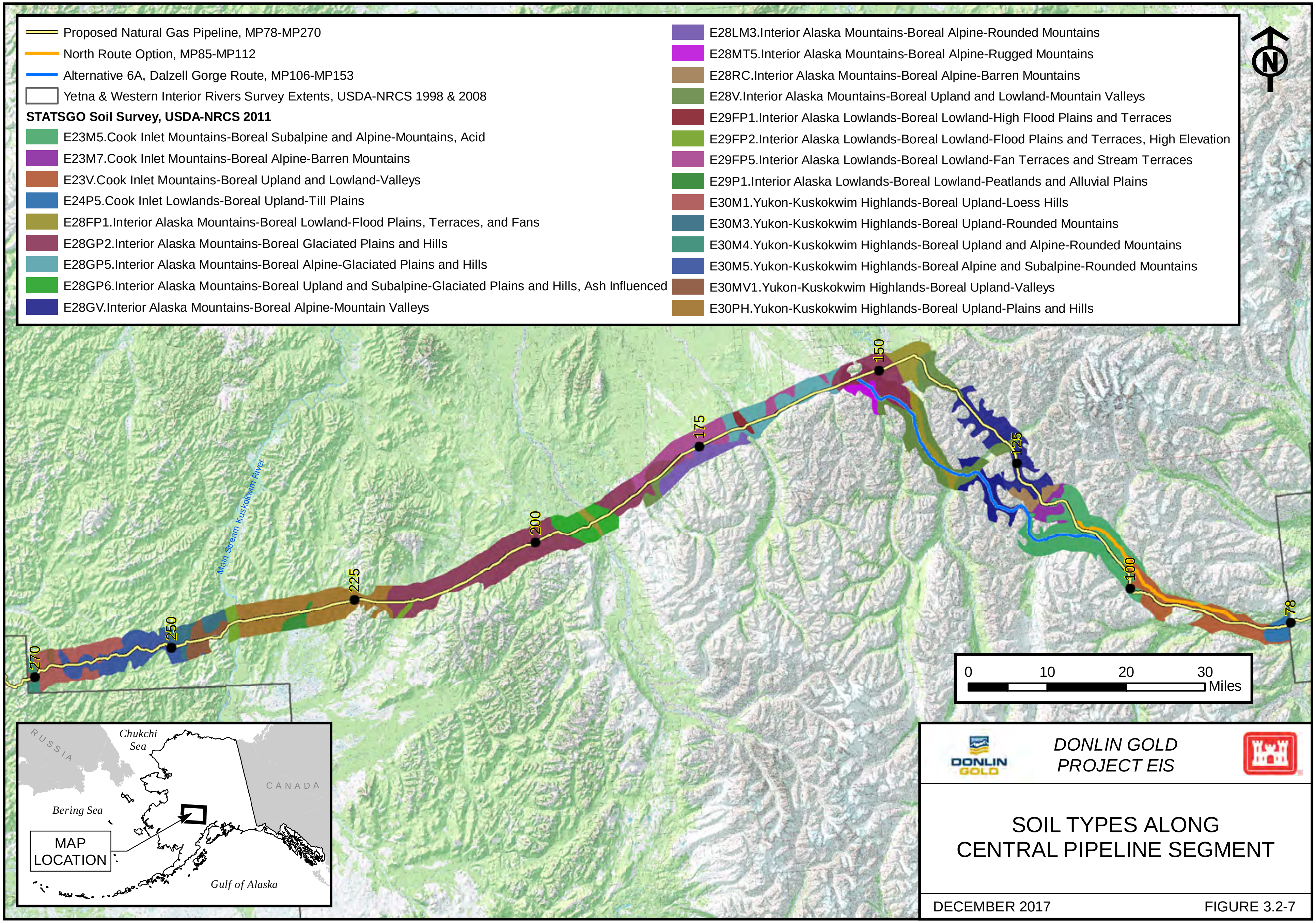
3.2.2.3.2 PERMAFROST

Permafrost Distribution

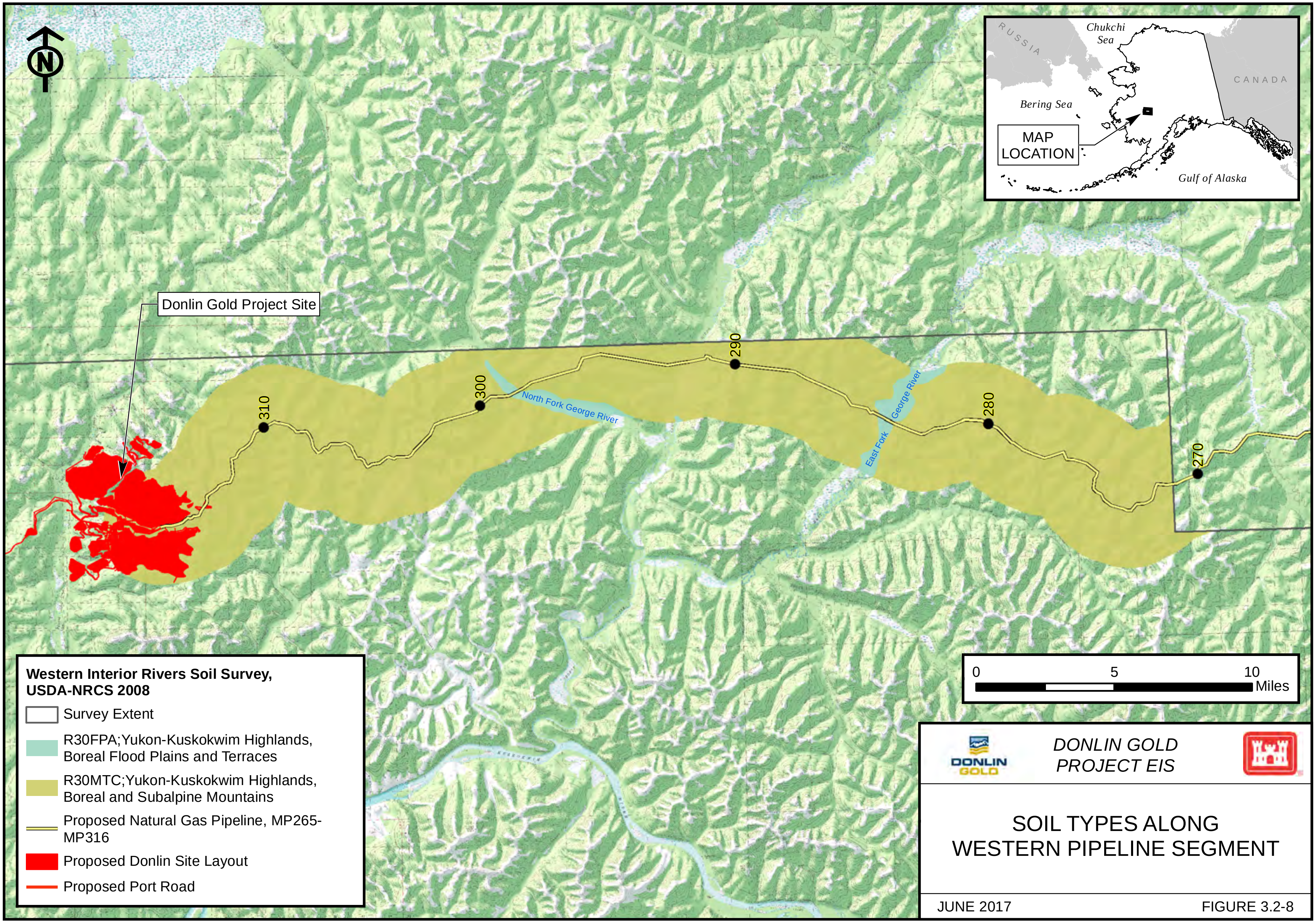
Most of the Pipeline route is located in the discontinuous permafrost zone of Alaska. The Cook Inlet-Susitna Lowlands are generally considered to be free of permafrost, although sporadic isolated masses are known to occur (Ferrians 1965, 1994; Jorgenson et al. 2008). In 2010 and 2013, geotechnical studies were conducted along the Pipeline corridor to investigate soil and permafrost baseline conditions and establish a ground temperature monitoring program. At select locations where permafrost conditions were encountered, tubing was installed in 66 borings for placing thermistor strings to measure ambient ground temperature (CH2MHill 2011b; BGC 2013c). Ground temperature data was acquired and evaluated from at least 45 of the 66 borings equipped for ground temperature acquisition.

Based on these investigations, the estimated total length of alignment where permafrost conditions are expected to exist is approximately 31 miles (CH2MHill 2011b; BGC 2013c; Fueg 2014). Permafrost occurrence and associated thaw-stable and thaw-unstable conditions are shown on Figure 2.3-34 (Chapter 2, Alternatives). The total estimated length of thaw-unstable soil conditions along the alignment is approximately 12 miles; these are locations where soils are expected to settle more than 1 foot when thawed, over time, between 4 and 25 feet in depth. The total estimated length of thaw-stable soils along the length of the alignment is approximately 19 miles. These are mostly coarse-grained areas where soils are not expected to settle appreciably when thawed. Frozen soils encountered in borings only in the top few feet were assumed to be seasonal and were not counted in these totals unless they extended deeper. There are approximately 300 mapped transitions between thaw-unstable soils and either thaw-stable or non-permafrost soils, where differential thaw settlement is more likely to occur.

The ground temperature data collected along the Pipeline route indicate warm permafrost soil conditions ranging from 31° to 32° Fahrenheit. The narrow temperature range is indicative of a fragile equilibrium, and the isothermal nature of the data suggests ongoing thermal degradation or near degradation conditions (CH2MHill 2011b).



Proposed Natural Gas Pipeline, MP78-MP270
North Route Option, MP85-MP112
Alternative 6A, Dalzell Gorge Route, MP106-MP153
Yetna & Western Interior Rivers Survey Extents, USDA-NRCS 1998 & 2008
STATSGO Soil Survey, USDA-NRCS 2011
E23M5.Cook Inlet Mountains-Boreal Subalpine and Alpine-Mountains, Acid
E23M7.Cook Inlet Mountains-Boreal Alpine-Barren Mountains
E23V.Cook Inlet Mountains-Boreal Upland and Lowland-Valleys
E24P5.Cook Inlet Lowlands-Boreal Upland-Till Plains
E28FP1.Interior Alaska Mountains-Boreal Lowland-Flood Plains, Terraces, and Fans
E28GP2.Interior Alaska Mountains-Boreal Glaciated Plains and Hills
E28GP5.Interior Alaska Mountains-Boreal Alpine-Glaciated Plains and Hills
E28GP6.Interior Alaska Mountains-Boreal Upland and Subalpine-Glaciated Plains and Hills, Ash Influenced
E28GV.Interior Alaska Mountains-Boreal Alpine-Mountain Valleys
E28LM3.Interior Alaska Mountains-Boreal Alpine-Rounded Mountains
E28MT5.Interior Alaska Mountains-Boreal Alpine-Rugged Mountains
E28RC.Interior Alaska Mountains-Boreal Alpine-Barren Mountains
E28V.Interior Alaska Mountains-Boreal Upland and Lowland-Mountain Valleys
E29FP1.Interior Alaska Lowlands-Boreal Lowland-High Flood Plains and Terraces
E29FP2.Interior Alaska Lowlands-Boreal Lowland-Flood Plains and Terraces, High Elevation
E29FP5.Interior Alaska Lowlands-Boreal Lowland-Fan Terraces and Stream Terraces
E29P1.Interior Alaska Lowlands-Boreal Lowland-Peatlands and Alluvial Plains
E30M1.Yukon-Kuskokwim Highlands-Boreal Upland-Loess Hills
E30M3.Yukon-Kuskokwim Highlands-Boreal Upland-Rounded Mountains
E30M4.Yukon-Kuskokwim Highlands-Boreal Upland and Alpine-Rounded Mountains
E30M5.Yukon-Kuskokwim Highlands-Boreal Alpine and Subalpine-Rounded Mountains
E30MV1.Yukon-Kuskokwim Highlands-Boreal Upland-Valleys
E30PH.Yukon-Kuskokwim Highlands-Boreal Upland-Plains and Hills
N
150
175
125
200
100
225
78
250
270
Main Stream Kuskokwim River
0
10
20
30
Miles
RUSSIA
Chukchi Sea
CANADA
Bering Sea
MAP LOCATION
Gulf of Alaska
DONLIN GOLD
DONLIN GOLD PROJECT EIS
SOIL TYPES ALONG CENTRAL PIPELINE SEGMENT
DECEMBER 2017
FIGURE 3.2-7



SOIL TYPES ALONG WESTERN PIPELINE SEGMENT

JUNE 2017

FIGURE 3.2-8

Permafrost is notably absent on floodplains and rivers throughout much of the route, and is absent from the Pipeline start at Cook Inlet to approximately MP 100 in the upper Skwentna River Valley. The North Option (MP 85 to MP 112) is characterized by well drained alluvial terrace and morainal soils and a near absence of permafrost (Wilson et al. 2012; Donlin Gold 2017k).

Permafrost occurrence in the Alaska Range is discontinuous, and exists in both thaw-stable form and ice-rich thaw-unstable form. Many of the frozen soils are associated with mass wasting or alluvial fan deposits (BGC 2013a).

Thaw-unstable permafrost is most prevalent along the north flank of the Alaska Range from about MP 150 to MP 215. Numerous areas of ice-rich soil are present in this area, typically associated with fine-grained till deposits. The area west of the Big River includes hummocky hills, braided floodplain channels, and glacial till outwash that contain discontinuous permafrost consisting of ice-rich silt, sand, and gravel mixtures with localized occurrences of appreciable clay fractions (CH2M Hill 2011b).

Permafrost soil conditions are generally absent from MP 215 to the route terminus at the Mine Site, although intermittent ice-poor permafrost conditions may be present in fine-grained silt along ridgetops of the Kuskokwim Mountains. While the active layer may be greater than 6 feet at these locations due to the lack of organic cover, thaw settlement is likely limited due to the shallow depth of weathered bedrock (CH2M Hill 2011b).

Seasonal freeze depth along the alignment is variable and is often influenced by insulative conditions attributed to peat-rich vegetative surface cover and snow cover. The active layer depth in areas of thick vegetative cover is generally less than 2 feet, and may be up to 6 or more feet deep in areas with mineral-rich soil.

3.2.2.3.3 EROSION

<u>Processes</u>

Various geologic processes that cause erosion are described in Sections 3.2.2.1.3 and 3.2.2.2.3. Primary erosion mechanisms attributed to pipeline construction activities include hydraulic erosion and thermal erosion. The potential for each are present throughout the alignment, and coincide along numerous Pipeline segments. Slope length and steepness significantly influence hydraulic soil erosion rates (Warren et al. 1989), and slopes of various grades and aspects are prevalent along the Pipeline corridor, including sloped approaches to numerous waterbody crossings (CH2M Hill 2011b). Surficial organics and peat are present over much of the alignment, and because much of the route is underlain by erosion-susceptible non-cohesive soils, disturbances to the overlying protective organics can influence hydraulic and thermal erosion processes.

Thermal erosion of ice-rich, thaw unstable permafrost soils can result in ground subsidence, slope instability and drainage alteration. Although natural permafrost degradation processes exist along the alignment, disturbance of insulative properties associated with surface organics will increase thermal erosion rates, leading to an increased active layer with ongoing freeze-thaw conditions throughout the year. Pipeline segments with fine-grained thaw unstable permafrost conditions would be more vulnerable to thermal erosion processes, secondary hydraulic erosion, and accelerated erosion scenarios (e.g., construction, off-road vehicles

[ORVs]). The occurrence of these conditions at Pipeline stream crossings, where open cut construction techniques could expose soil particularly vulnerable to both thermal and hydraulic erosion, is presented at the end of this section.

Other ice related physical processes that may influence soil erosion includes the adverse formation of seasonal ice on ground surfaces. Successive freezing of water on ground surfaces from surface or groundwater sources (e.g., seeps) during winter months can result in a layered buildup and propagation of ice. This process is referred to as aufeis formation, or annual winter glaciation. Aufeis formation on ground surfaces is generally associated with seeps or springs daylighting at ground surface. Seeps often occur along toeslopes at or near valley bottoms where unique shallow subsurface conditions exist such as permafrost or other impermeable material (e.g., clay, hardpan). Surface disturbances (slope cuts) or man-made structures can sometimes induce or augment aufeis formation through changes in surface water or groundwater flow conditions. Aufeis formation can potentially influence erosion through episodic alteration of surface water drainage patterns and prolonged soil saturation through ice-water melt runoff. Aufeis formation is anecdotally reported to occur between MP 90 through MP 97 along sloped sections of the Iditarod National Historic Trail. The most prominent drainage for aufeis formation occurrence is the Big River floodplain (CH2MHill 2011b). Aufeis formation within streams or drainages is also referred to as overflow, and is derived from stream water upwelling under pressure through frozen surfaces. Additional discussion regarding this type of aufeis formation is presented in Section 3.5, Surface Water Hydrology.

Distribution

NRCS provides a measure of water and wind erosion susceptibility for different soil types. Erosion hazards for soil map units that coincide with the eastern portion of the Pipeline are summarized in Appendix F (NRCS 1998). Descriptions range from slight to severe for water-caused erosion, assuming the organic mat has been removed. Soil types with severe ratings for water erosion are generally associated with silt loam on floodplains, steep mountain slopes, and moraines. Wind erosion hazards for the Pipeline corridor range from slight to severe, the latter generally associated with mountain slopes, ridges, alluvial terraces, and moraines.

Available erosion data for the central portion of the Pipeline are summarized in Appendix F (USDA-NRCS 2013). These are based on STATSGO data and include values for soil erodibility (K-Factor), soil loss tolerance (T-factor), and WEG, described in Section 3.2.2.1.3.

Soil map units associated with the western portion of the Pipeline alignment are located within the mapped area of the Western Interior Rivers Soil Survey, Alaska (NRCS 2008). The map units in this area (Figure 3.2-8) are the same as those described in Section 3.2.2.1.3 for the Mine Site. Erosion descriptions by water for each of these units are provided in Appendix F, and range from slight to severe, the latter of which is associated with colluvial slopes. Wind erosion hazards for these soils are rated slight to moderate.

Pipeline segments with fine-grained thaw unstable permafrost conditions (Figure 2.3-34, Chapter 2, Alternatives) would be more vulnerable to thermal erosion processes and secondary effects associated with hydraulic erosion. Stream crossings in permafrost terrain were screened for soil types particularly vulnerability to erosion by reviewing geotechnical borehole details at each of the coincident locations. Of roughly 400 proposed stream crossings, about 80 are located in permafrost soils; these are listed in Table 3.2-2. Of these, about 30 are associated with fine-grained soils considered particularly vulnerable to erosion, and about 20 of those have known or potential fish habitat. Streams with an overall rating of moderate to high permafrost erosion concerns, including those with potential fish habitat, are highlighted in orange and peach in Table 3.2-2, and those with moderate overall ratings are highlighted in blue. Rationale used in the ratings is provided in the table key following the tabularized data. Fish have been documented at eight of the stream crossings with an overall moderate-high rating (OtterTail 2013). These include a Jones Creek tributary, Middle Fork Kuskokwim River and several tributaries to this river, and two tributaries to Tatlawiksuk River.

Table 3.2-2: Stream Crossings in Permafrost Terrain – Screening for Erosion Vulnerability

Nearest Milepost	Stream Crossing			Soil Type	Permafrost Information					Fish Information		
	Stream ID	Stream Name	Drainage	Borehole Data to 5' (silt thickness in feet) (1)	Terrain Unit (if no borehole data)	Thaw Settlement (2)	Existing Bank Erosion (Left Bank/Right Bank) (3)	Level of Permafrost Bank Erosion Concern (4)	Rationale for Permafrost/Soil Erosion Rating	Fish Presence or Potential (5)	Water Present in Late Summer for Baseline Sampling	Level of Fish Concern (6)
MP 108	sHA3	Happy River	Skwentna	GP-002-J: OL(0.3')/SP	- (7)	stable	- (7)	L	mostly sand	Chinook salmon, Dolly Varden, slimy sculpin	yes	H
MP 113	sTMT17	Threemile Creek tributary 17	Skwentna	GP-015-J: SW	-	stable	-	L	sand and gravel	no defined channel - wetland	yes	L
MP 113	sTMT16	Threemile Creek tributary 16	Skwentna	GP-015-J: SW	-	stable	-	L	sand and gravel	no defined channel - dry (Sept)	no	L
MP 115	sTMT12	Threemile Creek tributary 12	Skwentna	GP-100-J: SP	-	stable	-	L	sand and gravel	no fish found	yes	L-M
MP 115	sTMT11	Threemile Creek tributary 11	Skwentna	GP-100-J: SP and GP-021-J: GP	-	unstable	-	L	sand and gravel	no fish found	yes	L-M
MP 115	sTMT99	Threemile Creek tributary 99	Skwentna	GP-101-J: GP/ML(2.2')/GW and GP-022-J: SW	-	stable	-	M-H	thick silt in between gravel in 1 of 2 borings	no fish found	yes	L-M
MP 115	sTMT10	Threemile Creek tributary 10	Skwentna	GP-101-J: GP/ML(2.2')/GW and GP-022-J: SW	-	stable	-	M-H	thick silt in between gravel in 1 of 2 borings	no fish found	yes	L-M
MP 116	sTMT9	Threemile Creek tributary 9	Skwentna	GP-022-J: GW	-	stable	-	L	silty gravelly sand	no fish found	yes	L-M
MP 117	sTMT5	Threemile Creek tributary 5	Skwentna	GP-026-J: SM	-	unstable	-	L	mostly gravel	no defined channel - dry (Sept)	no	L
MP 117	sTMT3	Threemile Creek tributary 3	Skwentna	GP-027-J: SM	-	stable	-	L	gravelly silty sand	no defined channel - dry (Sept)	no	L
MP 119	kTAT30	Tatina River tributary 29	Kuskokwim	GP-030-J and GP-106-J: GW	-	unstable	-	L	mostly gravel	no defined channel - wetland	yes	L
MP 120	kTAT29	Tatina River tributary 29	Kuskokwim	GP-033-J: SW and GP-034-J: GW	-	unstable	-	L	mostly gravel	no fish found	yes	L-M
MP 120	kTAT28	Tatina River tributary 28	Kuskokwim	GP-109-J and GP-033-J: SW	-	stable	-	L	sand and gravel	defined channel - dry (Sept)	no	L
MP 120	kTAT27, kTAT27_OH1	Tatina River tributary 27	Kuskokwim	GP-035-J: SM and GP-109-J: SW	-	unstable	-	L	silty sand and gravel	no defined channel-dry at crossing; no fish found at nearby optimum habitat	no at crossing; yes at nearby optimum habitat	L-M
MP 122	kTAT20	Tatina River tributary 20	Kuskokwim	GP-040-J: ML(1.5')/GW	-	stable	-	H	thick silt	no defined channel - wetland	yes	L
MP 130	kJNT41	Jones Creek tributary 41	Kuskokwim	GP-059-J: ML(1')/SP	-	stable	-	L-M	thin-moderately thin silt	defined channel - dry (Sept)	no	L
MP 130	kJNT40	Jones Creek tributary 40	Kuskokwim	GP-059-J: ML(1')/SP	-	stable	-	L-M	thin-moderately thin silt	defined channel - dry (Sept)	no	L
MP 131	kJNT39	Jones Creek tributary 39	Kuskokwim	GP-059-J: ML(1')/SP	-	stable		L-M	thin-moderately thin silt	no fish found	yes	L-M
MP 139	kJNT12	Jones Creek tributary 12	Kuskokwim	GP-076-J: SM	-	unstable	-	L	sand and thin silt	no defined channel - dry (Sept)	no	L

Table 3.2-2: Stream Crossings in Permafrost Terrain – Screening for Erosion Vulnerability

Nearest Milepost	Stream Crossing			Soil Type	Permafrost Information					Fish Information		
	Stream ID	Stream Name	Drainage	Borehole Data to 5' (silt thickness in feet) (1)	Terrain Unit (if no borehole data)	Thaw Settlement (2)	Existing Bank Erosion (Left Bank/Right Bank) (3)	Level of Permafrost Bank Erosion Concern (4)	Rationale for Permafrost/Soil Erosion Rating	Fish Presence or Potential (5)	Water Present in Late Summer for Baseline Sampling	Level of Fish Concern (6)
MP 139	kJNT11	Jones Creek tributary 11	Kuskokwim	GP-077-J: SP	-	stable	-	L	sand and gravel	no defined channel - dry (Sept)	no	L
MP 140	kJNT10	Jones Creek tributary 10	Kuskokwim	GP079-J: ML(2')/SM	-	unstable (North bank only)	-	H - North bank, L - South bank	thick silt	Dolly Varden	yes	H
MP 140	kJNT9	Jones Creek tributary 9	Kuskokwim	GP-79-J: ML(1.5')/SM and GP-80-J: SW/SP	-	stable	-	M-H	thick silt in 1 of 2 borings	no defined channel - dry (Sept)	no	L
MP 141	kJNT8	Jones Creek tributary 8	Kuskokwim	GP-081-J: ML(0.8')/SW	-	stable	-	L	thin silt	defined channel - dry (Sept)	no	L
MP 141	kjNT7	Jones Creek tributary 7	Kuskokwim	GP-081-J: ML(0.8')/SW	-	stable	-	L	thin silt	no defined channel - dry (Sept)	no	L
MP 143	kSFT80	South Fork Kuskokwim River tributary 80	Kuskokwim	GP-084-J: ML(5'+)	-	stable (North bank only)	-	H	thick silt	defined channel - dry (Sept)	No	L
MP 143	kSFT79	South Fork Kuskokwim River tributary 79	Kuskokwim	GP-084-J: ML(5'+)	-	stable	-	H	thick silt	defined channel - dry (Sept)	No	L
MP 144	kSFT78	South Fork Kuskokwim River tributary 78	Kuskokwim	GP-084-J: ML(5'+)	-	unstable	-	H	thick silt	defined channel - dry (Sept)	No	L
MP 148	kSFT57	South Fork Kuskokwim River tributary 57	Kuskokwim	GP-092-J: PT/OL	-	stable	-	M-H	thick organic silt	no defined channel - wetland	yes	L
MP 153	kSFT23	South Fork Kuskokwim River tributary 23	Kuskokwim	none	Bog silt (>2') over alluvial fan	unstable (East bank only)	slight/slight	M-H	thick silt potential	no fish found, defined channel, winter dry	yes	L-M
MP 153	kSFT24	South Fork Kuskokwim River tributary 24	Kuskokwim	GP212: OL (2.5')/CL		stable	slight/slight	M-H	thick organic silt	defined channel - dry (Sept)	no	L, but potential downstream effects in breakup
MP 153	kSFT43	South Fork Kuskokwim River tributary 43	Kuskokwim	GP214: PT/OL(0.5')/GM	-	stable	-	L	mostly gravel	defined channel - dry (Sept)	no	L
MP 154	kSFT26	South Fork Kuskokwim River tributary 26	Kuskokwim	none	outwash, silty gravel	stable	-	L	mostly gravel	no defined channel - dry (Sept)	no	L
MP 154	kSFT27	South Fork Kuskokwim River tributary 27	Kuskokwim	none	outwash, silty gravel	stable	-	L	mostly gravel	no defined channel - dry (Sept)	no	L
MP 157	kSHT15	Sheep Creek tributary 15	Kuskokwim	GP218: PT/OL (3.5')/SC		stable	-	M-H	thick frozen organic silt	defined channel - dry (Sept)	no	L, but potential downstream effects in breakup
MP 158	kSHT16	Sheep Creek tributary 16	Kuskokwim	none	colluvium/ alluvium: sand-silt over gravel	stable	-	L	minor silt potential	no defined channel - dry (Sept)	no	L

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	Stream ID	Stream Name	Drainage	Borehole Data to 5' (silt thickness in feet) (1)	Terrain Unit (if no borehole data)	Thaw Settlement (2)	Existing Bank Erosion (Left Bank/Right Bank) (3)	Level of Permafrost Bank Erosion Concern (4)	Rationale for Permafrost/Soil Erosion Rating	Fish Presence or Potential (5)	Water Present in Late Summer for Baseline Sampling	Level of Fish Concern (6)
MP 158	kSHT17	Sheep Creek tributary 17	Kuskokwim	GP219: PT/OL (1')/GM-GP	-	stable	-	L-M	thin-moderately thin silt	no defined channel - dry (Sept)	no	L
MP 159	kSHT18	Sheep Creek tributary 18	Kuskokwim	GP219: PT/OL (1')/GM-GP, GP220: PT/OL (0.3')/SM/PT/SP-SM	-	stable	slight/slight	L	thin silt	defined channel - dry (Sept)	no	L
MP 159	kSHT19	Sheep Creek tributary 19	Kuskokwim	GP220: PT/OL (0.3')/SM/PT/SP-SM	-	stable	slight/slight	L	minor silt	no fish found, defined channel, winter dry	yes	L-M
MP 160	kSHT20	Sheep Creek tributary 20	Kuskokwim	none	colluvium/ alluvium: gravel with silt to silty gravel	stable	-	L	mostly gravel	no defined channel - dry (Sept)	no	L
MP 160	kSHT21	Sheep Creek tributary 21	Kuskokwim	none	colluvium/ alluvium: gravel with silt to silty gravel	stable	-	L	mostly gravel	no defined channel - dry (Sept)	no	L
MP 161	kSHT6	Sheep Creek tributary 6	Kuskokwim	none	till/outwash: silty/clayey sand with gravel to silty gravel	unstable	none/none	L	mostly sand-gravel	no defined channel - dry (Sept)	no	L
MP 162	kSHT22	Sheep Creek tributary 22	Kuskokwim	GP222: PT/GM/SC	-	unstable	slight/slight	L	mostly gravel-sand	no defined channel - dry (Sept)	no	L
MP 163	kSHT4	Sheep Creek tributary 4	Kuskokwim	GP224: PT/ML(1')/OL(2.5')/Ice+ML	-	unstable	none/none	H	frozen silt over ice	no defined channel - dry (Sept)	no	L, but potential downstream effects in breakup
MP 164	kSHT5	Sheep Creek tributary 5	Kuskokwim	GP224: PT/ML(1')/OL(2.5')/Ice+ML	-	unstable	-	H	frozen silt over ice	no fish found, defined channel, winter dry	yes	L-M
MP 166	DR94	Pitka Fork tributary, drainage 94	Kuskokwim	GP226: PT to 5'/SM	-	unstable	-	L	peat: high thaw settlement, but low erosion potential	too limited habitat for fish	yes	L
MP 166	kPI1	Pitka Fork	Kuskokwim	GP226: PT to 5'/SM	-	unstable	slight/slight	L	peat: high thaw settlement, but low erosion potential	no fish found, defined channel, winter dry	yes	L-M
MP 168	kWI1	Windy Fork	Kuskokwim	GP228: PT to 9'/OH	-	unstable (East bank only)	slight/slight	L-M	peat: high thaw settlement, but low erosion potential	coho salmon, Dolly Varden, slimy sculpin	yes	H
MP 170	kKHT1	Khuchaynik Creek tributary 1	Kuskokwim	GP231: PT/OL (0.5')/GM/SM	-	stable	none/none	L	thin silt, mostly gravel	no defined channel - dry (Sept)	yes	L
MP 173	kMFT1	Middle Fork Kuskokwim River tributary 1	Kuskokwim	GP235: PT/OL(3')/GP-GM	-	stable (West bank only)	none/none	M-H	thick organic silt	no defined channel - dry (Sept)	no	L, but potential downstream effects in breakup
MP 173	kMFT13	Middle Fork Kuskokwim River tributary 3	Kuskokwim	GP235: PT/OL(3')/GP-GM	-	stable	none/none	M-H	thick organic silt	no defined channel - dry (Sept)	no	L, but potential downstream effects in breakup

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	Stream ID	Stream Name	Drainage	Borehole Data to 5' (silt thickness in feet) (1)	Terrain Unit (if no borehole data)	Thaw Settlement (2)	Existing Bank Erosion (Left Bank/Right Bank) (3)	Level of Permafrost Bank Erosion Concern (4)	Rationale for Permafrost/Soil Erosion Rating	Fish Presence or Potential (5)	Water Present in Late Summer for Baseline Sampling	Level of Fish Concern (6)
MP 176	kMFT16	Middle Fork Kuskokwim River tributary 16	Kuskokwim	GP238 East bank: PT to 7'/CL; GP239: unfrozen Pt/OL (1.8')/ML(2.5') on West bank	-	unstable (East bank only)	none/none	M	frozen peat and unfrozen silt	no fish found, defined channel, winter dry	yes	L-M
MP 176	kMFT17	Middle Fork Kuskokwim River tributary 17	Kuskokwim	GP239 just East of permafrost extent: unfrozen Pt/OL (1.8')/ML(2.5')	moraine: Sand/Silt w/ Gravel to Silty Gravel	stable	-	L-M	minor-moderate silt	no defined channel - dry (Sept)	no	L
MP 178	kMFT9	Middle Fork Kuskokwim River tributary 9	Kuskokwim	GP241: PT/ML(3')/SM	-	stable (West bank only)	slight/slight	H	thick frozen silt	low, discontinuous surface flow	yes	L, but potential downstream effects in breakup
MP 179	kMFT5	Middle Fork Kuskokwim River tributary 5	Kuskokwim	GP244: PT/ML (3')/CL and GP243: PT/CL (3')/GM	-	stable (West bank only)	none/none	H	thick frozen silt over clay W bank	Dolly Varden	yes	H
MP 179	kMFT19	Middle Fork Kuskokwim River tributary 19	Kuskokwim	GP244: PT/ML (3')/CL and GP243: PT/CL (3')/GM	-	stable (West bank only)	none/none	H	thick frozen silt over clay W bank	Dolly Varden	yes	H
MP 180	kMFT6	Middle Fork Kuskokwim River tributary 6	Kuskokwim	none	outwash: ice-rich clay with gravel to sandy gravel	unstable	slight/slight	M		Dolly Varden	yes	H
MP 181	kMFT20	Middle Fork Kuskokwim River tributary 20	Kuskokwim	none	outwash: sand/silt with gravel to silty gravel	unstable	-	L-M	minor-moderate silt	no fish found, defined channel, winter dry	yes	L-M
MP 181	kMFT7	Middle Fork Kuskokwim River tributary 7	Kuskokwim	GP245: PT/OL (unfrozen 0.3')/ML (1.5' unfrozen)/frozen SM	-	stable	none/none	L-M	moderately thick silt, but unfrozen	no fish found, defined channel, winter dry	yes	L-M
MP 183	kMF1	Middle Fork Kuskokwim	Kuskokwim	GP247: unfrozen GP-GM; GP248: PT/frozen OL(0.5')/frozen ML (1.5')/GP-GM	-	unstable (West bank only)	-	M-H	GP248 upper W bank high erosion potential; GP247 lower W bank low erosion potential	Dolly Varden, slimy sculpin, Coho salmon	yes	H
MP 184	kMFT10	Middle Fork Kuskokwim River tributary 10	Kuskokwim	GP250: PT/OL(0.5)/ML (9')	-	unstable	active/active	H	thick frozen silt	Dolly Varden, slimy sculpin	yes	H
MP 186	kMFT11	Middle Fork Kuskokwim River tributary 11	Kuskokwim	none	moraine: sand/silt with gravel to silty gravel	unstable	-	L-M	minor-moderate silt	no defined channel - dry (Sept)	no	L
MP 186	kBIT9	Big River tributary 9	Kuskokwim	GP254: PT/ML (1')/PT to 5'/SM	-	unstable	-	L-M	minor-moderate silt	no fish found, defined channel, winter dry	no	L-M
MP 187	kBIT12	Big River tributary 12	Kuskokwim	GP255: PT/OL(0.3')/CL to 5'/ML and GP256: PT/unfrozen ML (3')/SC	-	unstable	none/none	M-H	thick frozen CL E bank; unfrozen thick ML W bank	no fish found, defined channel, winter dry	yes	L-M

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Nearest Milepost	Stream Crossing			Soil Type	Permafrost Information					Fish Information		
	Stream ID	Stream Name	Drainage	Borehole Data to 5' (silt thickness in feet) (1)	Terrain Unit (if no borehole data)	Thaw Settlement (2)	Existing Bank Erosion (Left Bank/Right Bank) (3)	Level of Permafrost Bank Erosion Concern (4)	Rationale for Permafrost/Soil Erosion Rating	Fish Presence or Potential (5)	Water Present in Late Summer for Baseline Sampling	Level of Fish Concern (6)
MP 188	kBIT14	Big River tributary 14	Kuskokwim	None	kettle & kame/moraine: sand/silt with gravel to silty gravel, ice-rich	unstable	-	M	minor-moderate silt	no defined channel - wetland	yes	L
MP 193	kBIT4	Big River tributary 4	Kuskokwim	GP262: PT/unfrozen CL to 3.5/frozen CL	-	unstable (West bank only)		M-H	thick frozen clay, W bank upper slope	no fish found, defined channel, winter dry	yes	L-M
MP 195	kBIT99	Big River tributary 99	Kuskokwim	GP264: PT/unfrozen OL/unfrozen CL to 4'/frozen CL	-	unstable	-	L-M	minor-moderate frozen clay to trench depth	no fish found, defined channel, winter dry	yes	L-M
MP 195	kBIT6	Big River tributary 6	Kuskokwim	GP264: PT/unfrozen OL/unfrozen CL to 4'/frozen CL to 8.5'	-	unstable	-	L-M	minor-moderate frozen clay to trench depth	no fish found, defined channel, winter dry	yes	L-M
MP 203	kBIT8	Big River tributary 8	Kuskokwim	GP274: PT/unfrozen ML to 4.5'/frozen ML	-	unstable	none/none	M	thick silt, but mostly unfrozen	no fish found, defined channel, winter dry	yes	L-M
MP 206	kTLT3	Tatlawiksuk River tributary 3	Kuskokwim	GP279 in unstable permafrost to West: PT/CL(3.5')/ML (1')	till/colluvium: sand/silt trace gravel	stable	none/none	M	minor-moderate silt in surficial unit; thick frozen clay in boring to West	no fish found, defined channel, winter dry	yes	L-M
MP 207	DR86	Tatlawiksuk River tributary, drainage 86	Kuskokwim	GP279: PT/CL(3.5')/ML (1' to 5' depth)	-	stable	-	M-H	thick frozen clay	too limited habitat for fish	yes	L, but potential downstream effects in breakup
MP 207	kTLT4	Tatlawiksuk River tributary 4	Kuskokwim	GP279: PT/CL(3.5')/ML (1')	-	stable	none/none	M-H	thick frozen clay	no fish found, defined channel, winter dry	yes	L-M
MP 208	kTLT5	Tatlawiksuk River tributary 5	Kuskokwim	GP280: PT/unfrozen OL (0.5')/frozen CL-ML(2.5')/GP-GM	-	stable	slight/slight	M-H	thick frozen clay-silt	Dolly Varden	yes	H
MP 208	kTLT99	Tatlawiksuk River tributary 99	Kuskokwim	GP280: PT/unfrozen OL (0.5')/frozen CL-ML(2.5')/GP-GM	-	stable	-	M-H	thick frozen clay-silt	no fish found, defined channel, winter dry	yes	L-M
MP 213	kTLT36	Tatlawiksuk River tributary 36	Kuskokwim	GP287: PT/ frozen OL (0.5')/unfrozen ML(3.5')/frozen SM	-	stable (West bank only)	-	M	thick silt, but mostly unfrozen	no fish found	yes	L-M
MP 214	kTLT9	Tatlawiksuk River tributary 9	Kuskokwim	West bank no permafrost; East bank in stable permafrost GP287: PT/ frozen OL (0.5')/unfrozen ML(3.5')/frozen SM	bog silt and peat (>2') over till (sandy silt with trace gravel)	stable	none/none	M	thick silt, but mostly unfrozen	coho and Chinook salmon	yes	H
MP 283	kEF2	East Fork George River	Kuskokwim	EG-3/EG-4: PT+unfrozen ML(0.3')/unfrozen SM/frozen SP-SM	-	stable (West bank only)	slight/active	L	HDD site to be setback from bank, low erosion potential near surface	coho, Chum, and Chinook salmon; Arctic grayling, Burbot, Dolly Varden, whitefish, slimy sculpin, ninespine stickleback	yes	H

Table 3.2-2: Stream Crossings in Permafrost Terrain – Screening for Erosion Vulnerability

Nearest Milepost	Stream Crossing			Soil Type	Permafrost Information					Fish Information		
	Stream ID	Stream Name	Drainage	Borehole Data to 5' (silt thickness in feet) (1)	Terrain Unit (if no borehole data)	Thaw Settlement (2)	Existing Bank Erosion (Left Bank/Right Bank) (3)	Level of Permafrost Bank Erosion Concern (4)	Rationale for Permafrost/Soil Erosion Rating	Fish Presence or Potential (5)	Water Present in Late Summer for Baseline Sampling	Level of Fish Concern (6)
MP 283	kEF12	East Fork George River tributary 12	Kuskokwim	GP-342: PT(0.2')/CL	-	stable	-	M-H	E. George HDD setback also avoids this crossing	not sampled	-	-
MP 284	kEF13	East Fork George River tributary 13	Kuskokwim	GP-342: PT(0.2')/CL	-	stable	-	M-H	E. George HDD setback also avoids this crossing	not sampled	no	-
MP 241	kGE2	George River	Kuskokwim	G-4: PT+ML(0.4')/SM(2.1')/ML	-	Stable (West bank only)	slight/ -	H	HDD site to be setback from bank, low erosion potential near surface	coho, Chum, and Chinook salmon; Dolly Varden, whitefish, slimy sculpin	yes	H

Notes:

1. From CH2MHill (2011) and BGC (2013): CL=clay, GM=silty gravel, GP=gravel, ML=inorganic silt, OL=organic silt, PT=peat, SC=clayey sand, SM=silty sand, SP=poorly graded sand, SW = well-graded sand.
2. Stable if <1' settlement when thawed to 25', unstable if >1' settlement when thawed to 25', based on thaw modeling by Fueg (2014).
3. From OtterTail (2013).
4. Rationale for permafrost erosion concern:
   High: thick (>1') inorganic silt
   Moderate-High: thick organic silt or clay (may bind better)
   Low-Moderate: silt =1' or peat >5' over fines (assumes all peat would be trenched/removed), fines on trench bottom only
   Low: <1' silt; dominantly gravel or sand; peat >5' over coarse material (peat=high settlement but low erosion potential)
5. From OtterTail (2012a) Fish Map book or SRK (2013b)
6. Rationale for fish concern:
   High (H): fish found (any kind)
   Low-Moderate (L-M): defined channel/habitat/water present in late summer, but no fish found; could be some though; channel dry in winter
   Low (L): no defined channel, limited habitat, wetlands, dry in fall, low discontinuous flow
7. - = not available or not applicable

Results:
~400+ stream crossings
~80 in permafrost terrain
~30 in permafrost terrain + erodible soils (Moderate to Moderate-High overall ratings, blue or oranges)
~20 in permafrost terrain + erodible soils + fish habitat (Moderate-High overall ratings, oranges)
8 in permafrost terrain + erodible soils + fish habitat + fish found (Moderate-High overall rating, bright orange): Jones Creek tributary #10, Middle Fork Kuskokwim River + 4 tributaries, 2 Tatlawiksuk River tributaries

Sources: CH2MHill 2011b; OtterTail 2012a; BGC 2013c; SRK 2013b; Fueg 2014.

Combined permafrost erosion and fish concern:

Moderate-High:	Stream crossings with high to moderate permafrost erosion concern with fish present.
Moderate-High:	Stream crossings with a) high or moderate-high permafrost erosion concern in absence of fish, if potential fish habitat identified; or b) high permafrost erosion concern in absence of fish habitat due to potential effects on wetlands or downstream effects on larger fish stream in breakup.
Moderate	Stream crossings with a) moderate-high permafrost erosion concern in absence of fish habitat, dry in late summer, and rated moderate overall due to potential downstream effects on larger fish stream in breakup; and b) low-moderate permafrost erosion concern with fish habitat present.
Low	Stream crossings with a) low permafrost erosion concern regardless of fish habitat or presence; b) low-moderate or moderate permafrost erosion concern with no fish or habitat present, dry in late summer; or c) unstable permafrost and fish present, but horizontal directional drilling (HDD) planned for crossing.

3.2.2.3.4 SOIL QUALITY/CONTAMINATED SITES

Review of the federal CWA Impaired Water Section 303(d) listings indicated that no known affected watersheds are present along the Pipeline corridor. Review of the federal CERCLIS database indicated no known federally funded Superfund sites within the Pipeline corridor.

Review of the ADEC Contaminated Sites database indicated no sites within the Pipeline corridor of Alternative 2; however, about six sites are located near the proposed Beluga camp and storage yard, and a number of additional sites are located along the Alternative 3B diesel Pipeline corridor. In addition, several sites are located within communities near the Pipeline corridor and may coincide with use of infrastructure such as airfields. These sites are shown on Figure 3.2-9 and are listed in Appendix F from south to north, and east to west.

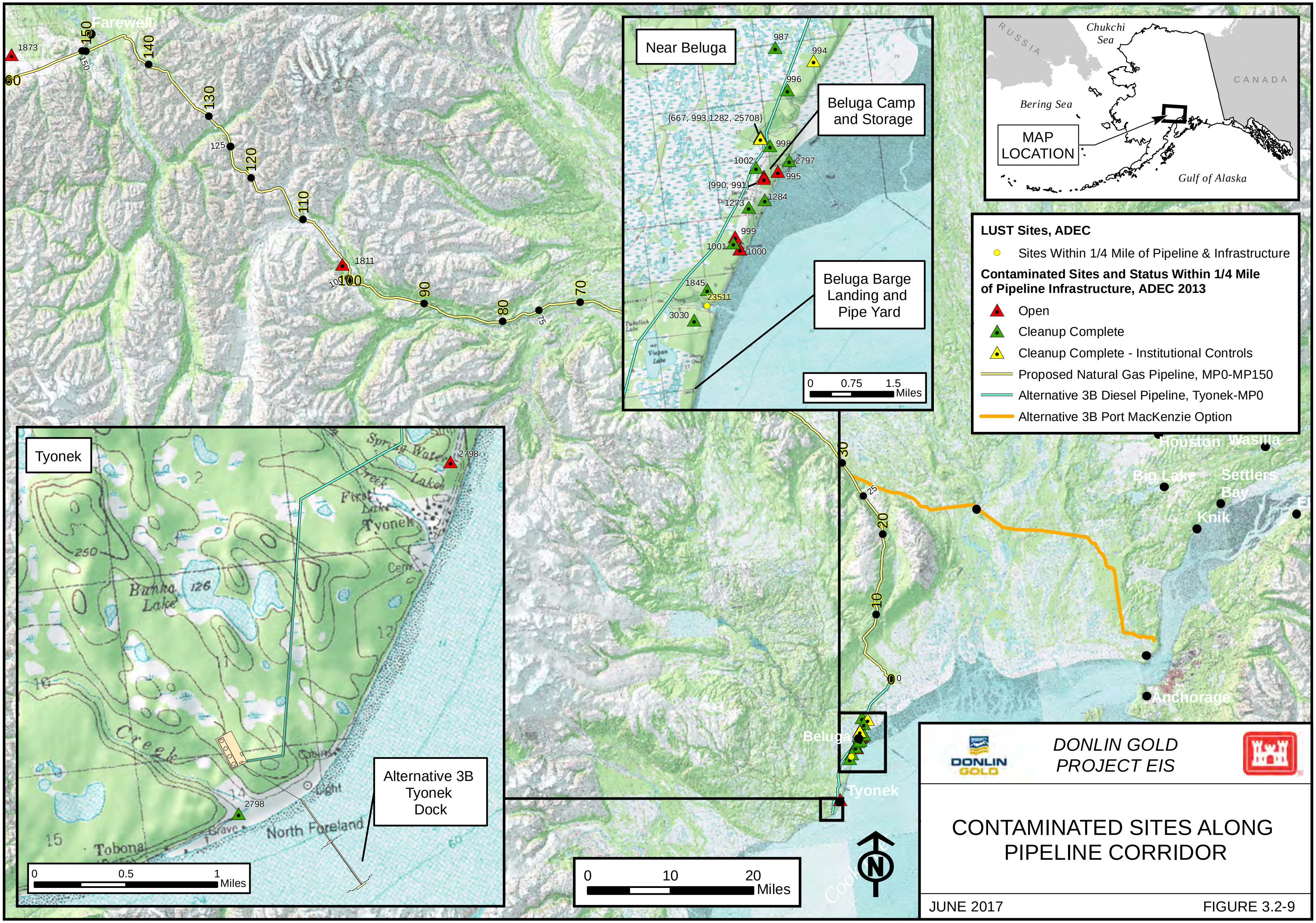
A number of contaminated sites were identified in the Tyonek / Beluga area associated with oil and gas field infrastructure and the Beluga power plant. Several of these are located within several hundred feet of the diesel Pipeline alternative, and six surround the proposed camp and storage yard at Beluga, two of which are listed as open sites (Figure 3.2-9). These six include a private property, metering facility, tank farm, and other infrastructure associated with the Beluga River Gas Field. A group of four sites, listed as cleanup complete with institutional controls, are located about 500 feet northwest or upgradient of the diesel Pipeline alternative; these include a floor drain, transformer, meter release, and fuel line removal associated with either the Beluga power plant or the Beluga River Gas Field. The rest of the sites are located on the downgradient side of the diesel Pipeline alternative, south of the camp and storage yard.

The FAA Puntilla Lake Station contains elevated levels of Diesel Range Organics in soils at the former location of three ASTs and associated piping. The tanks and pipelines were removed in 1999; however; no contaminated soils were removed during this effort and the site currently remains in an open status.

The FAA Farewell Station site represents a group of petroleum hydrocarbon impacts originating from heating oil tanks and piping associated with housing and other support buildings at the airfield. This site currently remains open in regard to cleanup status. The site is located approximately three miles northeast of the Pipeline route, and while it does not pose a major threat to the ROW, the airfield is for use during pipeline construction and operations.

3.2.2.4 CLIMATE CHANGE

Climate change is affecting resources in the EIS Analysis area and trends associated with climate change are projected to continue into the future. Section 3.26.3 discusses climate change trends and impacts to key resources in the physical environment including atmosphere, water resources, and permafrost. Current and future effects to soils are particularly tied to changes in permafrost and increased risk of erosion (discussed in Sections 3.26.3.3 and 3.26.3.2).



DONLIN GOLD PROJECT EIS

CONTAMINATED SITES ALONG PIPELINE CORRIDOR

JUNE 2017

FIGURE 3.2-9

3.2.3 ENVIRONMENTAL CONSEQUENCES

This section describes potential impacts on soils and permafrost as a result of the project.

Table 3.2-3: Impact Methodology for Effects on Soils and Permafrost

Type of Effect	Impact Factor	Assessment Criteria		
Changes to Soils or Permafrost	Magnitude or Intensity	Changes in soils may not be measurable or noticeable. Thermal regime is maintained and rehabilitation can be accomplished through natural recolonization. Standard BMPs are successful in preventing erosion. Soil quality effects are below regulatory limits, or within range of natural baseline variation outside of mineralized zone.	Disturbance requires revegetation by active methods (such as seeding or sod replacement) to prevent drainage/erosion issues and for successful site rehabilitation. Design is adequate for expected range of permafrost hazards. Special BMPs and more frequent monitoring/maintenance needed for successful erosion control. Soil quality effects are small compared to baseline; and/or can be mitigated to stay within baseline ranges or below levels of human health concern.	Acute or obvious changes in resource character. Permafrost disturbance results in settlement requiring substantial fill for successful rehabilitation to prevent ponding or erosion. Active methods required for revegetation. BMPs are unsuccessful in controlling erosion. Permafrost hazards likely to exceed design parameters. Soil quality substantially exceeds baseline; mitigation not effective.
	Duration	Soils or permafrost would be impacted not longer than the span of the project construction and would be expected to return to pre-activity levels at the completion of the activity.	Soils or permafrost would be impacted through the life of the project and would return to pre-activity levels up to 100 years after completion of the project.	Irreversible impact on soil character/ quality or thermal regime. Resources would not be anticipated to return to previous levels. Rehabilitation not possible for many years after life of project.
	Extent or Scope	Impacts to soils or permafrost limited geographically; discrete portions of the Project Area affected.	Affects soils or permafrost beyond local area, potentially throughout the Project Area or outside the Project Area.	Affects soils or permafrost beyond the region or the EIS Analysis Area.
	Context	Affects usual or ordinary resources widely distributed in region; not depleted or protected by legislation.	Affects depleted resources within the locality or region, resources protected by legislation, or resource hazards governed by regulation.	Affects unique resources or resources protected by legislation.

Notes:
BMP = Best management practice

Impacts to soil can be substantially reduced or controlled through the proper application of BMPs, and specific plans like erosion and sedimentation control plans (ESCPs), and SWPPPs. In most cases, the necessary agency permits will specifically require such plans to be completed, reviewed, and approved before work can commence. Appendix F describes planning documents, instituted programs, and associated permitting requirements that either comprehensively or partially address soil impacts through design features and BMPs. These are considered part of the project and are assumed to be in place in the analysis of effects in this section.

The evaluation of permafrost hazard impacts on the Project and the environment incorporates an understanding of planned mitigation in the form of engineering design and maintenance that can greatly reduce impacts. Where known based on Donlin Gold plan documents and engineering reports, planned mitigation (e.g., design to withstand permafrost effects) are considered part of the Project description, and assessment criteria are applied with them included. This is also the case where such planned mitigation may not be specified, but is considered typical or standard engineering practice. In cases where planned mitigation is unknown or unclear, and may not be a common situation encountered, the lack of planned mitigation is taken into account in the impact ratings, and mitigation recommendations are provided in Chapter 5, Impact Avoidance, Minimization, and Mitigation, that could reduce impact levels.

The following sections detail the impacts of the various alternatives on soil resources, as well as the potential impacts of soil hazards on the alternatives. Effects evaluated include those related to soil disturbance, permafrost degradation, erosion, and soil quality issues (fugitive dust and contaminated sites). In evaluating negative and positive impacts on soils, relevant factors for this project include:

- The types and area of soil that would be disturbed, and whether project footprints would be reclaimed;
- The amount of permafrost degradation expected, as well as permafrost hazard effects on project infrastructure;
- Net erosion expected in the presence of planned BMPs;
- The presence of pre-existing contaminated soils that could affect project activities; and
- Planned project activities that could have an effect on soil quality (unplanned situations that could affect soil quality are covered under Section 3.24, Spill Risk).

3.2.3.1 ALTERNATIVE 1 – NO ACTION

The No Action Alternative is representative of existing conditions. Development, operation, and reclamation (close out) activities associated with the Mine Site area, Transportation Corridor, natural gas Pipeline, and other alternatives would not exist. For these reasons, no project-related impacts to soil conditions would exist under this alternative.

3.2.3.2 ALTERNATIVE 2 – DONLIN GOLD'S PROPOSED ACTION

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

- North Option: The MP 84.8 to 112 North Option would realign this segment of the natural gas pipeline crossing to the north of the INHT before the Happy River crossing and remain on the north side of the Happy River Valley before rejoining the alignment near MP-112 where it enters the Three Mile Valley. The North Alignment would be 26.5 miles long, with one crossing of the INHT and only 0.1 mile physically located in the

INHT right-of-way (ROW). The average separation distance from the INHT would be 1 mile.

3.2.3.2.1 SOIL DISTURBANCE/REMOVAL

Soil impacts addressed in this section are primarily concerned with the types and amounts of soils disturbed by the project. Per NRCS, soil depth thickness descriptors include very shallow (i.e.,-surface) soils (< 20 inches); shallow soils (10 to 20 inches); moderately deep (20 to 40 inches), deep soils (40 to 60 inches), and very deep soils (> 60 inches). Soil depths generally most susceptible to disturbance throughout the Project Area are the productive, organic rich materials in surface to moderately deep soils; however, this can extend to greater depths. These soils are collectively referred to as surface soils. Although overburden is inclusive of soils, soils and select overburden will be managed based on growth media attributes and end use applications. Disturbances of bedrock and surficial geologic deposits (overburden beneath surface soils), including effects at material sites, are addressed in Section 3.1, Geology. Permafrost degradation and soil erosion are addressed separately in Sections 3.2.3.2.2 and 3.2.3.2.4, respectively. Impacts to vegetation, nonnative invasive species impacts, and associated management practices are addressed in Section 3.10, Vegetation and Nonnative Invasive Species. Impacts to wetlands as a result of reduction/loss of soil productivity through dewatering, disturbance/removal are addressed in Section 3.11, Wetlands. Emission of greenhouse gases (GHGs) derived from soil induced processes (wetlands and permafrost) is addressed in more detail in Sections 3.8, Air Quality and 3.26, Climate Change.

Mine Site

Construction

The total estimated footprint of potential disturbances to soils at the Mine Site area during construction phase of the project (pre-production) would be roughly 5,800 acres, including: 80 acres at the open pit, 2,400 acres at the Tailings Storage Facility (TSF), about 700 acres in the first few lifts of the Waste Rock Facility (WRF), and roughly 2,600 acres for other Mine Site infrastructure (BGC 2011b; SRK 2016a, c, f). The geographic extent of soil disturbances at the Mine Site is considered local, as they would be contained within discrete footprints within the overall Project Area.

Soil disturbances of specific Mine Site components would result in direct impacts over the three to four year construction period from noticeable to obvious changes in soil cover, ranging from compaction to complete removal of surface soils and permanent placement of engineered fill, stockpiles, or waste materials over existing surfaces. Selective reclamation of disturbed areas would be implemented immediately (concurrent) with the construction phase as practicable. Major mine components and related surface soil changes and design features utilized to minimize effects include the following:

- Pit Preparation and Related Stockpile Materials: Surface soils and overburden excavated from the open pit would be stockpiled and salvaged for concurrent and future reclamation activities, and placed in two specially designed stockpiles designated as the north overburden stockpile (NOB) and south overburden stockpile (SOB). The NOB would receive materials such as woody debris, peat, loess, and alluvium, which would be used as growth media to revegetate reclaimed areas at closure. These materials would come from topsoil and subsoil layers, which contribute to soil productivity with organic matter, nutrients, and minerals (O, A, and B horizons); as well as fine-grained parent material (C horizon) which have physical properties that affect soil productivity like drainage and porosity. NOB materials would have a minimum 50 percent composition of fine-grained materials, of which 50 percent would ideally consist of organics. These materials would be segregated from coarser, less productive parent material (such as colluvium and terrace gravels) which would be placed in the SOB (SRK 2016a). The stockpiles would remain uncovered throughout operations. Moisture content, drainage, and erosion would be managed through berms and diversion channels as further described below and in Section 3.2.3.2.3.

- NOB and SOB Stockpile Design: The fine-grained peat/loess mixtures in the NOB stockpile would be used to reclaim the WRF and are anticipated to have low strength and high moisture/ice characteristics. The NOB stockpile would include a containment berm constructed of locally derived, coarse-grained, ice-poor, colluvium and alluvium materials. The stability of the containment berm would not rely on any strength characteristics of impounded fine-grained materials. The NOB stockpile will be constructed in three lifts totaling approximately 198 feet in height. The SOB stockpile would generally receive structurally competent, ice-poor, coarse-grained overburden materials derived from the American Creek area. The stockpile design (overlapping lifts) would rely on the structural characteristics of the stockpiled materials, which would not exceed a 20 percent organics/fine-grained soil concentration by volume for compaction. The SOB will be placed in five lifts totaling approximately 165 feet in height.
- TSF and Related Stockpiles: Major components of the TSF include temporary and permanent dams and a lined tailings impoundment area to be constructed over a 2-year period. Prior to liner placement, surface soils up to 3 feet thick would be grubbed and stripped, and overburden up to 26 feet thick would be cleared to bedrock. To the extent practicable, excavated organics would be segregated for use as eventual TSF closure cover material. Impoundment clearing is intended to remove a majority of ice-rich materials that would contribute to differential thaw settlement (Section 3.2.3.2.2). Excavated shallow materials would be replaced with liner bedding material consisting of terrace gravel or comparable silty gravel mixture derived from terrace gravel source areas located along the east side of Crooked Creek and the mine pit (Section 3.1, Geology). Excavated overburden from the TSF would be placed into three separate engineered stockpiles downstream of the TSF, two of which would coincide with material sites to minimize additional surface soil disturbances and exploit engineered surfaces prepared during terrace gravel removal.
- WRF: During the construction period, existing soils beneath the first few lifts along the toe of the WRF would be pre-stripped for foundation stability purposes, and rock drains would be placed on existing soil surfaces above these lifts. A foundation of non-acid generating (NAG) rock would be placed on top of existing soils at the potentially acid generating (PAG) management area to isolate PAG material from the ground beneath (BGC 2011b).
- Other Mine Site Infrastructure: Topsoil and organic materials removed from ground surfaces during construction of the Mine Site and process components (tailings dam, freshwater dam, mill site, crusher, maintenance shops, etc.) would be salvaged and

selectively stockpiled as growth media for later use. All timber and woody debris unsuitable for sale will be salvaged and stockpiled for future reclamation use or incorporated as amendment in the growth media. Salvaged overburden stockpiles retained for future reclamation use would be stabilized as necessary to minimize erosion and maintain viability for future use. Additional details regarding reclamation practices are addressed in the erosion section under Mine Site (Section 3.2.3.2.4).

The types of surface soils and unconsolidated deposits that would be disturbed during mine construction are described in Sections 3.2.2.1.1 and 3.1 (Geology), respectively. Based on review of available NRCS data applicable to the Mine Site and surrounding area, the disturbed surface soil types are considered usual or ordinary in context based on their wide distribution. Furthermore, no agricultural areas are present in the vicinity of the mine, nor are any areas considered to be prime farmland, forest land, or rangeland (see Section 3.15, Lands). These usage considerations are largely attributed to Mine Site soil characteristics as well as physical climatic conditions.

Operations

Continued disturbances to soil would occur throughout Mine Site operation, which would have an active life of approximately 28 years. The intensity of effects on soils would be the same as described above for construction. The area of soils removed from the pit would expand to roughly 1,500 acres. The TSF would be constructed in six stages over the mine life, reaching a maximum of approximately 2,400 acres. Ongoing development of the WRF would continue throughout operations based on planned bottom up development, reaching a maximum of approximately 2,200 acres where existing soils would be permanently covered with successive lifts of waste rock.

Additional disturbances to soil at other Mine Site infrastructure would include those associated with pit dewatering throughout operation. Pit dewatering will lower the groundwater table, resulting in adverse impacts to some sensitive soil conditions (i.e., wetlands) that presently rely on un-perched shallow groundwater processes. Soils (wetlands) most susceptible to dewatering activities are primarily located at low elevations in mine site drainages, as discussed in Section 3.11, Wetlands. Wetland areas susceptible to dewatering could total approximately 2,700 acres (BGC 2015b). Approximately 550 acres of the total acreage would be located outside the mine footprint (Donlin Gold 2015e). Soil disturbances will also result in the release of greenhouse gas (GHG) emissions. Calculated mean total organic carbon concentrations in wetland and upland surface soils (0 to 10 centimeters) at the mine ranged from 26.2 percent to 24 percent, respectively (ARCADIS 2014). Estimates of GHG emissions from soils and other sources influenced by project activities are presented in Section 3.8, Air Quality.

Excluding the 550 acres of impacted wetlands (dewatering) located outside the mine footprint, the total area of previously undisturbed or permanently covered soils during the mine life, including those described under Construction, would be on the order of 9,000 acres (SRK 2015g). This total acreage of soil disturbance would be of a lesser value at any given period throughout the mine life or closure period due to planned concurrent or phased reclamation.

Selective reclamation of disturbed areas within the WRF, material sites, access roads, and other areas no longer required for mining activity would be implemented concurrently throughout the operational period whenever possible. These activities (described below in Closure, Reclamation, and Monitoring) would optimize beneficial stabilization and restoration of disturbed soils and vegetation in some areas of the Mine Site during operations, instead of postponement to Mine Site closure.

Closure

The objective of reclamation is to return Project Area developments to an acceptable standard of productive use. Reclamation activities would occur throughout operations and at closure as mine components reach their intended design life. It is estimated that approximately 14.7 million cubic yards (cy) of non-organic material (overburden / growth media) and 8.7 million cy of organics (peat / woody debris) would be salvaged and reused for reclamation purposes (SRK 2015g). Growth media salvage and stockpiling would be an on-going process as the pit and WRF are developed. Common measures implemented to reclaim disturbed soil areas would include contouring, ripping to mitigate compaction effects, placement of growth media, and revegetation. Additional measures may be introduced pending innovations in reclamation techniques as they become available. Further details regarding reclamation practices are addressed in the erosion section under Mine Site (Section 3.2.3.2.4).

Major Mine Site components that would be reclaimed in place at closure, remaining in perpetuity beneath engineered soil covers designed to promote controlled runoff and reduce infiltration, include the WRF and TSF. Soil and overburden consisting of primarily fine-grained peat / loess mixtures stored in the NOB stockpile would be used to reclaim the WRF. Borrow sites would be reclaimed using salvaged surface materials from each site. In the event that any TSF overburden stockpile material remains following TSF closure, these materials would also be used for additional reclamation of terrace gravel borrow sites. Additional closure proceedings associated with the WRF and TSF are presented in Section 3.2.3.2.3 (Erosion).

Surface soils would not be replaced within the mine pit. Cut benches, slopes, and haul roads in the pit would be left to naturally revegetate on their own. Additional disturbances to existing soils during the closure and reclamation phase would occur during construction of the Crevice Creek spillway from the TSF. The water treatment plant (WTP) would be sited in an area of soils previously disturbed during construction and operations.

The amount of growth media available in stockpiles is expected to be more than adequate for reclamation needs. Generally, a minimum of 6 inches would be applied to reclaimed sites needing additional growth media to promote revegetation, although application thicknesses may vary by facility and existing surface conditions, with rocky areas potentially requiring a greater thickness than areas with fines (SRK 2015g). Assuming that 7,500 acres of the Mine Site would be reclaimed, the volume of available stockpiled overburden and organics would allow for application of up to 2 feet of growth media on average.

Continued operation and inspection of reclamation infrastructure and soil covers would be conducted for a large portion of the mine area (roughly 7,500 acres) well after mine operations cease. This would include monitoring of the open pit, WRF, TSF, WTP, and associated drainage networks (SRK 2016d).

Soil disturbance during closure would be minimal, since activities would primarily focus on reclamation. Reclamation of exposed ground surface areas with growth media for soil stabilization and revegetation are considered viable and consistent with the post mine land use objectives (recreation and wildlife).

Summary of Mine Site Impacts

In terms of intensity, direct impacts to soils from ground disturbances at the Mine Site during construction and operation of Alternative 2 would range from noticeable compaction or burial of existing soils requiring revegetation to acute or obvious changes in the resource character due to complete soil removal. However, the intensity of these effects in most areas would be reduced through reclamation. These activities would result in the irreversible alteration of a total of roughly 9,000 acres of surface soil. The extent or scope of impacts would be limited to areas within the mine footprint. The context of impacts would disturb surface soil types considered usual or ordinary resources and are widely distributed in the region.

Transportation Corridor

Construction

Soil disturbances during construction of specific Transportation Corridor components would result in noticeable to obvious changes in soil cover, which could range from compaction to removal of surface soils and placement of engineered fill or stockpiles over existing surfaces. Soil disturbance effects would be limited to areas within the footprints of specific Transportation Corridor components. Complete construction of the Angyaruaq (Jungjuk) Port site and mine access road would span a period of approximately 1.5 years; however, both would be operational in approximately 0.5 years. Similar to the Mine Site, construction of the Transportation Corridor would result in wetland disturbances and subsequent GHG emissions which are presented in Sections 3.11, Wetlands, 3.8, Air Quality, and 3.26, Climate Change. Effects on soils for specific transportation infrastructure components are described below.

Mine Access Road and Airport: The 30-mile long road between the Mine Site and Angyaruaq (Jungjuk) Port site, and 3-mile spur road between the mine access road and airport, would be constructed as two-lane, 30-foot wide, and all-season gravel roads with restricted public access. The total estimated area of soil disturbance associated with the roads and airstrip is approximately 400 acres. Soil disturbance effects during road construction would be irreversible, as the roads would remain in perpetuity to support post-Closure activities. About half of the route would be constructed using conventional cut and fill techniques, and half with elevated fill embankments about 3 to 5 feet thick. Heavy equipment would be used for conventional cut and fill construction techniques; no excessively large cuts or fills would be required (Recon 2011a). Elevated fill sections would be employed where permafrost and snow accumulation issues exist (Section 3.2.3.2.2). Scrub materials would be tracked over, and cleared materials placed on the downslope side of the clearing limits in sloped areas. Reclamation and surface stabilization measures would be implemented during and after construction (Section 3.2.3.2.4). If winter ground conditions are unsuitable, an estimated 92,000 cy of material and geotextile would be imported for suitable substrate materials over the southernmost 4 miles of road from the port (Recon 2011a). Road design alignments would be based on the American Association of State Highway and Transportation Officials (AASHTO) standards, or as required to meet transport specifications. Soil map units that would be impacted along the access roads, airstrip, and Angyaruaq (Jungjuk) Port site are shown on Figure 3.2-1 and listed in Appendix F. More than 90 percent of disturbed areas from road construction activities would impact two soil types that are prevalent throughout the Project Area among slopes and low mountains of the Kuskokwim Hills and extend well beyond the alignment corridor (i.e., R30MTB and R30MTC and Appendix F). Less prevalent soil types within the road construction corridor, but also prevalent throughout the Project Area, include those associated with permafrost, floodplains, and terraces (Appendix F and NCRS 2008).

- Material Sites: Disturbances of surface soil at material sites along the mine access road would encompass roughly 440 acres. These effects would be the same as those described in Section 3.1, Geology.
- Angyaruaq (Jungjuk) Port Site: The Angyaruaq (Jungjuk) Port site would occupy an area of 21 acres including a five acre overburden stockpile. The port area would be stripped of surface soil and overburden, which would be stockpiled in an engineered storage area. Approximately 10,000 cy of dredged material derived from shoreline development (sheetpile infrastructure) would also be placed in the stockpile. The overburden stockpile would be situated adjacent to the northernmost and upslope extent of the constructed port site pad. Construction BMPs would include surface stabilization and installation of erosion and sedimentation control (ESC) measures along disturbed surfaces, including the overburden stockpile.
- Kuskokwim River Corridor: Soils along the Kuskokwim River could potentially be disturbed at certain critical sections where barges may need to be relayed during low water conditions. Disturbances from mooring activities and intermittent foot traffic causing potential soil compaction at relay points may not be measurable or noticeable. Based on information presented in Section 3.5, Surface Water Hydrology, impacts on riverbank soils from barge-induced wake would not substantially impact Kuskokwim River bank erosion rates based on river tractive energy studies of barge traffic, wave height, and energy (BGC 2015m). Wave heights during upstream travel were estimated to be between 0.05 and 0.22 feet, and approximately 0.34 to 0.74 feet during downstream travel with increased barge speed. Furthermore, the primary cause of bank erosion along the lower Kuskokwim River is related to thermo-erosional niching associated with high water levels. Additional information for estimated project barge requirements is addressed in Section 2.3 (Chapter 2, Alternatives).
- Bethel Cargo Terminal (connected action): Disturbances to soils at the proposed 16-acre cargo terminal would include grading, contouring, cut and fill, and paving to accommodate storage yards, berths, buildings, roads, and other facility infrastructure. Effects on soils would be such that there would be obvious surface changes, but these would occur mostly on previously disturbed soils in an existing industrial area. Shoreline development would include construction of an open cell sheetpile bulkhead spanning approximately 850 feet to prevent erosion of the river bank. Approximately 40,000 cy of sand and gravel fill and 1,600 cy of riprap would be placed behind and at the ends of the sheetpile, resulting in the creation of about three acres of new ground containing well-drained surface soils (Corps 2014a). These effects would be beneficial in that they would result in the permanent creation of new soils useful for community and industrial purposes. Well-drained sandy soils range from common to important in the region, as much of the Bethel area is covered by poorly drained permafrost soils with difficult foundation conditions.
- Bethel Fuel Terminal (connected action): An existing fuel terminal at the Bethel Port would be used to support project fueling needs, with three additional fuel storage tanks constructed within the existing facility. The site is already developed and equipped with tank pads, liners, and containment to accommodate the additional tanks. Due to the

existing fuel farm infrastructure, additional disturbances to native soil conditions during construction would likely be very limited, if any.

- Dutch Harbor Port Site: Indirect effects from expansion and upgrades to an existing third-party Dutch Harbor facility may impact an estimated area of four to six acres of soils. Disturbances to soils would be necessary during construction; however, it is possible that construction would occur in previously disturbed areas re-appropriated for fuel storage. Overburden would be temporarily displaced to accommodate construction of tank foundations, secondary containment, pipeline distribution, and access. Soils derived from volcanic deposits in the Dutch Harbor area are widespread in the Aleutians and Alaska Peninsula, are generally poor or unsuitable for agricultural purposes (USDA 1979), and thus considered common in context.

Operations

Little to no additional soil disturbance is anticipated at the Transportation Corridor sites following construction. Minor maintenance dredging activities at the Angyaruaq (Jungjuk) Port site would involve annual placement of an additional 1,200 cy of river sediment in the designated waste soil disposal area on the upslope side of the port area (Fernandez 2014b). (Effects of dredging in the river are discussed in Section 3.5, Surface Water Hydrology.) Road maintenance could involve minor grading or placement of additional fill in areas needing repair. Placement of material within previously constructed road and stockpile footprints would cause incremental effects from compaction and grading that may not be measurable or noticeable.

Indirect effects of maintenance dredging at the Bethel Port would likely involve placement of similar volumes of river sediment at an in-river location (Section 3.5, Surface Water Hydrology). Maintenance dredging details for this port are not yet available, and would be determined through a Corps permit process if a permit were issued (Corps 2014a). Disposal of maintenance dredge material at an upland location is not anticipated as the Bethel area is tidally influenced and saline material disposal at an uplands site is unlikely to be permitted. Any actions that would occur at Dutch Harbor or the Port of Bethel at the Bethel Yard Dock are not part of the proposed action, and are considered connected actions (see Section 1.2.1, Connected Actions, in Chapter 1, Project Introduction and Purpose and Need).

Closure

Project related soil disturbances during closure would be limited to the Angyaruaq (Jungjuk) Port site. The mine and airport access roads would remain indefinitely to support post-Closure activities at the mine, and the Bethel and Dutch Harbor facilities would likely continue to operate under third-party ownership. Incremental effects on soil disturbance from long-term road maintenance would be the same as described above under Operations. Any actions that would occur at Dutch Harbor or the Port of Bethel at the Bethel Yard Dock are not part of the proposed action, and are considered connected actions (see Section 1.2.1, Connected Actions, in Chapter 1, Project Introduction and Purpose and Need).

The Angyaruaq (Jungjuk) Port site would be reclaimed following removal of all above-ground infrastructure from the site, including sheetpile infrastructure and associated fill. Surface soils would be restored and stabilized through grading, contouring, and revegetation. In terms of intensity, these disturbance activities would initially require revegetation by active methods during reclamation, but would be beneficial over time due to permanent replacement of disturbed soils, ultimately resulting in effects that may not be noticeable. Additional closure and reclamation activities and BMPs for the port site related to erosion are presented in Section 3.2.3.2.4.

Summary of Transportation Corridor Impacts

In terms of intensity, impacts to soils from ground disturbances at the various Transportation Corridor components during construction and operation of Alternative 2 would range from compaction and grading in previously disturbed port areas that may not be measurable or noticeable to acute or obvious changes in the resource character from the complete removal of native soils at road cuts. However, the intensity of effects in some areas would be reduced through reclamation. Soil disturbances under Alternative 2 would result in the irreversible alteration of a total of roughly 900 acres of surface soil. The extent or scope of impacts would be limited geographically to areas within the footprints of the individual infrastructure components. The context of impacts would affect soil types associated within disturbed areas that are prevalent beyond the impacted areas.

Pipeline

Construction

Soil disturbance considerations for the Pipeline include soil types impacted and the area of disturbance associated with Pipeline components. Construction activities resulting in soil disturbances to wetlands and subsequent GHG emissions are detailed in Sections 3.11, Wetlands, 3.8, Air Quality, and 3.26, Climate Change.

The 316-mile Pipeline alignment traverses a variety of soil types, physical conditions, and landscape terrains. Surface soils along the Pipeline are described in Figure 3.2-6 and Figure 3.2-7 for the eastern and central portions of the Pipeline, and Appendix F, and Figure 3.2-8 for the western portion of the Pipeline. Unconsolidated deposits and physiographic terrain are described in Section 3.1, Geology. Soil types present along the alignment are prevalent throughout the Project Area and considered usual or ordinary resources in context.

Direct impacts to soils during construction would range from minor compaction of frozen native soils to clearing, grading, excavation, fill placement, and installation (and removal) of buried and above-ground infrastructure. The total acreage of potential surface soil disturbances associated with ROW and off-ROW infrastructure throughout the construction period is approximately 8,300 and 2,600 acres, respectively (SRK 2013b). The geographic extent of effects would be limited to discrete areas within the ROW and off-ROW facility footprints.

The construction period would span three to four years, including ROW preparation and initial infrastructure build-out to construction rehabilitation and reclamation. Preliminary winter work that could affect soils before the first year of pipeline installation would include clearing and grading of the ROW and certain access roads; material site development; construction of storage yards, camp pads, and new airstrips; and existing airstrip upgrades. Recovery of most soil disturbances are expected to last through the life of the project, with reclamation and soil/vegetation recovery within the first few years following construction. Longer lasting permafrost effects are described in Section 3.2.3.2.2.

Although some construction methods are common to various Pipeline components, unique construction methods exist for specific components. Factors influencing soil disturbances include construction methodology, soil and vegetation sensitivities, and physical conditions inherent to the location and time of construction (i.e., seasonal conditions, slope gradient, permafrost). Construction activities that would create soil disturbances are described below for the ROW corridor and ancillary facilities located mostly outside the ROW.

Pipeline ROW

The ROW area that would be cleared for construction is roughly 4,150 acres (150 feet wide), with up to an additional 4,150 acres available (up to 300 feet wide) for additional temporary space that may be needed in areas of challenging ground conditions (SRK 2013b). Together these total 8,300 acres. The ROW area for the North Option would be approximately the same as the main route. As shown on Figure 2.3-28, the ROW would consist of three major surface components: the trench centerline area, a trench spoils side, and a working side with makeup areas and travel lane. While soils would be completely removed from the trench area, soil disturbance effects on the working and spoils sides of the ROW would consist primarily of soil compaction in relatively flat regions. Areas with large cross-slopes subject to cut-and-fill construction would have greater areas of total soil removal. The total length of ROW with cross-slopes requiring cut-and-fill construction (generally greater than six percent) would be about 262 miles.

Pipe installation would occur in eight sections over a two year period. The estimated duration of total construction at any single point along the Pipeline ROW would be approximately three to four months from initial surveying to finish grading. Approximately 68 percent, or 215 miles of the total Pipeline length would be constructed during frozen winter conditions to minimize soil disturbances from support equipment. Approximately 100 miles of the total Pipeline length would be constructed in the summer. Areas selected for summer or fall construction would be based on geotechnical, terrain, safety, and work length (pipeline) continuity considerations. Favorable geotechnical conditions would include stable permafrost that would result in minimal ground settlement (less than one foot) over the life of the Pipeline, and/or suitable near surface soils to support equipment (e.g., gravel floodplains). A majority of the mitigation and restoration activities would be performed concurrently during construction, and would be completed during the spring shoulder season and/or the summer after pipe installation. Specific ESC and restoration measures and access to various Pipeline components are presented in Section 3.2.3.2.4, and those specific to permafrost terrain are discussed in Section 3.2.3.2.2.

The 150-foot construction ROW area would be cleared of brush, trees, roots and other large obstructions before grading. Snow/ice, gravel, and/or graded work pads would be installed after clearing and grading. With the exception of two above-ground crossings over active faults, the Pipeline would be installed subsurface in an excavated trench or through horizontal directional drilling (HDD) (Section 3.3, Geohazards and Seismic Conditions). Installation depths (cover) would be a minimum of 2-1/2 feet in upland soil, 4 feet in drainages or ephemeral waterways, and up to 10 feet at stream crossings for scour protection (Section 3.5, Surface Water Hydrology). The process of lowering in or making tie-ins with loaded sidebooms would be one of the main activities resulting in disturbance to surface soils and vegetation. Each sideboom will consist of CAT 561 or 572 –class tracked equipment. Up to three sidebooms (and other equipment as needed) will operate simultaneously to configure, lower, place, and situate each pipe segment for tie-in. In comparison to other pipeline construction activities, this process will generally result in the most localized heavy equipment track movement adjacent to the trench.

Soft soil conditions incapable of supporting construction equipment would be covered with work pads constructed of swamp mats, corduroy timber, granular rock materials or snow and ice. Wide track high flotation equipment (i.e., excavators) would also minimize disturbances to more sensitive soil conditions along the alignment. Organic soil would be segregated and stockpiled during trench excavation, and re-used as growth media surface completion material following pipeline installation and backfilling. Where possible, attempts would be made to use finer grained materials in the absence of organic soils for future revegetation efforts. Temporary impoundment of saturated organic soils may be required during ditch excavation in wetland areas. Backfilling would be initiated as soon as practicable following pipe installation to minimize additional efforts to remove accumulated snow, precipitation, or resulting disturbances.

Ancillary Facilities

The following infrastructure would be located mostly outside of the construction ROW corridor resulting in soil disturbance effects ranging from compaction of native soils for winter road construction or drilling in previously disturbed soils that may not be measurable or noticeable to acute or obvious changes in the resource character from grading and cut excavations along access roads and airstrips. Temporary infrastructure would be reclaimed following pipeline construction. Together, the off-ROW infrastructure throughout the construction period affects approximately 2,600 acres. Infrastructure for the North Option would cover a total of about 6 acres more than the Alternative 2 main route. Specific ancillary facility descriptions are addressed in Section 2.3 (Chapter 2, Alternatives), and include corresponding footprint acreages, lengths (where applicable), and seasonal usage.

- Temporary Roads: These would include graded or gravel-filled access roads for all season use, and ice access roads that would be limited to winter activities only. Approximately 45 new temporary access roads and shoofly roads would be used in the summer only; 59 used in winter only; and 13 constructed for all season use (SRK 2013b). Temporary roads would include a seasonal winter access corridor (Oilwell Road or Willow Landing Route) that would serve as a major supply route from the Parks Highway (see Figure 2.3-23). The access corridor would be constructed mostly on existing winter trails. The winter access corridor would require minimal clearing, and would be on frozen ground conditions fortified with ice from water withdrawal sites. Equipment accessing the winter corridor would consist of tracked or rubber-tired vehicles with greater weight-to-surface area distribution to minimize compaction of soils underlying the snow and ice.

- Camps and Storage Yards: These temporary facilities include mainline construction camps, airstrip construction camps, smaller fly-in camps, HDD camps and worksites, and pipe and equipment storage yards comprising a total of about 300 acres under any Alternative 2 routing option. Impacts to surface soils would include disturbances mostly during grading, leveling, and drilling activities. Storage yards would generally be developed approximately one year before the pipe-laying season, and would be cleared and graded with gravel if existing soil conditions are unsuitable. Camps would be relocated at the end of each construction season and demobilized as pipeline construction is completed.

- Material Sites: Approximately 70 proposed material sites would impact a total estimated area of about 1,100 acres under any Alternative 2 routing option, with the North Option affecting approximately 30 fewer acres for material sites. The sites would supply gravel fill material for roads, airfields, camp pads, storage yards, compressor station, and gravel work pads (as needed). Sites would be situated in areas that avoid environmentally sensitive areas. Topsoil at these sites would be removed and stockpiled for later reuse during reclamation. Additional effects and mitigation measures at these sites in relation to surficial deposits and resource reduction are discussed in Section 3.1, Geology.
- Airstrips: A total of 12 new and existing airstrips would be used to support construction activities along the Alternative 2 proposed pipeline route, with one additional airstrip proposed under the North Option route. No new earthwork would be required at two airstrips, at Beluga and the Donlin Gold Mine Site. While new airstrip locations have been selected to minimize cut and fill construction requirements, acute or obvious changes in the resource character would result from cut excavations, fill placement, and contouring at six airstrips (seven under the North Option). Clearing and grading only would be conducted at the four remaining airstrips. An area of approximately 670 acres would be disturbed through construction of new airstrips under Alternative 2, ranging in lengths of 3,500 feet to 5,000 feet. Approximately 15 additional acres would be disturbed through construction of the new airstrip under the North Option route at Glacier Creek (Donlin Gold 2017k). Specific airstrip details are addressed in Section 2.3 (Chapter 2, Alternatives).
- Compressor Station and Transmission Line: Construction of the compressor station at MP 0.4 would disturb approximately 2 acres of soils. A short buried transmission line would disturb soils from the compressor station to the metering station at MP 0. The transmission line would either be collocated within the first 0.4 miles of the Pipeline ROW, or lie in a separate ROW adjacent to the pipeline ROW (Donlin Gold 2017k).
- Valves, Pig and Metering Stations: Small areas of soil disturbance comprising less than one acre total are associated with three pig launcher and receiver stations, metering stations located at either end of the Pipeline, and 19 main line (block) valves (MLVs). Two of the three pig stations and four of the 19 MLVs would be co-located with other planned structures (e.g., compressor station).

Operations

Since all temporary facilities, roads, airstrips, and storage yards would be reclaimed immediately following construction, soil disturbances attributed to Pipeline operation are limited to facilities and footprint areas retained for use. No new or expanded infrastructure, such as airstrips or roads, is planned during Pipeline operation. With the exception of the compressor station and other permanent ancillary needs, the construction ROW area would not be retained outside the permanent ROW. Area estimates for Pipeline operation activities include about 1,900 acres for the reduced, post-construction, Pipeline ROW and about 30 acres for the transmission line. O&M activities and inspections related to ESC are described in Section 3.2.3.2.4. Corrective maintenance activities that have the potential to disturb previously restored soil conditions include routine and non-routine pipeline monitoring and maintenance activities such as vegetation clearing, removal/replacement of equipment, pipeline inspections, and

ROW mitigation and stabilization that could potentially occur anywhere along the length of the Pipeline. Soil disturbance during these activities would be limited to the corrective maintenance activity and involve compaction, fill placement, or grading. The duration of effects could occur intermittently over the planned period of use (30 years), and potentially persisting for months or years beyond initial disturbance until stabilization criteria are met. These activities would be performed per the established O&M Plan/Manual, and follow BMPs and directives outlined in the Stabilization, Rehabilitation and Reclamation (SRR) Plan and ESCP (Section 3.2.3.2.3).

Closure

A variety of future conditions may influence final closure determinations (continued use, retained infrastructure, etc.); however, discontinued use of the Pipeline and associated infrastructure is assumed for planning purposes and analysis of soil effects. As described in Section 3.2.3.2.3, a revised SRR Plan would be developed at closure to address final reclamation actions, and incorporate BMPs and ESC/restoration measures based on review of prior practices.

In-place abandonment of all subgrade pipeline following purging would cause little to no surface soil disturbance along most of the ROW. All above-grade pipeline and structural facilities would be removed. Pipeline surface protrusions and foundation piles would be capped/blinded below ground surface. Gravel pads would be left in place, and salvaged overburden stockpiles distributed and spread. Surfaces would be scarified in preparation for revegetation. Soil disturbances would likely be more intensive where above-grade abandonment activities occur, such as at fault crossings, the compressor station, and pig launcher/receiver stations, where closure activities are anticipated to include small excavations, grading, contouring, and revegetation. The duration of impacts during closure are expected to be similar to those for operations. While the season of final Pipeline termination/reclamation is not specified in the current Pipeline Plan of Development (SRK 2013b), closure activities that occur during the winter season (similar to construction) would help to minimize surface disturbances to soil (Chapter 5, Impact Avoidance, Minimization, and Mitigation).

Summary of Pipeline Impacts

In terms of intensity, impacts to soils from ground disturbances along the Pipeline ROW and ancillary facilities during all phases of Alternative 2 would range from compaction of frozen native soils along winter roads that may not be measurable or noticeable to acute or obvious changes in the resource character from cuts and fills along ROW, roads, and airstrips. However, the intensity of effects would be reduced in most areas through reclamation following construction. Soil disturbances under Alternative 2 would impact a total of 8,350 to 14,100 acres, depending on the amount of additional ROW space needed in areas of challenging ground conditions. While the Pipeline crosses several regions of Alaska, this extent of impacts would be limited to areas within the footprint of the construction ROW corridor and individual infrastructure components, and potentially streambeds adjacent to or downstream of that footprint. Soils would be irreversibly altered in areas of the highest intensity construction effects, although the duration of most effects following reclamation would persist for several years until stabilization criteria are met. Soil types present along the alignment are prevalent throughout the Project Area.

3.2.3.2.2 PERMAFROST

Mine Site

Construction

Permafrost stability or anticipated changes to existing permafrost conditions can substantially influence design and construction of the project. Sporadic discontinuous permafrost is present throughout the Mine Site area (Section 3.2.2.1.2 and Figure 3.2-2), is regionally extensive in Alaska, and is considered a common resource in context. Ice-rich soils at the Mine Site that are most susceptible to differential thaw settlement are generally associated with valley bottoms and lower slopes, thick organic cover, poor drainage conditions, and a relatively thin active layer.

The intensity of effects on permafrost in disturbed areas would range from thawing in areas of thaw stable soils that does not result in noticeable ground settlement, to acute or obvious changes from partial excavation of frozen, thaw unstable soils beneath major Mine Site components to achieve tolerable design limits and reduce the intensity of effects.

Permafrost removal is a requirement for the project, given that existing permafrost could potentially result in adverse impacts on the stability of important structures if not mitigated. The extent of frozen soils that could potentially cause acute or obvious consequences from structural failure is localized beneath the specific structures. Physical forces associated with these structures concerning permafrost and structural integrity generally include, but are not limited to increased heat transfer and loading forces (e.g., overburden, hydrostatic).

Other effects associated with permafrost degradation include the release of GHGs when thawed. Permafrost acts as storage for carbon contained in organic soils, which can be released to the atmosphere in the form of carbon dioxide and methane upon thawing (e.g., O'Donnell 2010; Tarnocai et al. 2009). Estimates of the amount of permafrost soils that would be thawed during Construction are summarized in Table 3.2-4. Estimates of permafrost GHG emissions resulting from Mine Site construction activities are presented Section 3.8, Air Quality, and effects are discussed in Section 3.26, Climate Change. Effects on and from permafrost are described below for specific Mine Site facilities.

Table 3.2-4: Permafrost Degradation, Mine Site

Facility	Permafrost Degradation by Phase			Approximate % Permafrost Occurrence (by area)	Area (acres)		Approximate Depths Permafrost Removal/ Degradation (ft)		Approximate Thickness Permafrost Soil Removal/ Degradation (ft)		Permafrost Soil Volume Lost (cy)		Permafrost Soil Mass Lost (tons) [1]	
	Construction	Operations	Closure		Total	Permafrost	Construction	Operations	Construction	Operations	Construction	Operations	Construction	Operations
Open Pit	Excavation/ complete removal to bedrock	na [2]	na [2]	30 [3]	1,536	460	7-19 [4,5]	na [2]	12	0	27,000,000	na [2]	36,000,000	na [2]
Dams (TSF+SRS, Snow Gulch, CWDs, FWDDs)	Excavation/ complete removal to bedrock	na [2]	na [2]	35 [3]	216	76	7-19 [4,5]	na [2]	12	0	4,400,000	na [2]	5,900,000	na [2]
TSF impoundment	Shallow excavation and 2-yr thaw	na [6]	na [6]	30 [3]	2,226	670	7-9 [16]	na [6]	2	0	6,500,000	na [6]	8,700,000	na [6]
WRF	Excavation/ complete removal in foundation soils, across about 40% of footprint [7]	Excavation/ complete removal in foundation soils, across remaining footprint	na [2]	30 [3]	2,222	670	7-19 [4,5]	7-19 [4,5]	12	12	15,000,000	23,000,000	21,000,000	31,000,000
Ridge Material Sites (Snow Gulch, Upper American Creek)	na [8]	na [8]	na [8]	na [8]	na [8]	na [8]	na [8]	na [8]	0	0	na [8]	na [8]	na [8]	na [8]
Terrace Material Sites with Co-located Stockpiles (MS4-5/SOB, MS6/growth media, MS7/growth media)	Excavation of material site/ partial removal, and thaw due to surface disturbance [9]	Slower thaw degradation due to stockpile insulation	na [2]	35 [3]	357	130	7-9 [5,9]	9-19 [4,10]	2	10	1,200,000	3,600,000	1,600,000	4,900,000
Other Stockpiles (NOB, ore, TSF SP1/growth media)	na [11]	na [11]	na [11]	na [11]	340	na [11]	na [11]	na [11]	0	0	na [11]	na [11]	na [11]	na [11]
Unlined Reservoirs (Snow Gulch, CWDs) [12]	na [13]	Thaw due to covering by water	na [14]	30 [3]	152	46	na [13]	7-19 [4,5]	0	12	0	2,600,000	0	3,600,000
Facility Pads, Plants, Storage, Laydown Areas	na [8]	na [8]	na [8]	na [8]	na [8]	na [8]	na [8]	na [8]	0	0	na [8]	na [8]	na [8]	na [8]
Mine Site Roads and Construction Buffers/Work Areas	Thaw due to surface disturbance	Continued thaw due to surface disturbance [15]	na [14]	10 [3]	2,125	210	7-10 [5,16]	10-19 [4,16]	3	9	3,100,000	9,300,000	4,200,000	12,00,000
												Total	**77,000,000**	**52,000,000**

Notes:
1. Assumes density of 1.6 g/cc for silty permafrost soils (USDA-NRCS 2013; Zollinger et al. 2013).
2. All permafrost soils excavated by end of earlier mine phase.
3. Based on approximate average extent in Figures 3.3-2 and 3.11-18.
4. Average depth of base permafrost is 19 ft, where present in valley bottoms and side slopes (BGC 2006).
5. Assumes top of permafrost (bottom of active layer) is at 7 ft (BCG 2006).
6. Permafrost >2-3' deep would continue to thaw, but GHGs would be trapped by liner.
7. Based on BGC (2011b) end of period maps.
8. No permafrost present in ridge areas (Figure 3.2-2).
9. Assumes average depth of material site excavations of 9 ft, based on material take-off estimates in Construction period from BGC (2011a).
10. Assumes remaining 10 ft permafrost would be thawed by end of mine life, though at a slower rate due to stockpile insulation.
11. Permafrost protected by stockpile in Construction/Operations, and reclamation (soil placement and revegetation) in Closure.
12. Permafrost impacts from Anaconda FWDD ponds accounted for under TSF impoundment.
13. Assumes minimal disturbance beneath pond footprints in Construction; no permafrost impacts until Operations when ponds fill and remain unfrozen at the bottom year-round.
14. Assumes limited additional thawing following reclamation and revegetation; and/or all permafrost would be thawed by end of previous phase.
15. Assumes road settlement due to permafrost thaw would be repaired with additional fill/grading as needed, i.e., roads would not be constructed with an extra thick gravel prism to prevent thaw.
16. Assumes rate of permafrost degradation of roughly 1 ft/yr, based on ROW modeling results using McGrath and Farewell temperature data (27-ft thaw depth after 30 years) (Fueg 2014, Zarling 2011) and conditions in Bethel (see Table 3.2-5).

Effects on Permafrost

- Dams (TSF and Other): Planned design features for all dams (temporary or permanent) would require complete excavation of overburden and ice-rich materials to bedrock followed by replacement with suitable fill material. The purpose of this is to increase the strength and stability of the dam foundation by locating it directly on bedrock. These actions are expected to reduce the likelihood and intensity of impacts from permafrost hazards on dam stability.

- TSF Liner – Thaw Settlement: Ice-rich soils with greater than 20 percent visible ice in the form of segregated ice lenses have been observed at depths up to about 50 feet in the TSF valley bottom upstream of the dam, and up to 3 feet in midslope areas. These conditions are generally limited to silty soils where present. Frozen soils would be excavated within the impoundment area up to nominal depths of 3.3 feet in the valley bottom and 1.6 feet on the slopes to remove a majority of thaw sensitive organics and permafrost soils containing excess ground ice, but some permafrost would remain beneath the impoundment area. Progressive widespread thaw settlement is anticipated across the Anaconda Creek valley bottom over the operational period, and thawing of remaining permafrost foundation soils could result in differential settlement. This effect would be partially mitigated by pre-thawing during construction: liner bedding material sourced from gravel deposits would be placed on top of the stripped soils, compacted, allowed to thaw over one summer season, and recompacted prior to liner installation. Thaw settlement analyses based on a variety of conditions (i.e., moisture content, overburden pressures) were used to evaluate and select a relatively flexible, textured low density polyethylene (LLDPE) geomembrane liner (60 mil or 1.5 mm) that is expected to withstand freezing temperatures, sharp rocks, and anticipated settlement scenarios. Groundwater modeling studies of the TSF currently assume a small amount of leakage from liner defects (0.16 square inch flaw / acre, Section 3.6.2.2.1, Groundwater Hydrology). The liner is unlikely to experience excessive strain from basin-wide settlement, and conditions that could result in excessive localized (abrupt) settlement that would challenge this defect assumption are also considered unlikely based on current understanding of bedrock conditions, overburden types, overburden thicknesses and distribution, ground ice distribution, and the planned over-excavation of shallow ice-rich soils (BGC 2011a). For example, using a maximum recommended allowable liner strain of eight percent based on a factor of safety of two (below tested strain limits), BGC (2011a) predicts that a maximum differential settlement of 8 to 16 feet would have to occur over a short distance of three to six feet before the recommended limit is reached, and that such variable conditions are not expected to be present following impoundment preparation. If actual foundation conditions encountered during construction are more variable than anticipated, pre-thawing and recompaction during construction are expected to mitigate the risk of differential settlement causing a compromised liner.

- TSF Liner – Ice Loading: The TSF liner could also be subjected to vertical and lateral stresses from ice on top of the TSF pond as a result of wind movement or water levels rising and falling, which could cause liner damage and increased seepage flow if not mitigated. Efforts would be made to minimize ice touching the liner through tailings beach development and monitoring. However, it is possible that ice could contact the liner over significant lengths under certain precipitation conditions (SRK 2016c). These effects and contingencies proposed to prevent liner damage are further described in Section 3.3.3.2.3 (Other Hazards).

- WRF: Ice-rich, fine-grained soil conditions exist in certain areas of the WRF which could create unstable conditions when thawed through development of excess porewater pressure. During construction, organic and ice-rich soils would be stripped beneath the footprint as the WRF expands, particularly along the toe of the WRF, to secure the leading face of the WRF and reduce the likelihood of instability (SRK 2016d). The removed materials would be replaced with coarse, durable waste rock. Based on the design and information presented in Section 3.3, Geohazards and Seismic Conditions, the WRF stability meets or exceeds design criteria under earthquake loading conditions, assuming that ice-rich soil and fine-grained material is removed from the toe of the WRF to an average depth of about eight feet and that no remaining ice-rich materials would liquefy. However, if fine-grained and/or ice-rich soil conditions exist below this depth, the stability of the soils as they thaw under future loading conditions is uncertain with respect to seismic events (BGC 2011b) and could result in acute or obvious effects downgradient in the event of WRF deformation or slope failure. Recommendations for further investigation to determine if any additional liquefiable materials exist below this depth, and possible additional excavation during site preparation, are described in Chapter 5, Impact Avoidance, Minimization, and Mitigation. Additional seismic and earthquake information regarding WRF stability evaluation is presented in Section 3.3, Geohazards and Seismic Conditions.
- Stockpiles: Frozen soils and overburden from the open pit would progressively be stripped to bedrock, consolidated with selectively excavated ice-rich materials from the WRF and TSF, and placed in the NOB, SOB, and TSF overburden stockpiles. Each stockpile would be contained within a series of engineered berms for each independent lift of material to contain the high moisture content (ice), low strength materials, and would not rely on any cohesive strength attributes of the stockpiled materials. Partial excavation of ice-rich soil materials would be performed during construction of containment berms at the overburden stockpiles and ore body stockpile. For example, TSF overburden stockpile berms would be excavated to an average depth of 1.6 feet to remove unsuitable organic and ice-rich materials. Berms would be constructed of rock fill to facilitate subsurface drainage derived from the progressive thaw of stockpiled materials. Upstream berm faces would be lined with woven geo-fabric to entrain fine material and minimize sediment infiltration into the berm rock fill material. These activities would likely result in irreversible impacts to permafrost during mine construction, but result in beneficial effects on the stability of the berms and stockpiles, and their ability to contain sediment and protect downgradient water quality.
- Plant Area Infrastructure: Excavation and replacement of ice-rich shallow overburden materials with engineered fill may be necessary for specific Mine Site infrastructure, such as the fuel farm and containment area, process plant, and power plant slab foundations and structures, depending on the presence and severity of frozen soil conditions and site-specific design criteria. Foundation designs for plant area infrastructure are not specified in planning documents to date (SRK 2016a). While most of these facilities would be located on a shallow bedrock ridge with minimal permafrost, many data points are unconfirmed (Figure 3.2-2). Permafrost effects may not be

measurable or noticeable in this area, but would need to be confirmed in final design or site preparation. It is reasonable to assume that standard arctic construction BMPs, such as additional geotechnical evaluation, excavation of ice-rich permafrost, pile foundations, ground (thermal) insulation, or cooling (forced or natural convection), would be incorporated into these facilities in final design where appropriate and practicable to minimize heat transfer to frozen subsurface conditions.

- Other Mine Site Areas: As described in Section 3.2.3.2.1, insulative surface vegetation and soils would be disturbed or completely removed over a wide area at the Mine Site during construction for roads, storage yards, and laydown areas, and would be salvaged for future reclamation purposes. Roads involving conventional cut and fill construction methods would also disturb permafrost soils. The duration of interim removal (28 years) could result in appreciable permafrost degradation where present; however, elevated fill and unspecified final design plans and construction methodologies (BMPs) for infrastructure components would generally mitigate adverse settlement over respective service lifetimes.

Thus, the intensity of effects from permafrost hazards in Mine Site construction would range from changes in permafrost that may not be measurable or noticeable, to disturbances that require revegetation by active methods. Designs are expected to be adequate assuming that additional evaluation would typically be conducted in final design. One area is noted above (WRF) where low likelihood conditions may exist that could cause effects on increased intensity, and that could potentially require additional mitigation pending further investigation to reduce the level of effects.

Operations

Varying amounts of permafrost thaw and subsidence would occur throughout the 28-year mine life pending the Mine Site component, localized subsurface conditions, and final construction and design practices. Permafrost disturbances associated with certain Mine Site infrastructure and more thaw stable areas (e.g., roads, buildings, processing facilities) would likely reach a nominal state of stability (equilibrium) during the operational period. Continued and/or permanent degradation of frozen soils are accounted for in stability analyses and thaw settlement design at mine facilities of critical importance, such as the TSF and WRF, which would reduce most permafrost impacts during operations. Specific monitoring requirements for facilities of critical importance would be based on final design and construction (e.g., Tailings Dam Operation and Maintenance Manual) which would include daily, weekly, monthly, and annual evaluations as described in Chapter 2. Estimates of the amount of permafrost soils that would be thawed during Construction are summarized in Table 3.2-4. GHG emissions associated with permafrost degradation during mine operation are presented Section 3.8, Air Quality.

As described above, frozen soils would be excavated from the toe of the WRF during construction. While less permafrost is expected at higher elevations at the WRF, based on subsurface site investigation programs and physical processes associated with permafrost occurrence (e.g., sunlight exposure and slope aspect, less insulative organic surface cover, substrate material types), isolated patches may exist that could affect the WRF as it expands upward in operations. Areas of localized instability upslope of the toe could result where excess ice and porewater pressures exist under loaded conditions in materials with poor permeability and drainage characteristics. Dispersion of potential high pore pressures would be variably addressed through bottom-up construction if the initial lifts of waste rock are sufficient to promote thaw drainage, which would be distributed via engineered rock drains beneath the WRF. If necessary, synthetic or natural materials may be necessary to prevent infiltration of fines into the rock drain. Hydraulic erosion and alteration of existing surface water drainage patterns could also result in some contribution to permafrost thaw during WRF operations. This effect would be minimized through surface water drainage controls to direct and contain contact water. The incremental effects of these issues in operations may or may not be noticeable, and design is generally adequate for conditions.

Permafrost occurs around the western rim of the open pit adjacent to Crooked Creek. Thaw settlement of ice-rich soils in this area during operations could lower the elevation of the narrow rim between the pit and Crooked Creek floodplain, and increase the likelihood that lateral erosion during a flood event could breach this barrier. A discussion of this potential effect is provided in Section 3.3, Geohazards and Seismic Conditions. A nominal value of 1 percent vertical strain or 10-foot reduction in the pit rim elevation was assumed in an analysis of these effects by BGC (2014c) without identifying thaw settlement as a separate causative factor. The potential effect of flooding/lateral erosion breaching this barrier would result in acute or obvious changes in permafrost, but is generally considered low in likelihood based primarily on flood frequency analyses. Mitigation recommendations are also provided in Section 3.3, Geohazards and Seismic Conditions, to reduce the likelihood that this impact could occur.

Closure

Permafrost degradation at the Mine Site begun during construction and operations would continue through Closure and post-Closure until thermal equilibrium is reached. While restoration of frozen soil conditions is not anticipated nor planned during Closure, reclamation and revegetation of areas cleared of soils during construction would preserve remaining permafrost or slow the rate of degradation in the post-Closure period and result in effects that may not be measurable or noticeable. The effects of climate change on permafrost, which are likely to impede permafrost recovery, are discussed in Section 3.10, Vegetation.

Minor additional permafrost disturbances could occur during closure activities at the Crevice Creek spillway and WTP facilities. The WTP would be constructed in an area of previously disturbed soils on a ridge with little permafrost; thus, incremental impacts on permafrost at this facility may not be measurable or noticeable. The Crevice Creek spillway would be located in the upper Anaconda Creek valley where only isolated occurrences of permafrost are expected, and the intensity of effects would be the same as above for the WTP.

Summary of Mine Site Impacts

In terms of intensity, impacts to and from permafrost at the Mine Site during all phases of Alternative 2 would range from ground settlement that may not be measurable or noticeable, to complete removal of permafrost soils, and progressive widespread thaw settlement across the Anaconda Creek valley bottom over the operational period. However, specific low probability conditions may exist that could cause increased intensity effects that may be acute or obvious, but could be reduced through additional mitigation. Effects on permafrost would be limited to areas beneath facility footprints and cleared areas. The total amount of thawed permafrost soils that could lead to GHG emissions is estimated to be roughly 130 million tons over the life of the mine. The duration of permafrost thaw effects would range from unstable foundations that reach equilibrium within the life of mine, to irreversible impacts where restoration of permafrost is not expected. In terms of context, discontinuous permafrost is a usual or ordinary resource based on its regional distribution.

Transportation Corridor

Construction

Evaluation of Transportation Corridor permafrost impacts are limited to components where frozen soil conditions are known to exist. This would include the mine access road, Angyaruaq (Jungjuk) Port site, Kuskokwim River corridor, and Bethel Port site (connected action) as described below. These components are located in the regionally extensive discontinuous zone of permafrost in Alaska, and are considered usual or ordinary resources in terms of context. The Dutch Harbor Port site is located in an area that is considered free of permafrost. Estimates of the amount of permafrost soils that would be thawed during Construction are summarized in Table 3.2-5. Evaluation of GHG emissions resulting from permafrost degradation is presented Sections 3.8, Air Quality and 3.26, Climate Change.

- Mine Access Road: The presence of permafrost along the road alignment is generally limited to intermittent segments near Juninggulra Mountain, the North Fork of Getmuna Creek, Angyaruaq (Jungjuk) Creek area, and the Angyaruaq (Jungjuk) Port site. These areas of the road comprise less than about five miles of the total road length. Frozen fine-grained soils that extend from approximately 0.3 to 0.6 miles north from the port site are considered extremely unstable, coincide with active thermokarst terrain, and would likely result in significant settlement (Recon 2011a). These conditions would typically be managed through special design in the final engineering stage of the Project. Proposed road design features would address thaw consolidation of moderate ice content, fine-grained soils, which could potentially settle up to approximately 3 feet. Construction practices that generally include placement of geotextile materials over existing ground cover, followed by placement of a suitable lift of imported material, are expected to reduce the severity of thermokarst effects. These effects would be limited to the immediate vicinity of the road footprint, and could extend beyond the initial construction period. The initial phase of construction would occur during winter months, and would be monitored as described below under Operations. The nature and extent of permafrost near Juninggulra Mountain and Getmuna Creek is such that the road can be constructed using conventional fill techniques (Recon 2011a).
- Angyaruaq (Jungjuk) Port Site: Isolated areas of permafrost occur in the southwest corner and northeast side of the port footprint, and do not appear to extend below depths of 10 to 30 feet. No permafrost has been encountered below the fuel storage tank footprint (Recon 2013b; BGC 2013h). Marginal soil conditions and shallow permafrost-bearing soils would likely require limited excavation and placement with suitable fill materials. While these details have not been specified as part of Alternative 2 yet, it is reasonable to assume that they would be addressed in final design. Excavated permafrost materials would likely be placed in the engineered 5-acre stockpile and consolidated with both organic/mineral soils from port clearing activities and saturated river sediment excavated from the berth area. The stockpile would be situated on relatively level thaw-

stable ground on the upland side of the port away from waterbodies and wetlands, and constructed with low sloping profiles. While ESC design features specific to thawing permafrost soils (such as a sediment pond) have not been defined yet for the stockpile, it is reasonable to assume that these would be addressed in final design as part of SWPPP permitting, such that the likelihood of sediment-laden runoff flowing towards the Kuskokwim River is considered low.

- Kuskokwim River Corridor: The Kuskokwim River is in the discontinuous zone of permafrost, and permafrost melting is considered one of two main riverbank erosion mechanisms. The primary means permafrost thaw and subsequent erosion is attributed to a process called “thermo-erosional niching” which is addressed further in Section 3.5, Surface Water Hydrology. Although wakes from barge traffic could appreciably contribute to permafrost degradation during ice free barging seasons, other natural processes and variables influence permafrost degradation such as slope bank aspect, warm water eddies during summer months, and prevailing wind wave action (Dorava and Hogan 1995). Since barge induced waves are not expected to substantially impact Kuskokwim River bank erosion rates, subsequent effects to river bank areas where permafrost exists are also expected to be minimal in comparison to existing processes.
- Bethel Port Site (connected action): The top of permafrost in the vicinity of the Bethel Port site ranges from three to 50 feet below ground surface, and could potentially be encountered during construction of the 16-acre facility depending on distance from the river (thaw bulb) and amount of previously disturbed soils. Much of Bethel is built on pile foundations due to shallow permafrost conditions. While site preparation and construction details are currently unavailable for this third-party site, it is reasonable to assume that site-specific excavation and/or special design would be completed during final engineering, such that effects from thaw unstable soils and thaw settlement may or may not be noticeable and the design is adequate for conditions.

Table 3.2-5: Permafrost Degradation, Transportation Corridor

Facility	Permafrost Impacts by Phase			Approximate % Permafrost Occurrence (by area)	Area (acres)		Approximate Depths Permafrost Removal/ Degradation (ft)			Approximate Thickness Permafrost Soil Removal/ Degradation (ft)			Permafrost Soil Volume Lost (cy)			Permafrost Soil Mass Lost [1]		
	Construction	Operations	Closure		Total	Permafrost	Construction	Operations	Closure	Construction	Operations	Closure	Construction	Operations	Closure	Construction (tons)	Operations (tons)	Closure (tons/yr)
Alternative 2 - Proposed Action (and Alternatives 3A, 3B, 5A, and 6A)																		
Mine Access Road to Jungjuk, Material Sites, and Jungjuk Port																		
Road near Crooked Creek (MP30 to MP24)	Vegetation clearing, cut and fill [2]	Continued thaw due to surface disturbance [3]	na [4]	25 [5,6]	22 [7]	6	7-10 [8,9]	10-19 [2,9,10,11]	na [4]	3	9	na [4]	87,000	260,000	na [4]	120,000	350,000	na [4]
Road near BTC Junction (MP14-16 and MS07)	Vegetation clearing, cut and fill for road, cut for MS [12]	Continued thaw due to surface disturbance [3]	na [4]	25 [6]	29 [7]	7	7-10 [8,9]	10-25 [2,9,13]	na [4]	3	15	na [4]	100,000	510,000	na [4]	140,000	690,000	na [4]
Road South of BTC Junction (MP0.6-14; MS8-9 and MS12-16)	Vegetation clearing, cut and fill	Continued thaw due to surface disturbance [3]	na [4]	5 [14]	138 [7]	14	7-10 [8,9]	10-30 [2,9,15]	na [4]	3	20	na [4]	200,000	1,400,000	na [4]	270,000	1,800,000	na [4]
Road near Lower Jungjuk Creek (MP0-MP0.6)	Vegetation clearing, cut and fill	Continued thaw due to surface disturbance [3]	na [4]	50 [16]	2 [7]	1	7-10 [8,9]	10-16 [2,9,17]	na [4]	3	6	na [4]	15,000	29,000	na [4]	20,000	39,000	na [4]
Jungjuk Port	Thaw due to surface disturbance [18]	Continued thaw due to surface disturbance	na [4]	10 [19]	21	2	7-10 [8,9,18]	10-26 [9,20]	na [4]	3	16	na [4]	29,000	150,000	na [4]	39,000	210,000	na [4]
Subtotal																590,000	3,100,000	0
Alternative 4 - Birch Tree Crossing (BTC)																		
Mine Access Road to BTC, Material Sites, and BTC Port																		
Road near Crooked Creek (MP0-6)	Vegetation clearing, cut and fill [2]	Continued thaw due to surface disturbance [3]	na [4]	25 [5,6]	22 [7]	6	7-10 [8,9]	10-19 [2,9,10,11]	na [4]	3	9	na [4]	87,000	260,000	na [4]	120,000	350,000	na [4]
Road West of Jungjuk Junction (MP11-73)	Vegetation clearing, cut and fill	Continued thaw due to surface disturbance [3]	na [4]	70 [21]	223 [7]	160	7-10 [8,9]	10-26 [2,9,22]	na [4]	3	16	na [4]	2,300,000	12,000,000	na [4]	3,100,000	16,000,000	na [4]
Material Sites near West End of Road (MS50-MS51)	Vegetation clearing and cut [12]	Continued thaw due to surface disturbance	na [4]	100 [32]	50	50	7-10 [8,9]	10-23 [9,32]	na [4]	3	13	na [4]	726,000	3,200,000	na [4]	980,000	4,200,000	na [4]
BTC Port (including MS52)	Thaw due to surface disturbance, and cut for MS [18]	Continued thaw due to surface disturbance	na [4]	10 [24]	114	11	7-10 [8,9,18]	10-30 [9,25]	na [4]	3	20	na [4]	160,000	1,100,000	na [4]	220,000	1,400,000	na [4]
Crooked Creek Winter Road	Vegetation degradation/ compaction	na [23]	na [23]	25 [5]	43 [7]	11	7-10 [8,9]	na [23]	na [23]	3	na [23]	na [23]	160,000	na [23]	na [23]	220,000	na [23]	na [23]
Subtotal																4,600,000	22,000,000	0

Table 3.2-5: Permafrost Degradation, Transportation Corridor

Facility	Permafrost Impacts by Phase			Approximate % Permafrost Occurrence (by area)	Area (acres)		Approximate Depths Permafrost Removal/ Degradation (ft)			Approximate Thickness Permafrost Soil Removal/ Degradation (ft)			Permafrost Soil Volume Lost (cy)			Permafrost Soil Mass Lost [1]		
	Construction	Operations	Closure		Total	Permafrost	Construction	Operations	Closure	Construction	Operations	Closure	Construction	Operations	Closure	Construction (tons)	Operations (tons)	Closure (tons/yr)
All Alternatives - Bethel Yard Dock (BYD)																		
Bethel Yard Dock - developed part	Continuation of existing surface disturbance [26]	Continued degradation from existing surface disturbance	Continued thaw at slower rate	100 [27]	13	13	30-32 [28,29]	32-43 [28,29]	43-52 [29,31]	2	11	9	130,000	690,000	570,000 [31]	170,000	930,000	25,000 [31]
Bethel Yard Dock - undeveloped part	Vegetation removal, surface disturbance [26]	Degradation due to new surface disturbance	Continued thaw at slower rate	100 [27]	13	13 [30]	5-10 [8,18,29]	10-30 [29]	30-43 [29,31]	5	20	13	320,000	1,300,000	820,000 [31]	420,000	1,700,000	37,000 [31]
Subtotal																590,000	2,600,000	62,000
Total, Alternatives 2, 3A, 3B, 5A, and 6A																**1,200,000**	**5,700,000**	**62,000**
Total, Alternative 4																**5,200,000**	**25,000,000**	**62,000**

Notes:
1. Assumes density of 1.6 g/cc for silty permafrost soils (USDA-NRCS 2013; Zollinger et al. 2013).
2. Includes no correction for side slopes: depth to top permafrost would be same as average of original condition, i.e., equally shallower on cut side as it is deeper on fill side.
3. Assumes road settlement due to permafrost thaw would be repaired with additional fill/grading as needed; roads would not be constructed with an extra thick gravel prism to prevent thaw.
4. All permafrost would be thawed by end of previous phase.
5. Based on approximate average extent of Figures 3.2-2 and 3.11-18.
6. Based on Recon (2007a, 2014) and BGC (2014); no permafrost at airstrip, MS-1/permanent camp, MS02-MS06, MS-10/Getmuna Flats, or road MP16-MP24 (mileposts from Table 2.3-9).
7. Based on 30-ft wide road corridor.
8. Assumes top of permafrost (bottom of active layer) is at 7 ft for mine access roads (BCG 2006, DMA 2007a), and 5 ft for undeveloped part of BYD (Busey et al. 2000).
9. Assumes rate of permafrost degradation of roughly 1 ft/yr for mine access roads and material sites (MS) where present, based on ROW modeling using McGrath and Farewell temperature data (27-ft thaw depth after 30 years) (Fueg 2014, Zarling 2011) and conditions in Bethel (see note 28).
10. Average depth of base permafrost is 19 ft, where present in valley bottoms and side slopes (BGC 2006).
11. Assumes maximum depth of permafrost similar to Mine Site (Table 3.2-4).
12. Assumes no permafrost removal during MS excavation: average depth excavation is within active layer (based on Tables 2.3-9 and 2.3-38).
13. Based on subsurface descriptions in Recon (2007a) and 3 nearby borings (Recon 2011a; DMA 2007a), assuming base of permafrost 10 ft below total depth (TD) if TD in permafrost.
14. Based on permafrost present in 1 borehole out of 21 (Recon 2011a).
15. Assumes base of permafrost 10 ft below maximum geoprobe depth in GP-1003 (Recon 2011a).
16. Based on 2 borings with permafrost out of 4 total, over southernmost 0.6 mile of road (DMA 2007b; Recon 2011a; BGC 2014).
17. Based on maximum depth of permafrost averaging 16 ft bgs (Recon 2011a).
18. Assumes no excavation of permafrost soils for foundation preparation.
19. Current port footprint avoids most of permafrost identified in DMA (2007b) and BGC (2014).
20. Average base of permafrost based on DMA (2007b) and BGC (2014), assuming base of permafrost 10 ft below TD if TD in permafrost.
21. Based on permafrost presence in about 2/3rds of borings along about 45 mi of 62-mi road length (73%), and in about 2/3rds of borings near material sites (Section 3.2.3.5.2, Recon 2007b).
22. Based on average of maximum permafrost depths in DMA (2007a), assuming base of permafrost 10 ft below TD if TD in permafrost.
23. Assumes complete vegetation recovery by end of Construction period.
24. Assumes discontinuous permafrost conditions similar to Jungjuk Port (Section 3.2.3.5.2) and MS52 (Recon 2007d), and port/MS siting to avoid most permafrost.
25. Based on average of maximum permafrost depths in closest borings and MS' (DMA 2007a; Recon 2007d), assuming base of permafrost 10 ft below TD if TD in permafrost.
26. Assumes surface disturbance only; no deep foundation excavations into permafrost required in Construction.
27. Assumes thaw bulb beneath Kuskokwim River does not extend west of cut bank (Dorava and Hogan 1994).
28. Assumes previous surface disturbance in developed part of BYD is approximately 30 years old (Bethel Planning Department 1983) and permafrost is currently thawed to 30 ft, based on: 1) conditions at a nearby site in operation since before 1980s (Bethel Planning Department 1983; Busey et al. 2000) with depth to top permafrost between 3 ft and >50 ft, and 2) Fueg (2014) results for ROW modeling north of Alaska Range (27-ft thaw depth after 30 years).
29. Thaw depth assuming rate reduces as a function of the square-root of time (thaw depth = constant x square-root of time) (e.g., Woo 2012), using extrapolation of constant 5.5 based on 30 ft thaw depth in 30 years (see Note 28).
30. Assumes development of all previously unused portions of BYD site would be needed.
31. Based on estimated thaw in first 30 years of Closure; thaw is expected to continue beyond this point to the base of permafrost though at a slower rate.
32. Based on Recon (2007d); no permafrost noted for MS1-MS49.

Operations

Since no additional development is planned during Transportation Corridor operation, impacts would be limited to continuing permafrost thaw effects described above under Construction (Table 3.2-5). Thaw settlement along the mine access road would be monitored continuously with ongoing traffic throughout mine construction and operations. It is possible that permafrost (where present beneath the access road) would completely thaw during the 28-year period of Mine Site operation or reach a state of equilibrium.

Corrective actions would be implemented as needed based on post-construction inspections in permafrost affected areas. Due to the limited presence of permafrost along the road alignment and planned mitigation in design, continued stabilization or rehabilitation activities are expected to be isolated and minimal. Measures to repair thaw effects would include placement of fill from borrow material sites and correction of drainage problems derived from thermal subsidence. Where appropriate, temporary and long-term ESC measures would be installed as described in Section 3.2.3.2.4.

Closure

Anticipated closure and termination activities would be limited to the Angyaruaq (Jungjuk) Port site, since the mine access road would remain indefinitely to support monitoring and the pit lake water treatment plant operation, and the Bethel Port site would likely continue to operate under third-party ownership (Table 3.2-5). It is likely that there would be no additional permafrost effects for the mine access road in Closure, as most of the expected thaw would occur by the end of Operations. Due to the continued use of the developed Bethel dock site in post-Closure and deep extent of warm permafrost in this area, thaw is expected to continue beyond Closure at this site. Any actions that would occur at Dutch Harbor or the Port of Bethel at the Bethel Yard Dock are not part of the proposed action, and are considered connected actions (see Section 1.2.1, Connected Actions, in Chapter 1, Project Introduction and Purpose and Need).

Most of the Angyaruaq (Jungjuk) Port facility would be reclaimed following Mine Site closure, and infrastructure removed that is no longer required to support post-Closure monitoring and water treatment. Surfaces would be graded, contoured, and revegetated as necessary for surface stabilization. Recovery of permafrost conditions at the port site is not expected to occur, although reclamation would likely preserve remaining permafrost or slow degradation.

Summary of Transportation Corridor Impacts

In terms of intensity, permafrost impacts at transportation infrastructure facilities during all phases of Alternative 2 would vary, and may or may not be noticeable due to thaw settlement along short road segments or erosion and sedimentation of thawing soils at the Jungjuk Port stockpile, assuming that impacts are effectively managed through planned special design. The extent or scope of effects would be limited to areas within the immediate vicinity of infrastructure footprints. The total amount of thawed permafrost soils is estimated to be 6.9 million tons over the life of the mine, and roughly 62,000 tons / year in Closure (Bethel site only). Most permafrost thaw effects would range from impacts lasting throughout the life of the project (e.g., road conditions reach equilibrium within several years) to irreversible impacts where restoration of permafrost is not expected. In terms of context, discontinuous permafrost is considered context usual or ordinary resource based on its prevalence throughout the Project Area.

Pipeline

Construction

The 316-mile long Pipeline route crosses an estimated 31 miles of discontinuous permafrost: about 19 miles of thaw stable permafrost soils, and 12 miles of thaw unstable soil conditions that are expected to settle more than 1 foot when thawed over time (SRK 2013b; Fueg 2014) (Section 3.2.2.3.2, Figure 2.3-34). Permafrost occurs intermittently between MP 100 and MP 150 in the Alaska Range, including along the primary and North Option routes under Alternative 2, and ice-rich soil conditions extend along the north flank of the Alaska Range between about MP 150 and MP 215. Approximately 30 stream crossings coincide with permafrost and fine-grained soils potentially susceptible to thermal erosion (Section 3.2.2.3.3). Extensive bodies of massive ground ice have not been documented based on preliminary geotechnical investigations. In terms of context, permafrost is considered a usual or ordinary resource, based on the Pipeline route traversing the regionally extensive discontinuous permafrost zone, and the presence of pre-existing thermokarst terrain along segments of the route.

Permafrost effects pertinent to pipelines include differential thaw settlement and thermal erosion. Differential thaw settlement can have effects on pipeline integrity and drainage patterns that persist through the life of the project. Thermal erosion commonly occurs when soil cover over permafrost is removed, triggering melting and erosion. These effects can start immediately following clearing and / or soil removal during Construction and last for years. An estimate of the amount of permafrost soils that would thaw during the mine life is provided below under Operations. GHG emissions derived from permafrost degradation along the natural gas Pipeline route (construction and operation) are presented in Section 3.8, Air Quality.

Disturbances to frozen soil conditions are primarily associated with invasive pipeline construction activities and disturbances to the subsurface thermal regime via heat transfer along the pipeline trench and cleared ROW. Conditions generally considered most susceptible to thermal erosion include areas of massive ground ice where the soil moisture content (ice) is greater than 250 percent of the dry weight; disturbed ice-rich soils adjacent to water bodies; and areas of exposed ice-rich soils along cut slopes that could potentially result in thaw flow slides, gullying, subsidence, and surface water ponding (Davis 2001; SRK 2013b). These conditions would likely be most susceptible to retrogressive thaw slumps, and would have the greatest potential to occur during the first season of thaw following construction, but could also be cyclic with additional headwall retreat in subsequent years. Other construction disturbances that would influence immediate or prolonged thermal erosion of ice-rich soils include drainage pattern alteration, excavation, and removal / disturbance of insulative vegetation cover.

Edges of water bodies (stream crossings and wetlands) would be more susceptible to retrogressive thaw where ice-rich frozen soil conditions exist. Conditions influencing the severity of thaw at these areas include the amount of construction disturbance, slope gradient, soil texture (fine-grained versus coarse-grained materials), permafrost stability, and stabilization and restoration measures.

The types of impacts described above would generally result in changes to permafrost that may not be measurable or noticeable in thaw stable soils, and possibly acute or obvious changes in thaw unstable soils without the application of planned mitigation. Construction of the Pipeline and off-ROW facilities would incorporate the following specialized design, BMPs, and ESC measures to minimize and mitigate thaw settlement and thermal erosion (SRK 2013b). The use of these features and practices is expected to reduce permafrost effects in thaw unstable soils.

Pipeline Design

There are approximately 300 mapped transitions between thaw unstable soils and either thaw stable or non-permafrost soils. These transitions are more likely to result in adverse thaw settlement or differential ground movement that could subject the pipeline to additional strain. That would require design considerations and safety conditions beyond the requirements of the present gas pipeline code (49 CFR Part 192) in order to safely utilize strain-based design (SBD). Under PHMSA regulations, SBD may be considered where high longitudinal strain caused by special geotechnical conditions, such as frost heave or differential thaw settlement, can safely stress the pipe beyond the typical elastic range allowed by SBD. The results of thaw modeling used in assessing the need for SBD are described below under Operations. Additional description of the purpose and need for SBD, as well as geohazard and environmental conditions that PHMSA uses to evaluate the likelihood of pipeline failure as a result of SBD, are described in the attached Donlin Gold PHMSA Special Permit Conditions and Environmental Analysis Report (Appendix E).

Mitigation in areas where strain is anticipated to approach or exceed 0.5 percent would include project-specific design parameters, pipeline materials, construction, and O&M practices described as conditions in the PHMSA Special Permit. An SBD conditions document (that becomes part of the Special Permit) would include an SBD Plan that addresses these specifications and procedures. While extensive continuous bodies of massive ground ice have not been documented along the Pipeline route based on preliminary geotechnical investigations, additional geotechnical work would be performed prior to construction to re-evaluate ice contents along the trench line for final design planning. Based on the results of additional geotechnical work, final design and construction considerations could include, for example, special wall thickness, weld specifications and x-ray inspections, welder training requirements, and insulation of specific sections of pipe to reduce subsurface heat transfer. A summary of mitigation measures and conditions that would be implemented during design, construction, and operations is provided in Appendix E. These are expected to manage the effects of permafrost thaw settlement on Pipeline integrity.

Pipeline Construction

Season of Construction: Approximately 68 percent of the total Pipeline length would occur during frozen winter conditions to accommodate support equipment and minimize disturbances to permafrost. To the extent practicable, summer or fall construction would be limited to favorable geotechnical conditions such as stable permafrost and/or suitable near surface soils to support equipment (i.e., gravel floodplains, bedrock). Additional considerations would include terrain and work length (pipeline) continuity.

ROW: Working surfaces would be narrower (smaller) adjacent to the pipeline work area to minimize cuts in thaw-unstable permafrost. Work pads would be constructed of snow and ice in thaw unstable areas when possible. In addition, frost packing would be performed to facilitate frost penetration (at depth) to accommodate equipment in soft soil conditions. Where applicable, imported gravel fill would be used for winter work pads on side slopes in the absence of snow and ice pads. To minimize thermal regime disturbances, organic layers would remain undisturbed below gravel work pads left in place. Land clearing activities would be limited to essential construction areas only, and surface vegetation removal would be avoided where possible.

Trenching: Compressible surface organic material would be segregated during excavation of the trench line and stockpiled separately in windrowed spoil piles from mineral soils for use in final cover and reclamation of the trench line. Trenching would result in excavation of some ice-rich fine-grained soils within the active layer, which typically extends to about 6 to 7 feet (maximum trench depth would be 4 feet). Near-vertical trench cuts would be made in these soils to minimize disturbances, and pipe installation would occur immediately. Ice-rich soil would be segregated from thaw stable soil, in addition to over-excavation of massive ice or high ice content soils to a depth of 10 feet below the bottom of the trench. Removed materials would be replaced with thaw stable bedding and backfill. Segregated ice-rich soils would be stockpiled as described below. Surface completion material spread (roached) over the trench line would be mounded to compensate for future settling associated with melting, water channelization (run off), or ponding. It is possible that dewatering activities may be necessary during trenching activities due to the influx of water from taliks (unfrozen thaw bulbs surrounding permafrost).

Temporary Soil Stockpiles (Ice-Rich): During trenching, ice-rich excavation spoils would be segregated due to the potential release of water upon thawing. Segregated ice-rich soils would be stockpiled and allowed to thaw and drain prior to reuse as construction material. Stockpiles would be located downslope of the ROW, on thaw stable ground, and a minimum of 30 feet away from water bodies or wetlands. Management of ice-rich stockpiles to minimize erosion would include low sloping profiles, surface roughening, silt fencing and wattles around inactive stockpiles, and plastic covering if there is an increased risk of runoff or high-risk weather conditions. After draining, the material would be spread (roached) over the trench line as surface completion material, or remain stockpiled for future use.

ESC Measures: Temporary and long-term ESC measures would be installed during and immediately following construction. Those pertinent to permafrost areas may include ground insulation or thermal blankets, earthen berms, and silt fences. Cuts in thaw unstable permafrost would generally be near vertical and patched with saved organic material and/or allowed to self-repair as thaw progresses and the uphill vegetative mat lays over the cut surface. Cuts may also be addressed through slope modification and placement of ESC measures where practicable. Stream banks in permafrost areas would be laid back and patched. Extensive silt fencing or other sediment barriers would be installed at the base of thaw unstable cuts. Silt fencing or other ESCs would also be placed along lengths of finished trench line in areas of thaw unstable soil as a precautionary measure. Appropriate temporary ESC measures would be employed to manage trench dewatering activities as described in Section 3.2.3.2.1.

Water Body and Wetland Crossings: Water bodies and wetlands are generally considered environmentally sensitive areas that would require additional precautionary ESC measures to mitigate soil erosion. Approximately 30 pipeline stream crossings are located in fine-grained permafrost soils that are considered particularly vulnerable to erosion and approximately 20 of these have known or potential fish habitat Table 3.2-2. Impacts and mitigation measures associated with fish are addressed in Section 3.13, Fish and Aquatic Resources. The following BMPs and ESC measures would be implemented at water body crossings and wetlands in permafrost areas as necessary:

- Installation of pipeline at most water bodies and wetlands during winter months when frozen ground and snow are present;
- Wetlands clearing would be limited to cutting vegetation flush with the ground, and stump removal would be limited to the trench line;
- Trench plugs would be used to prevent sediment from entering the water body, and decrease erosion of backfill material;
- Trench breakers would be placed above and below wetlands situated on sloping terrain;
- Excavated material would be compositionally segregated (organic vs. non-organic), salvaged, and backfilled in reverse order of removal to minimize groundwater flow and permafrost disturbances;
- As described above, excavated spoils would be placed a minimum of 30 feet from the receiving water body or wetland, and spoils that have no immediate use would be removed from the area and stockpiled at a designated prepared area;
- Where melting permafrost generates water in the trench, dewatering activities would incorporate filter bags for sediment removal prior to discharging to an energy dissipater or well established vegetation;
- Erosion control matting would be used to armor shorelines and approaches;
- Slope breakers would be installed upslope of the water body or wetland to reduce runoff and divert water to the surrounding terrain (as suitably determined);
- Wattles, silt fences, brush berms, rolled erosion control products (RECPs), or a combination of these would be installed parallel to shorelines across the entire construction ROW for erosion control and containment;
- Temporary silt curtains would be installed on an as-needed basis during active construction as a turbidity barrier to receiving waters;
- Graded banks would be covered with erosion control mats or RECPs, and banks would be graded to approximate original configurations, or a more stable configuration than pre-existing conditions, and if necessary the lay back and patching of thaw unstable waterbody slopes to mitigate sediment transport to receiving waters;
- Finish grading would account for surface water ponding and revegetation efforts; and
- Temporary ESC measures would remain in place until stabilization (revegetation) has sufficiently progressed to prevent erosion and sediment migration to the water body.

Post-Construction Reclamation: For winter activities, a cleanup crew would prepare the ROW for breakup once the pipe is laid, followed by a reclamation crew in summer. The reclamation crew would inspect the ROW in permafrost areas in the first summer season following winter construction to address thermal erosion problems that may have developed during the first breakup season. In summer-construction sections, the reclamation crew would follow behind the ESC crew in the same summer. Summer post-construction inspections and corrective actions for most of the Pipeline without permanent road access would be accessed and mobilized via ORV and low ground pressure vehicles, walking, aerial means, and/or watercraft. Additional reclamation/cleanup crew functions, monitoring/maintenance activities, and schedule are further addressed in Section 3.2.3.2.3.

Operations

Since no new or expanded infrastructure (airstrips or roads) are planned during Pipeline operation, impacts to permafrost during this phase would be from the continuation of thaw effects initiated during construction and use of the Pipeline. Although the Pipeline would operate near seasonal ambient ground temperatures and is not expected to freeze surrounding soils, subsequent heat transfer and ongoing effects in areas of disturbed surface soils could facilitate permafrost thaw and settlement in thaw unstable soils.

Thermal Modeling: Pipeline thermal modeling was performed to evaluate thaw settlement and pipeline wall thickness due to buried thermal regime conditions (CH2MHill 2011a 2011b; Fueg 2014; Zarling 2011). The modeling was conducted using TEMP/W to predict soil thaw profiles over time. The model predicts phase change in soils, with inputs including thermal properties of the soils and boundary conditions along the surfaces of the study area. Datasets included ground temperature thermistor information and soil type information acquired during geotechnical investigations along the Pipeline alignment. The analysis and subsequent thaw profile predictions were conducted using available weather data and thaw model for the anticipated 30-year design lifespan. Detailed discussion of the model parameters, inputs, assumptions, and procedures are provided in the Geotechnical Thermal Analysis of the Donlin Creek Mine Pipeline (Zarling 2011).

The model was run using historical annual temperatures from Farewell Lake. Model runs under climate change scenarios are described in Chapter 4, Cumulative Effects. Freezing and thawing factors (n-factors) were adjusted during the last 10 years of the simulation to account for revegetation of disturbed areas. Two different n-factors were run to simulate different snow thicknesses, and two soil profiles considered typical were analyzed for both n-factors. The modeled profiles were symmetrically aligned 70 feet wide on either side of the pipe centerline and the model was run to a depth of 50 feet.

The results of the analysis and associated scenarios by Zarling (2011) yielded predicted thaw depths beneath the disturbed ROW and trench ranging from 4 to 29 feet over 30 years; results using an updated version of the model using only the thin organic layer profile resulted in a predicted thaw depth of 27 feet (Fueg 2014). Conditions affecting thaw depth variability include soil type, moisture content, atmospheric conditions, vegetation, snow cover, and degree of disturbance attributed to construction.

Permafrost acts as storage for carbon contained in organic soils, which can be released to the atmosphere in the form of carbon dioxide and methane upon thawing (e.g., O'Donnell 2010; Tarnocai et al. 2009). Estimates of GHG emissions from melting permafrost caused by the project are provided in Section 3.8, Air Quality, and a description of the level of intensity of the impact is provided in Section 3.26, Climate Change. For the Pipeline, these estimates are based on a soil bulk density of 1.6 g/cc for silty permafrost soils (USDA-NRCS 2013; Zollinger et al. 2013), and assume that thawing is initiated across the full construction ROW (150 feet) and continues over the life of the mine to the 27-foot predicted thaw depth for operations (Fueg 2014). Based on these assumptions, about 33 million tons of permafrost soils are predicted to thaw by the end of the Operations Phase. Roughly 30 percent of this amount (about 10 million tons) is expected to thaw during the first 3 years following pipeline construction (i.e., over the 3-

year mine Construction period), based on thaw depth-time relationships in the literature (e.g., Woo 2012).

Based on the updated modeling results, thaw settlement at permafrost locations along the Pipeline was estimated to range from 0 to 21.1 feet at the ground surface, and 0 to 20 feet below the pipe. Of 132 geoprobe holes drilled in frozen soils and analyzed in these studies, about 70 percent showed little to no thaw settlement (i.e., settlement of 0 to 1 foot), and only three showed extreme settlements exceeding 10 feet. The latter are located along the Threemile Creek / Jones River portion of the alignment near MPs 115 to 120, in an area with additional geohazards such as slope instability where specialized construction techniques (e.g., HDD or deep bedrock trenching) are proposed that would also address concerns about thaw settlement (Fueg 2014). Thus, the primary area of concern for thaw settlement would be on the north side of the Alaska Range between the North Fork Kuskokwim River (MP 147) and the main stem Kuskokwim River (MP 240). About 37 percent of geoprobe holes in this area contain permafrost, with thaw settlement estimates ranging from 0.1 to 7.3 feet at ground surface, and 0 to 5.3 feet below the pipe. These percentages and settlement estimates are considered conservative, in that the geoprobes specifically targeted areas of suspected ice-rich permafrost, and those which hit refusal at depths shallower than the estimated thaw depth were assumed in the model to continue with the final soil layer logged, even though refusal on something other than frozen soils (such as boulders or bedrock) would be less likely to contain deep permafrost.

The effects of differential settlement below the pipe on pipeline integrity would be addressed through PHMSA Special Permit conditions as described above under Construction and in Appendix E. Conditions specific to the operations period could include, for example, in-line tool inspections, strain gages in problematic segments, and frequency of PHMSA reviews. The effects of settlement at the ground surface during operations, which could lead to acute or obvious adverse changes in drainage patterns and erosion if not mitigated, would be addressed primarily during construction by placing a mound of fill over the trench to allow for settlement. Additional fill may be required in some areas on an ongoing basis through proactive monitoring and maintenance as described below. These actions are expected to reduce the intensity of impacts.

Thermal Erosion: Thermally unstable conditions at areas with unique physical settings (e.g., massive ice, slope cuts, water bodies) would likely result in multi-year stabilization and restoration efforts to address subsidence, thaw flow slides, or other construction-induced thermokarst processes. Thaw settlement in areas of ice-rich permafrost along the ROW could result in altered drainage patterns and erosion where runoff flows into and out of subsided zones. The geographic extent of thermal erosion over the life of the mine would be mostly limited to areas within the immediate vicinity of the ROW. Retrogressive thaw slumps of cut slopes along the Pipeline would be evaluated on a case-by-case basis. Areas with exposed ice-rich, fine-grained permafrost could result in isolated cases where sedimentation reaches downstream water bodies. However, planned mitigation measures at or near water body crossings, described under Construction, are expected to be largely effective in maintaining effects to an intensity where the design is adequate for the expected range of permafrost hazards.

Monitoring and Maintenance Activities: Routine monitoring and surveillance activities would address areas of thaw-induced erosion or settlement and identified deficiencies during operations. Monitoring frequency would be based on prescribed inspection intervals, or as needed to address unique soil stabilization conditions. More intensive multi-year surface stabilization measures would be required on a limited as-needed basis at discrete locations that are more susceptible to thermal erosion, such as areas with cuts in unstable permafrost slopes and fine-grained ice-rich soil conditions near water bodies and wetlands, where cleanup of melted material behind sediment barriers would be conducted. Because most areas of the Pipeline lack permanent roads, access for monitoring and rehabilitation would be by aerial means, walking, ORV and watercraft in the summer and snowmachine in the winter (SRK 2013b).

Stabilization measures would be conducted in accordance with the SRR Plan. Measures to reduce permafrost thaw and facilitate reestablishment of seasonal active layers and thaw equilibrium would include placement of backfill or other form of ground insulation, or RECPs, as appropriate and practicable. Stabilization through natural rehabilitation could also be a more appropriate alternative in unique retrogressive thaw scenarios. High disturbance areas would be well documented, routinely monitored, and corrected accordingly. It is likely that thermal erosion stabilization measures along most segments of the Pipeline would eventually achieve a general state of equilibrium by the closure and termination phase, given the projected 30-year period of Pipeline operation. These measures are expected to reduce the intensity of thaw erosion.

Closure

Effects on permafrost during closure and termination would be comparatively limited due to the sizeable portion of in-place Pipeline abandonment; use of previously stabilized / restored work surfaces and trench mounding from pipeline construction and operation activities; and a revised SRR Plan that would incorporate BMPs and ESC / restoration measures based on review and modification of prior practices in permafrost areas.

The Pipeline thermal model (described above under Operations) was run for an additional 45 years beyond termination to evaluate the effects of continuing thaw settlement in areas of concern during the post-Closure period. An additional 10 feet of thaw depth was predicted to occur over this period to a total depth of 37 feet (Fueg 2014). It is likely that thaw degradation would eventually stabilize beyond this point in post-Closure due to regrowth of vegetation. Assuming that the additional thawing in post-Closure would occur across the 50-foot operations ROW, the additional amount of permafrost soils affected over 45 years post-Closure would be on the order of 4 million tons. Estimates of GHG emissions and the level of effects from melting permafrost during both Operations and Closure are provided in Sections 3.8, Air Quality, and 3.26, Climate Change.

Discounting areas of extreme thaw settlement in the Alaska Range, which would be addressed through specialized construction techniques, modeling results indicate that additional post-Closure settlement in the area of unstable permafrost along the north flank of the Alaska Range would occur in about 14 percent of boreholes in this area. The amount of incremental settlement is estimated to range from 0.2 to 1.7 feet at the ground surface (Fueg 2014). Ongoing assessment during the 30-year operations period is expected to provide a more accurate indication of the potential for post-Closure thaw settlement that would be incorporated into the revised SRR Plan prior to closure.

Thus, impacts to previously disturbed permafrost areas are likely to persist on a localized case-by-case basis following Pipeline closure. These circumstances would be addressed per the revised SRR Plan, which would be composed specifically for closure and termination activities, but would not necessarily cover thaw settlement restoration by Donlin Gold in the post-Closure period. The intensity of effects and monitoring / stabilization measures are expected to be mostly similar to those described under Operations, likely consisting of visual inspection during overflights and placement of additional fill and / or other erosion control measures as needed, although localized acute or obvious effects could occur in the absence of periodic monitoring / stabilization in post-Closure. Mitigation recommendations are provided in Chapter 5, Impact Avoidance, Minimization, and Mitigation, for permit conditions that could require that these activities be performed in the post-Closure period to reduce any localized effects to an intensity where the design is adequate for the expected range of permafrost hazards.

Summary of Pipeline Impacts

Permafrost impacts along the Pipeline during all phases of Alternative 2 would range from ground settlement or thermal erosion that may not be measurable or noticeable, to acute or obvious changes in permafrost, although pipeline design and BMPs are expected to be effective at controlling intermittent noticeable settlement or thermal erosion. Specific conditions may exist in post-Closure that could cause localized acute or obvious effects which could be reduced through additional mitigation. The extent or scope of effects would be limited to areas along intermittent ice-rich areas (mostly along the north flank of the Alaska Range) and within the immediate vicinity of infrastructure footprints. The total amount of thawed permafrost soils is estimated to be approximately 37 million tons. Most permafrost thaw effects would range in duration from areas where settlement reaches equilibrium within several years, to irreversible changes in permafrost where restoration of permafrost is not expected. In terms of context, discontinuous permafrost is considered context usual or ordinary resource based on its wide distribution.

3.2.3.2.3 EROSION

<u>Mine Site</u>

Both hydraulic (water) and wind erosion are anticipated to occur at the Mine Site throughout Construction, Operations, and Closure. Erosion can cause adverse effects on downgradient water quality, streams, wetlands, and other sensitive areas outside the project footprint through the breakdown of soil particles and transport of sediment, particularly during storm events, if not managed through the use of ESC measures that stabilize soil, control runoff, capture moving sediment, and promote revegetation. Plans and programs that describe activities related to the control and mitigation of erosion at the Mine Site, and which are considered part of the project under Alternative 2, are described in Appendix F. Activities resulting in erosional disturbances throughout mine development and closure would be conducted in accordance with an approved project SWPPP. Other plans applicable to the Mine Site include the Plan of Operations and related Monitoring Plan (SRK 2016a, e) which address surface water runoff and drainage control systems incorporated into mine design, operations, and compliance monitoring. Reclamation activities and erosion control measures would be performed throughout development, operation, and closure activities for the Mine Site. To the extent practicable, concurrent reclamation would be performed as locations / areas are no longer required or reach design life criteria.

Construction

Most soil conditions located at the Mine Site are generally considered to have a slight hazard of erosion by water (with the organic mat removed) (Appendix F, Figure 3.2-1). Three of the four major soil components associated with soil map unit R30FPA, which covers most of the Mine Site, are considered to have moderate hazard of erosion by air, whereas one component is considered to have a slight hazard of erosion by air. Soil profiles associated with this soil map unit typically include a surficial peat layer overlying varying fractions of silt-sand mixtures, which is underlain by gravels, and / or silt-sand mixtures.

Other soil types at the mine (map unit R30MTC) are limited to a small portion of the pit and terrace gravel material sites that would provide bedding material for TSF construction. The hazard of erosion by water for this map unit ranges from slight to severe, and the hazard of erosion by air ranges from slight to moderate. Soil profiles typically include a surficial peat layer overlying either gravel rich materials with varying fractions of silt and mixtures, or uniform mixtures of sand and / or silt. The erodible soils exposed during construction in most of these areas would either be completely removed during mine development and / or covered by overburden and growth medium stockpiles.

Mine Site activities over the three to four year construction period would occur year round, of which little erosion or no erosion is anticipated during winter months. The greatest potential for soil erosion would likely be during spring breakup from snowmelt, or from June through October from rainfall and surface water runoff.

As described in Section 3.2.3.2.1 (Soil Disturbance / Removal), large quantities of overburden material would be removed during development / construction of the mine pit, WRF, TSF, and engineered stockpile storage areas, resulting in temporary destabilization of ground surfaces throughout the construction period and potential secondary effects on downgradient water quality (Section 3.7, Water Quality) if not controlled. Exposed soils would be particularly vulnerable to ongoing hydraulic and wind erosion processes where not covered by constructed facilities. Erosional sources of varying significance include stockpiled overburden, road construction, and development of facility foundations. Overburden removal, fill material placement, grading, and contouring activities conducted using heavy equipment such as loaders, dozers, excavators and graders would contribute to wind erosion.

While most soils at the Mine Site may be more tolerant to hydraulic erosion than wind erosion based on the NRCS data, the intensity of both types of erosive effects during non-winter construction is anticipated to require revegetation by active methods to prevent erosion issues, and may result in acute or obvious changes in the resource character due to the large areal extent of disturbed surfaces. However, effects are anticipated to be reduced in intensity through proposed design features and BMPs similar to those applied during pipeline construction that would minimize erosion during construction. Much of the surface water and erosional runoff associated with major mine facilities would be intercepted and contained. This would typically include Mine Site “contact water” or “non-contact water” recycled or captured for use in the processing plant or treated and discharged. Drainage controls would include alteration and channeling of surface water drainage through underdrains and diversion ditches that would otherwise contribute to hydraulic erosion.

The geographic extent of erosion is considered local, in that design features and ESC measures described below are expected to keep potential effects within the immediate vicinity of mine facility footprints. Erosion effects may impact soil and water resources, and could also result in discharge impacts to receiving waters governed by regulation. Descriptions of potential or anticipated soil erosion scenarios during construction are provided below for major Mine Site components, along with planned site-specific mitigation measures to control erosion (SRK 2016a, 2017b).

Pit Clearing: Overburden stripping during pit development could lead to erosion downslope of the pit area. Because of the terrain, the initial excavation would be a sidehill cut on the north side of American Creek, rather than a flat scrape. A berm and sump-pump system is proposed on the downgradient side of the ACMA pit cut to control runoff and erosion (SRK 2017b); this would remain in place for about 1.5 years until the pit advances far enough to capture the runoff. Captured runoff would be conveyed to the Lower Contact Water Dam (CWD), or alternatively to the pit or Rob's Gulch depending on the period of development, and treated as mine drainage contact water.

Pit Dewatering Water Discharge: Discharge of treated dewatering water to Crooked Creek below Omega Gulch could cause erosion if not controlled using BMPs. The outfall structural design and location relative to exposed soils, stream banks, and existing flow would be determined during detail engineering prior to construction. Energy dissipators, erosion control measures, and methods for seasonal adjustments to prevent icing and scour would be identified and installed as needed to meet stormwater and water quality requirements (Fernandez 2015).

Ore Stockpile and Process Plant: To prevent discharge of contact water to Crooked Creek during the first year of construction, a containment berm and pump system would capture runoff from the ore stockpile. Contact runoff from the ore stockpile thereafter would report to the American Creek Magnetic Anomaly (ACMA) Pit once progressive pit expansion intersects American. Surface water runoff downgradient of the ore stockpile berm would discharge to the ACMA pit and be collected as described above. The potential also exists for adverse impacts to soil and air quality from wind erosion creating dust at the ore stockpile. These effects are described in Section 3.2.3.2.1, and Section 3.8, Air Quality. Anticipated impacts are expected to be limited due to planned mitigation measures. Mitigation measures include relatively short transport distances between the pit, ore stockpile, and process plant, minimizing the potential for dust dispersion. Water and surfactants would be applied to haul roads for dust control. Fugitive dust baghouses would control potential emissions at transfer points during crushing. Coarse ore would be stockpiled in an enclosed-steel framed structure to control dust. Subsequent grinding stages would occur within closed systems for slurry production. Additional mercury abatement and emission control systems in the process plant are described in Section 3.8, Air Quality.

Overburden Stockpiles: The NOB, SOB, and TSF overburden stockpiles would be constructed with sediment and runoff control structures. Design features would include upgradient diversion channels intercepting runoff to the stockpiles, and drainage ditches and sediment collection ponds downgradient of the stockpiles to collect runoff and seepage. Collected water from the SOB stockpile could be pumped to the Lower CWD and then managed as contact water.

TSF: Design features that would mitigate erosion and control sedimentation during TSF construction include the following:

- An aggressive temporary construction schedule would limit the amount of time that excavated surfaces are exposed;

- A TSF starter dam would be completed during the first winter of construction, impounding water from the upstream side of the TSF dam;
- A top-down method of slope excavation would be conducted, and slope angles of 2.5H:1V (horizontal to vertical) would be maintained to minimize erosion. Slope angles would be adjusted accordingly based on geotechnical engineer determinations during construction;
- Diversion channels for surface water runoff control on the north and south sides of the TSF would be completed during the first winter of construction, and the North and South Freshwater Diversion Dams (FWDDs) that would serve as cofferdams during TSF starter dam construction and liner placement. Diversion channels would be lined with 1.0-mm high-density polyethylene (HDPE) over a layer of riprap protection in overburden materials to prevent channel erosion and reduce ground infiltration. No liner would be installed in channel areas with a bedrock substrate;
- The impoundment area would be stripped of vegetation and overburden winter construction when soils are frozen. Freshwater diversion channels would be completed prior to summer to minimize erosion in the impoundment area during liner bedding material placement by intercepting and diverting runoff around the impoundment area; and
- TSF underdrains installed in the summer following overburden removal would help control runoff and drain permafrost melt away from stripped overburden surfaces.

WRF: Minimal soil removal and erosion is expected during construction of the WRF. Overburden stripping and removal would be limited to the Lower CWD, landslide stabilization berm (LSB), and ice-rich materials along the toe of the WRF. Most of the WRF would be constructed from the bottom up along the American Creek valley and placed on top of existing soil surfaces. The initial phases of water collection, diversion measures (e.g., Rob's Gulch), and rock drains would be completed during the first pre-production year of construction to control runoff. Construction of the American Creek FWDD would be completed about 6 months before completion of the Lower CWD to serve as a cofferdam and intercept and divert runoff. Appropriate energy dissipation structures would be constructed at the FWDD spillway to control erosion (SRK 2017b). The LSB would be constructed of chemically inert durable rock fill for slope stabilization.

Earthwork: A variety of measures would be implemented during earth-moving activities at the WRF lifts and large overburden stockpiles to control surface water run-off, infiltration, and potential erosion. Surface grading practices would include crowning or in-sloping of running surfaces of successive lifts to control runoff and erosion. Interim stockpile surfaces would be revegetated for surface stabilization, and/or surfaces would be progressively reclaimed throughout operation.

Material Sites: As noted above, erodible soils exposed during construction at most of the material sites would either be completely removed during mine development and/or covered by overburden and growth medium stockpiles. Specific plans for ESC measures at material sites not subsequently covered by overburden stockpiles are not provided in the current Donlin Gold Plan of Operations, but are expected to be included in the site-wide SWPPP. Development methods at material sites would range from surface ripping to drilling and blasting, depending upon material competency. In all circumstances, overburden will be stripped and salvaged during initial development for eventual reclamation. Sites would be excavated in stages meeting immediate demands to minimize disturbance areas and erosion potential. Management of temporary overburden and material stockpiles will consider the composition of the materials (e.g., organics, mineral soil, permafrost), local terrain, and include BMPs and ESC measures as described in Section 3.2.3.2.3 (Natural Gas Pipeline). Anticipated material site development and reclamation practices are further described under Transportation Corridor (Section 3.2.3.2.3), and site-specific design features pertinent to these mine components are provided in Chapter 5, Impact Avoidance, Minimization, and Mitigation.

Roads: Construction practices for roads would incorporate BMPs for stormwater control. These would be addressed in a SWPPP detailing appropriate use of ESC measures (e.g., silt fences, hay bales, sedimentation basins, and brush berms). Both general purpose mine roads and construction roads would be equipped with 3-foot wide drainage ditches and 23-foot wide safety berms (BGC 2011e). Surficial organics, loess, and ice-rich materials would be stripped and stored on the downslope side of roads or hauled to the NOB stockpile. Road subgrades would be graded and leveled, and constructed of suitable imported fill materials meeting road design requirements. Water trucks for dust control would be used to spray roads and working areas as needed to control wind erosion.

Operations

Erosion effects during mine operations would be comparatively less than during construction due to less soil removal, on-going reclamation and surface stabilization, operational drainage design features, and ongoing monitoring for compliance with SWPPP requirements. A major component of the operational period would include concurrent reclamation activities at the WRF and other areas no longer required for active mining. Since on-going reclamation and surface stabilization would be performed throughout the mine life, the anticipated intensity of effects may or may not be measurable or noticeable and special BMPs and more frequent monitoring / maintenance may be needed for successful erosion control. Planned design features and potential conditions unique to specific mine components during operations are described below.

- WRF Stability/Erosion: Erosion or sedimentation could potentially result from failure of localized unstable portions of the WRF if too much overburden is mixed with waste rock. Design calculations indicate that overburden placed in the WRF throughout operation should not exceed an overburden-to-waste rock ratio of 20 percent to avoid instability. Current plans would include an eight percent mixture of overburden by volume on an annual basis, which is below the calculated potential instability threshold. Additional efforts would also include overburden / waste rock mixing processes and selective placement of materials to maximize stability. Various types of overburden and waste rock would be mixed to achieve suitable strength characteristics during placement in the WRF. Materials would be distributed as such to minimize pore pressures, and selectively placed in non-structurally sensitive areas. Surface swales and / or ditches would direct flow to rock drains constructed in natural drainages. During operations, surface inspections for erosion or soil stability would be performed on a quarterly basis. Additional discussion of slope stability at the WRF is provided in Section 3.3, Geohazards and Seismic Conditions.

Due to the potentially acid generating nature of PAG 6 category waste rock, it is to be kept as dry as possible and isolated from other waste rock. A low permeability overburden cap will be placed on each series of 100 foot lifts of PAG 6 material to minimize infiltration of surface waters. Prior to installation of each successive cap, PAG 6 material (cells) may require placement of a finer layer of waste rock for leveling purposes and preventing the capping materials from settling into the underlying waste rock layer. Each cap would consist of engineered lifts of low permeability natural colluvium or terrace gravels that is more conditionally resilient (e.g., frictional strength) in comparison to synthetic materials evaluated. In-situ testing of cap source materials resulted in a hydraulic conductivity of approximately 4×10^{-9} cm/s, which is considered suitable for a PAG cap with appropriate moisture content and compaction. Field trials and a quality assurance/control program would be required during waste dump construction to confirm a hydraulic conductivity is achieved within an order of magnitude described above (BGC 2011b, SRK 2016d).

- TSF: The North and South FWDDs would be removed during the third year of operation. Their dam footprints would be removed, re-graded, and BMPs utilized for erosion and stormwater control as appropriate. TSF surface conditions, diversion ditches, and related BMPs would be inspected weekly throughout mine operation (SRK 2016c).
- Plant Site: Surface water runoff derived from the plant site during operations would be considered contact water and managed in the Lower CWD. The surface water and any entrained sediment would be diverted to the TSF via culverts to avoid comingling runoff streams with TSF diversion channels.
- Stockpiles: Although the berm at the ore stockpile would not be necessary when the pits are developed, the berm would remain in place throughout operations to minimize runoff to the ACMA pit. The overburden stockpiles would be progressively reclaimed as practicable throughout operations to minimize erosion, surface entrainment, and infiltration.

Closure

The Mine Site would be reclaimed to pre-mine erosion conditions to the extent practicable under the Reclamation and Closure Plan and ADNR reclamation requirements (SRK 2015g). Plans and programs that also describe activities related to the control and mitigation of erosion at the Mine Site are described in Appendix F, and would generally apply to all alternatives unless stated otherwise. New reasonable and practical stabilization and reclamation techniques would be evaluated and incorporated as appropriate as they are developed. Additional mitigation design features for Mine Site closure are provided in Chapter 5, Impact Avoidance, Minimization, and Mitigation.

Soil erosion is likely to occur during the closure and reclamation phase due to intrusive reclamation activities (i.e., heavy equipment) required to meet post-reclamation land use objectives, and sensitivities associated with newly reclaimed surfaces until stabilization is achieved. Large scale redistribution of topsoil would result in temporary destabilization of ground surfaces during Mine Site reclamation that would likely last for several years beyond closure.

Similar to the construction period, the potential for both hydraulic and wind erosion during closure would be greatest during non-winter months. The intensity of effects during non-winter construction are anticipated due to major earthworks and erosion inspection / maintenance tasks required for major Mine Site components (i.e., WRF, dam sites, TSF, infrastructure) before complete stabilization is achieved. However, effects are anticipated to be reduced in intensity through design features and BMPs.

Reclaimed components would be designed to withstand storm events (e.g., 100-year, 24-hour event) to maintain long-term stability, in addition to evaluation of select components in response to changing conditions (Chapter 4, Cumulative Effects). Ongoing reclamation activities would be monitored on a routine basis (weekly or other). Additional inspections would also be performed following major rainstorm events, and corrective actions implemented as necessary to stabilize reclaimed surfaces. Reclaimed surfaces would be monitored annually for five years, or until stable revegetated conditions are reached. Application of growth media on disturbed surfaces would vary on a case-by-case basis, but would generally include placement of a six inch lift. Growth media would be tilled, roughened, and / or compacted to increase water retention, minimize erosion, and facilitate revegetation. Mulched materials would be added on an as-needed basis to facilitate germination processes and minimize erosion. Additional revegetation details and reclamation performance criteria are evaluated in Section 3.10, Vegetation.

Considerable earthwork (slope contouring and grading) would be performed at major Mine Site components during reclamation. Areas would include WRF, TSF, freshwater and process ponds, and select pit areas. Slopes would generally be finished at 3H:1V slopes. Specific design features and reclamation ESC measures for major mine components to control sediment and erosion would include the following.

- WRF: Closure of isolated PAG category waste rock areas would involve more specific cap material specifications as described in WRF Operations. Inactive / dormant slopes of the WRF during operation would be regraded and contoured, and compacted to a 3H:1V slope ratio to promote runoff and minimize surface water ponding and subsequent infiltration. Interim reclaimed surfaces would be covered in a 1-foot lift of overburden, followed by placement of a 1.15-foot thick mixture of fine-grained materials with organics to establish vegetative cover during operation. Surface completions would include ripping, scarification, and seed distribution and mulching as necessary. Brush or earthen berms would be constructed on toeslopes as erosion control measures until vegetative communities are established. The Lower CWD would be breached, liner and fill removed, re-graded, and surface reclaimed to a natural state. The liner would also be removed from the Upper CWD and backfilled with waste rock. Completed WRF surfaces would be graded to drain to a series of surface water drainage channels. All channelized surface water run-off and seepage would be collected and discharged to the ACMA pit. During the closure period, erosional stability evaluations would be performed quarterly for the first five years; annually the next five years, and once every five years thereafter.
- TSF: TSF dam faces would be covered during closure activities; slopes reduced from a 1.7H:1V slope to a 3H:1V slope for erosional stability; and surfaces would be covered by growth medium. The TSF cover would include 3.3 feet of coarse inert waste rock (non-ML / ARD), one foot of colluvium / terrace gravel, and completed with 1.15-foot thick

peat/ mineral growth media mixture to reduce infiltration. All surface water (cover) runoff would be directed to the southeast corner of the TSF; collected in a lined pond, tested, and discharged. Initial surface water discharge would be to the pit lake, but is anticipated to be suitable for discharge to Crevice Creek in Year 6 of TSF closure.

The TSF cover layers are not intended to completely prevent infiltration, but to control erosion and direct infiltration towards the rockfill layer, where it would be captured along with porewater squeezed out of the tailings in the early closure/consolidation period. Limited surface water infiltration through cap materials and expelled porewater through Year 52 of TSF settlement would be captured in a series of manhole drains installed in the underlying layer of inert waste rock. The hydraulic conductivity of the TSF cover layers is expected to be on the order of 10^{-4} for the waste rock, 10^{-5} cm/s for the colluvium/gravel layer, and 10^{-4} to 10^{-3} cm/s for the peat mixture (BGC 2011a; Meiers et al. 2006; Rodger 2008). Infiltration would primarily be limited by the colluvium/gravel layer and the tailings themselves, which are estimated to have a hydraulic conductivity of roughly 10^{-6} to 10^{-5} cm/s (BGC 2011a). The waste rock layer would provide a capillary break between the cover materials, and also reduce salt mobilization into the upper growth medium. Collected water would be discharged to the ACMA Pit until TSF terminal density is reached by approximately year 52 of closure. No pumping would be required after terminal consolidation is reached. Additional discussion of TSF water volumes and water quality in closure is provided in Section 3.5, Surface Water Hydrology, and Section 3.7, Water Quality.

- Mine Site Facilities: Foundations would be broken up and reduced to rubble to facilitate infiltration. All buried debris would be covered with a minimum of 3.3 feet of gravel/ colluvium. Footprints would be ripped, graded, re-contoured, and seeded. Growth medium would be spread on an as-needed basis. Yard areas and other large undefined disturbances would be reclaimed using methods similar to the WRF. The solid waste landfill surface cover and monitoring would be managed per applicable waste permit criteria.
- Mine Site Roads: Mine roads no longer required for post-Closure monitoring and maintenance would be reclaimed using similar methods to Mine Site facilities. Reclamation of roadbed surfaces would include grading, ripping, and contouring of road bed and ditch surfaces to blend with existing landscapes. Asphalt road surfaces (where present) would be removed and buried in ditches and road depressions prior to grading and final reclamation. Seed would be sidecast following placement of growth media. A stream bank stabilization protocol would be developed to protect banks soils during reclamation at water body crossings that would incorporate guidance published in the State of Alaska (e.g., Walter et al. 2005).
- Snow Gulch Reservoir: This freshwater reservoir would be reclaimed during closure, including draining the reservoir and removing the dam. The dam footprint would be recontoured and revegetated. All power lines and pipelines would be decommissioned and reservoir access reclaimed. General reclamation procedures at closure include, but are not limited to earthwork activities at freshwater ponds. Inundation areas potentially most affected after dam closure (draining) would be located at elevations along the impoundment perimeter that correspond with the most frequent zone of water and ice fluctuation throughout operation (e.g., wave action, ice). Since water levels would

commonly exist at a maximum storage elevation unless there is a contingent need for supplemental process water, this would potentially result in a limited acreage of stripped or affected soils along the impoundment perimeter at closure.

Summary of Mine Site Impacts

Planned erosion control mitigation at the Mine Site during all phases of Alternative 2 are expected to result in effective erosion control and reduction of intensity such that changes in erosion may or may not be noticeable based on standard and site-specific BMPs incorporated into project design and monitoring/maintenance programs. The duration would range from impacts lasting not longer than the span of the project, to impacts lasting through the life of the project but returning to pre-activity levels up to 100 years after completion of the project. Impacts may potentially last for months or years until stabilization of ESC measures is achieved or revegetation criteria are met. The extent or scope of erosion effects would be limited to the immediate vicinity of the Mine Site footprints and stay within project property boundaries. In terms of context, erosion effects and affected soil resources have similar properties in the region; but some erosion scenarios could involve resource hazards governed by regulation (e.g., cover material/containment, natural hazards).

Transportation Corridor

Transportation Corridor compliance with erosion mitigation, control, and monitoring measures would be addressed in a SWPPP Plan and related documents to be developed during final design (Appendix F). The current Donlin Gold Plan of Operations (SRK 2016a) does not provide specific ESC details for the transportation infrastructure components of the project, although it is reasonable to assume for the purposes of evaluating effects, that such plans would be developed during permitting and be in place prior to construction.

Construction

Descriptions of potential or anticipated soil erosion scenarios during construction are provided below for the various transportation facility components. As described above under Mine Site, erosion effects are considered common to important in context, in that they impact common soil and water resources, but are also natural hazards governed by regulation. The duration of most erosion effects that are initiated during construction would be typically resolved within the span of the construction period or lasting for several years beyond it.

Mine Access Road, Airstrip, and Angyaruaq (Jungjuk) Port: Soil conditions along the mine access road, airstrip, and port site range from slight to severe for both water-induced and wind erosion (Appendix F and Figure 3.2-1). Those rated severe for wind erosion are associated with loess soils and silty floodplains. Soil types and locations considered most susceptible to hydraulic erosion include colluvium and loess on slopes, localized areas of ice-rich soils, soils at water body crossings, and higher gradient slopes and sidehill cuts (up to 7.5 percent grade). Planned water body crossings, locations, and types are addressed in Section 2.3 (Chapter 2, Alternatives).

Because a large portion of the most invasive period of predevelopment and initial construction of the road would occur during winter months, minimal erosion is anticipated due to frozen conditions. The greatest potential for erosion would likely occur during periods of thaw during spring breakup or from summer rainfall and runoff events. Anticipated erosion during construction would primarily be attributed to hydraulic processes, and to a lesser extent wind processes. Thermal erosion (permafrost degradation) would contribute to hydraulic erosion processes where frozen soil conditions exist at discrete segments of the access road and the port site (Section 3.2.3.2.2). Construction activities and conditions that would potentially create or contribute to soil erosion along the road include:

- Removal and clearing of vegetation during development of the road bed, road bed ROW, and port site;
- Vegetative mat removal and overburden clearing for suitable substrate placement (cut and / or fill construction);
- Stockpile management of removed overburden and dredged materials, including high moisture content materials (ice-rich soils and dredge spoils) at the port site;
- Development of material sites and construction of access roads; and
- Equipment staging / storage areas.

Thus, the intensity of erosion effects during construction would vary based on anticipated disturbances to a variety of surface conditions required during initial construction. Disturbance would require revegetation by active methods to prevent drainage / erosion issues. If uncontrolled, acute or obvious changes in the resource character may occur. While the degree of cut and fill along the road would largely depend on site-specific physical conditions (substrate materials and permafrost), minimum fill depths ranging from about three to five feet would help control erosion of exposed native soils in cuts. Culverts would be installed to control runoff and erosion at drainage crossings (Section 3.5, Surface Water Hydrology). Other than fill and culverts, current Donlin Gold plans do not provide specific ESC details or stabilization measures for the road and materials sites; however, a required SWPPP and discharge permit would also address erosion monitoring and mitigation.

Material site development and reclamation practices would vary based on physical conditions and material competency specific to each borrow site location. With the exception of MS10, material sites along the mine access road are in upland bedrock areas. BMPs employed during construction and operations to minimize erosion at these sites would include catch benches, slope angles appropriate to the competency of the material, controlled drainage, and overburden storage within site limits. At MS10, shallow pits would be developed in a raised alluvial plain between two tributaries of Getmuna Creek, and extend below the groundwater table. The pits would be separated from the creeks by distances ranging from 250 to 1,000 feet (Recon 2011c).

Material site reclamation would typically follow after no further material quantities are needed. Since some material sites would be re-purposed to serve other project needs (e.g., project man camp, staging area), reclamation at these sites may not occur until mine closure. Anticipated material site reclamation practices would include the following (Recon 2011c):

- Redirecting surface water drainage to naturally vegetated slopes or other engineered receptors (e.g., ditches, collection swales) during operation and final reclamation;
- Re-contouring unconsolidated soil slopes to a maximum 2:1 grade, and a minimum 1 percent grade. In some circumstances, soil slopes would be reduced to a maximum 3:1 grade;

- All loose soil slopes would be compacted (tracked) followed by placement of fertilizer and seed on a case-by-case basis;
- Compacted areas would be ripped and graded to conform with surrounding topography, and scarified for revegetation;
- Overburden would be distributed over pit floors, slopes, and other areas deemed most appropriate. This may include preferential use of overburden for material site access road reclamation where overburden availability is limited. Under these circumstances, some portions of the pit floor may be left as developed;
- Overburden would be spread over access roads, followed by tracking and seeding;
- Competent bedrock slopes would be left in benched configurations as developed during the mining process. Catch benches would extend 10 feet outward every 20 vertical feet of quarry wall and overall slopes will typically range from 1:1 to 1.5:1 slope angles. Weathered or highly fractured bedrock will typically be finished with 2:1 slope angles;
- Soil and gravel slopes above waterline at material sites extending below the water table (e.g., MS10) would be reduced to a 3:1 slope around each pond, and an undulating shoreline would be engineered at each pond using overburden materials. There are no current plans to connect the ponds to nearby creeks. All surfaces would be tracked and seeded for erosion control as necessary, or allowed to re-vegetate with local shrubs and grasses followed by tracking.

Overburden removal during grading and construction of the airstrip would be placed in two overburden dumps at either end of the airstrip (Figure 2.3-13). Soils at this site are composed of silty loess overlying weathered sandstone bedrock (with no permafrost) (BGC 2013h), which could be susceptible to erosion. While ESC measures and BMPs have not been specified for the airstrip dumps, these are typically addressed in final design as part of SWPPP permitting. As such, impacts such as runoff toward the creeks on either side of the airstrip, which are tributaries to northwest-flowing Montana Creek, are expected to be minimized through SWPPP requirements.

Approximately 10,000 cy of dredged materials derived from port construction would be placed in the 5-acre overburden stockpile at the port site. The stockpile would be situated on relatively level thaw-stable ground on the upland side of the port away from waterbodies and wetlands, and constructed with low sloping profiles. While other ESC design features specific to thawing permafrost soils (such as a sediment pond) have not been defined yet for the stockpile, it is reasonable to assume that this would be addressed in final design as part of SWPPP permitting, and the likelihood that sediment-laden runoff would flow towards the Kuskokwim River is considered low. Thus, ESC features at the airstrip dumps and port stockpile are expected to be effective in managing erosion impacts.

Kuskokwim River Corridor: Soils comprising bank material along the Kuskokwim River corridor could potentially be disturbed through hydraulic erosional processes derived from wave-induced, barge traffic; however, any contribution is likely to be small based on the information presented in Section 3.5, Surface Water Hydrology. Discussion detailing expected nearshore processes and subsequent water quality impact contributions from barge induced erosion is also presented in Section 3.13, Fish and Aquatic Resources. The level of effects from potential erosion at relay points would be the same as described in Section 3.2.3.2.1 (Soil Disturbances/Removal).

Bethel Port: Based on the fine-grained characteristics of surface materials (loam) at the Bethel Port, the potential for erosion exists during construction. However, site conditions are considered less conducive for erosional processes (hydraulic), as the local topography is predominantly level and the soils are well drained to moderately well drained. Potential erosion along higher gradient areas of the Kuskokwim River shoreline is expected to be mitigated by construction of a permanent sheetpile retaining wall in this area (Section 3.2.3.2.1). No maintenance dredging or uplands disposal of dredge material is currently proposed for the Bethel Port based on planned improvements to dock design and depth (Fernandez 2014b). Thus the intensity of erosion effects may not be measurable or noticeable for this site. Any actions that would occur at Dutch Harbor or the Port of Bethel at the Bethel Yard Dock are not part of the proposed action, and are considered connected actions (see Section 1.2.1, Connected Actions, in Chapter 1, Project Introduction and Purpose and Need).

Dutch Harbor Port Expansion: Unconsolidated materials over shallow bedrock at the Dutch Harbor Port could potentially become unstable during periods of heavy precipitation, particularly on steep slopes (if any). Surfaces would be most susceptible to erosion during construction when surfaces are disturbed. Effects would be local, limited to the immediate vicinity of the disturbed area (4 to 6 acres), and the period of construction would likely be limited to 1 year or less. Initial cargo and/or fueling infrastructure upgrade activities by a third-party contractor would likely include excavation and bedding material placement (as necessary). Because construction activities would likely occur at an existing facility, the third party would either modify an existing SWPPP for the facility that would address BMPs and ESC measures, or generate a project stand-alone SWPPP for regulatory review. It is also possible that the required expansion upgrades would occur in previously disturbed areas, and where ESC measures already exist or partially exist. Thus, the intensity of erosion effects at the Dutch Harbor Port is such that erosion could occur, but existing or new ESC measures are expected to be effective in controlling it. Stabilization of surfaces with respect to erosion would likely occur during or immediately after the construction phase. Any actions that would occur at Dutch Harbor or the Port of Bethel at the Bethel Yard Dock are not part of the proposed action, and are considered connected actions (see Section 1.2.1, Connected Actions, in Chapter 1, Project Introduction and Purpose and Need).

Operations

Erosion derived from the Transportation Corridor throughout operations would primarily be attributed to the mine access road, and to a lesser extent, the Angyaruaq (Jungjuk) and Bethel Port facilities (connected action). The intensity of erosion effects along the road during operations may or may not be measurable or noticeable, based on planned design features (e.g., culverts) and SWPPP monitoring/maintenance requirements. Although post-construction stabilization and restoration measures would address most immediate erosion concerns along the road, continued maintenance would be required over the indefinite life span of the road per the SWPPP. Visual inspections would be continuously performed throughout operation based on traffic reports and pre-determined inspection intervals. Ongoing soil stabilization and restoration measures would likely be required locally at high gradient slopes or side cuts, fine-grained soils, thermally unstable ice-rich soil, water body crossings, and wetlands.

Erosion at the port sites during operation would likely be minimal based on the comparatively small footprints, planned design features (e.g., Bethel shoreline fortification), and ongoing SWPPP monitoring/maintenance requirements. The most important incremental source of erosion during operations would be from minor maintenance dredge material from the Angyaruaq (Jungjuk) Port berth being placed in the uplands waste soil stockpile. These are expected to cause ongoing effects similar to, but on a smaller scale as, those described under Construction.

Closure

The mine access road would remain in an operational state indefinitely throughout Mine Site reclamation and post-Closure to support long term monitoring and WTP operation. Effects would be the same as described above under Operations, and would require continued monitoring and maintenance (as needed) per SWPPP requirements, and access restrictions for ORV use, if adopted. Monitoring and maintenance details for the road in post-Closure are not detailed in the Donlin Gold Monitoring Plan, but are expected to be addressed during final reclamation and closure planning.

A key source of potential erosion during closure would include reclamation (removal) of Angyaruaq (Jungjuk) Port shoreline infrastructure (e.g., moorage, approaches, sheetpile infrastructure, and associated fill). Surfaces would be graded, contoured, and revegetated as necessary for surface stabilization, and monitored until rehabilitation criteria are met, using similar practices described above for Mine Site closure (SRK 2015g). The intensity of erosion effects are expected to be minimized through BMPs in SWPPP requirements and reclamation practices. Post-reclamation monitoring (or corrective actions) would coincide with other scheduled Mine Site closure activities described in planning documents for reclamation performance standard compliance (Appendix F).

The Bethel and Dutch Harbor facilities would likely continue to operate in the Closure Phase. As such, impacts from erosion would be the same as described for Operations. Any actions that would occur at Dutch Harbor or the Port of Bethel at the Bethel Yard Dock are not part of the proposed action, and are considered connected actions (see Section 1.2.1, Connected Actions, in Chapter 1, Project Introduction and Purpose and Need).

Summary of Transportation Corridor Impacts

Erosion effects at the various Transportation Corridor components during all phases of Alternative 2 would result from road cuts or during port reclamation activities. In terms of intensity, these impacts would vary and may or may not be measurable or noticeable, assuming that required SWPPP and discharge permits address actions required. The duration of most erosion effects would range from several months for individual locations or events, to port reclamation or effects potentially lasting for years until restabilized. The extent or scope of erosion effects would be mostly limited to the immediate vicinity of individual infrastructure footprints. In terms of context, erosion effects are considered usual or ordinary soil and water resources, but are also natural hazards governed by regulation.

Pipeline

The following discussion addresses potential impacts along the Pipeline from hydraulic (water) and wind erosion. Interdependent relationships between hydraulic and thermal erosion processes (permafrost degradation) are addressed in Section 3.2.3.2.4.

Proposed erosion mitigation measures contained in the preliminary ESCP (SRK 2013b) would be required with each phase of the Pipeline project (construction, operation, and closure) to achieve eventual stabilization and reclamation criteria. Separate SWPPP, O&M, and SRR plans would be developed to address erosion controls related to stormwater runoff, erosion maintenance during operations and reclamation activities, and surety costs upon Pipeline closure and termination.). Specific references to these documents are provided below as applicable to soil erosion impacts along the Pipeline.

Construction

The Pipeline alignment traverses a variety of different soil types for which NRCS and STATSGO erosion criteria are available (Appendix F, and Figure 3.2-6 through Figure 3.2-8). Water and wind erosion descriptions for soil types along the Pipeline range from “not applicable” (e.g., poorly drained peat) to severe based on available information. Although multiple major soil components (shallow) associated with the central Pipeline segment have erosion factors (K_w) greater than 0.4 (Appendix F), values are predominantly less than 0.4.

Due to the variety of erosional susceptibilities and landform terrains traversed by the Pipeline, the potential for erosion exists along multiple segments of the 316-mile route. Much of the Pipeline ROW and ancillary components are associated with soil map units having moderate to severe erosion potential from both water and wind (with the organic mat removed). Erosional effects from wind would likely be less intense due to concurrent surface stabilization/reclamation efforts and physical environmental conditions associated with the Project Area. Physical conditions that would influence erosional processes include seasonal construction methods and associated surface disturbances (e.g., vegetation removal, compaction), slope gradient, soil moisture content, and alteration of surface water drainage patterns. In general, soils exposed during construction would be more susceptible to both hydraulic and wind erosion than soils with the organic mat left intact, partially intact, or compacted. This is particularly the case for fine-grained materials on steep exposed slopes.

A variety of construction activities could contribute to erosion, including on- and off-ROW clearing and grading; excavation trenching, stockpile management, and backfilling; multiple water body and wetland crossings; and development of gravel pads for certain ROW conditions and off-ROW facilities. Without mitigation, erosion from runoff and other hydraulic processes could result in adverse impacts to native or engineered soils and to downgradient sensitive areas (e.g., water bodies, wetlands). Most erosion effects are expected to be managed effectively through ESC measures. It is possible that isolated occurrences of uncontrolled erosion could occur that are not immediately contained by the BMPs described below. These cases would likely be controlled within a short period of time, due to planned redundancies in ESC measures and reclamation/cleanup crew functions at the end of the construction period. The duration would range from impacts lasting not longer than the span of the project (due to planned BMPs and reclamation measures immediately following construction of each Pipeline segment), to impacts lasting through the life of the project (for effects in more susceptible areas that last for several years beyond construction).

Specific construction activities that could cause erosion effects, as well as ESC measures and BMPs that would mitigate these effects (SRK 2013b), are described below for both ROW and off-ROW Pipeline components.

Pipeline ROW

Season of Construction: Approximately 68 percent of the Pipeline length would be constructed during frozen winter conditions to accommodate support equipment and minimize soil erosion. Temporary erosion control measures are not anticipated during winter construction that is planned to occur over two winter seasons. Areas planned for summer or fall construction are based on favorable geotechnical and terrain conditions, such as stable permafrost and/or suitable surface soils that would support equipment (e.g., gravel floodplains, shallow bedrock), and work length continuity considerations. Steep terrain and side slopes are also preferred for summer construction due to safety considerations for equipment operation.

Temporary ESC Measures – Summer Construction: Temporary stabilization and erosion controls would be installed in areas of summer construction as soon as practicable in the construction sequence in order to contain disturbed soils. Application of temporary stabilization controls would be addressed in the SWPPP and ESCP. Specific controls and measures used in summer construction areas would include:

- Minimization of areas of compacted vegetation, disturbance of natural waters, and existing drainage patterns where practicable;
- Salvaging organic mats above cuts for use as surface replacement material;
- Ripping/scarifying compacted areas and soil roughening using tracked machinery that would traverse slope fall lines to reduce surface water runoff and facilitate infiltration and revegetation;
- Installation of settlement basins;
- Filter bag use for dewatering discharge treatment;
- Installation of brush berms orientated perpendicular to surface water flow and keyed into surface soils;
- Installation of silt fences constructed of geofabric and trenched (keyed) or anchored to surfaces to intercept offsite migration of eroded sediment;
- Installation of silt curtains in placid or low-flowing water bodies adjacent to disturbed areas, that act as turbidity barriers to prevent dispersion of sediment-laden water;
- Finished slope angles designed to maximize stability and minimize erosion relative to soil types and hydrologic conditions;
- Engineered flow diversion over cut or fill slopes where appropriate, including installation of drainage levees and other structures to minimize ponding adjacent to embankments;
- Installation of slope breakers (water bars) constructed of native soil and orientated across slope or perpendicular to surface water flow to decrease runoff velocity and divert water into energy dissipaters or well established vegetation. Slope breakers would be installed at predetermined intervals based on slope gradient conditions;
- Installation of temporary and permanent trench breakers. Temporary trench breakers would be installed during construction to control sediment laden water movement in

the trench. Permanent breakers would be installed in sloping terrain to address preferential groundwater flow through trench backfill that may result in subsurface erosion or backfill alteration;

- Installation of surface protection controls, such as wattles or RECPs, which are stapled together and pinned down over uniform surfaces and slope breakers, or positioned perpendicular to the anticipated direction of runoff. The base of installed RECPs and wattles would be anchored or keyed into soils. Installation of chipped or shredded mulch derived from ROW clearing that would be applied at a uniform thickness of 1.5 tons per acre; and
- Watering of high traffic surfaces as needed for dust control using water trucks.

Trench and ROW Completion: Trench backfilling would be completed with a mounded (crowned) surface completion to accommodate settlement, and prevent ponding or surface water channelization. Finish grading in the ROW would direct surface water away from the pipeline, and water bars would be constructed on steep longitudinal slopes for drainage control and erosion mitigation. The ROW would be cleared of construction debris, and workpad surfaces graded and scarified to promote natural revegetation at suitable locations. Suitable locations selected for natural vegetation would have adequate natural seed sources or rootstock, and a low potential for erosion.

General BMPs – Revegetation: Vegetation disturbances could influence soil erosion through increased surface water runoff velocities, channelization or ponding (erosion), and potential thermal degradation of permafrost conditions (if any). Major vegetation removal would occur within the construction ROW to develop the work pad and trench line. For these reasons, areas of vegetation affected directly or indirectly by the Pipeline would be identified and corrected per the approved SRR Plan, other applicable plans and regulatory requirements (e.g., APDES permit and SWPP, ESCP), or as agreed upon with landowners outside the construction area as applicable. Corrective actions would include identification and documentation of the disturbance; rehabilitation and reclamation; and continued monitoring. Restoration measures would include distribution of slash and chipped vegetation within the ROW to facilitate erosion control and seeding and fertilization. Tree trunks used for corduroy road bed materials (where applicable) would be left in place on the workpad surface. Additional measures applicable to vegetation / reclamation management are described in Section 3.11, Wetlands.

General BMPs – Slopes: Planned slope cuts may result in soil instability. Key considerations include slope grade (topography), soil cohesion, and permafrost stability (where present). Both temporary and permanent ESC measures are anticipated for most slope cut activities; however, winter construction would reduce the need for temporary measures. Of primary concern is the erosion potential (energy) associated with higher velocity surface water flows on inclined surfaces, including flow channelization along the trenchline, within the trench, and destabilization (erosion and settlement) of surface soils and trench backfill materials. The following ESC measures would be based on final design and onsite evaluation during construction:

- Slope breakers would be used at predetermined intervals based on slope gradient criteria, and would divert water and sediment to stable vegetation or energy dissipaters;

- Permanent breakers would be installed in sloping terrain to address preferential groundwater flow through trench backfill that may result in erosion or backfill alteration;
- Fiber / geotextile or erosion mats would serve as both temporary or permanent ESC measures until vegetation is reestablished;
- Silt fencing and wattles would be installed for sediment retention control until stable conditions are achieved; and
- Completed slopes would be roughened and mulch installed to facilitate water infiltration, surface stabilization, and provide surface cover for regrowth of vegetation. If necessary, slopes would be seeded as soon as practicable.

Temporary Soil Stockpiles: Most material excavated during pipeline trenching would be used as backfill material or surface completion material during final grading and contouring. This would require temporary stockpiling of segregated materials based on intended salvage use. Stockpile location and design considerations would include seasonal conditions (rain, wind, meltwater, etc.), terrain (slope and vegetation), and material type (organics, permafrost, ground ice). Management of stockpiles would incorporate the following:

- Stockpiles would be situated sufficiently far from potential receptors or sensitive areas such as waterbodies or wetlands;
- Stockpiles would be constructed with low sloping profiles and roughened to minimize soil erosion;
- Silt fencing and wattles would be placed around inactive stockpiles; and
- Stockpiles would be covered with plastic if there is an increased risk of runoff to the surrounding area, or high-risk weather conditions. (Additional considerations for ice-rich stockpiles are provided in Section 3.2.3.2.2).

Water Approach Stockpiles: Most methods of construction associated with water body crossings could result in temporary stockpiling of excavated materials. Stockpile management at these locations would include:

- Excavated spoils would be segregated based on source materials (terrestrial vs. water body);
- Stockpiles would be situated a minimum set back distance of 30 feet from receiving water bodies;
- Erosion containment measures would be placed around the sides of the stockpile, in addition to the front edge upslope of the receiving water body; and
- Silt curtains would be installed along the bank as temporary turbidity barriers.

Additional measures applicable to fish and aquatic resource occurrence and management are described in Section 3.13, Fish and Aquatic Resources.

Snow Stockpiles: Snow clearing and management would be conducted as necessary during construction to allow for safe equipment operation. Stockpiles would be designed for snow storage, and would incorporate water diversion ditches to control meltwater drainage to well established vegetation or dissipaters. Other sediment control measures would be used as necessary so that all discharge would comply with approved Pipeline project permits (e.g., settlement ponds, straw bales, silt fences).

HDD Sites: Soil impacts associated with HDD work areas include disturbances to existing conditions from heavy equipment excavation, drilling, and support equipment operation. HDD work sites would be set back from the riverbanks in distances ranging from 400 to 3,900 feet, and delineated to minimize soil disturbance impacts while accommodating operational efficiency and safety. Visual inspection would be conducted throughout drilling to verify drilling mud management and ESC measures. Silt fences, straw bales, or wattles would be placed around stockpiled spoils generated for drill entry and exit. All excess drilling mud would be removed from the site, and disposed of as required in relevant regulations and permit stipulations.

Cleanup and Reclamation Crews: Designated crews would address both cleanup and reclamation activities following pipeline installation and backfilling. Cleanup crews would perform all cleanup activities during the same summer or winter Pipeline installation season. Reclamation crews would immediately follow cleanup crews during summer installation or the next shoulder season following winter work. Cleanup crew activities would occur immediately after trench backfilling. The cleanup crew would be responsible for finish grading and surface completion activities, including:

- Removal of temporary bridges, culverts, tools, materials, support equipment, and trash from the ROW;
- Reconnaissance for any contaminated soil conditions, and addressing if necessary by treatment and / or removal from the Project Area for proper disposal;
- Grading of spilled bedding / padding material or gravel over ice, snow, or frost-packed work pads for traction, or placement over the trench line;
- Crowning of the pipeline trench mound using salvaged organic materials or suitable fine-grained materials for revegetation;
- Excavation or cutting breaks in the mounded trench surface to allow cross drainage along the ROW, and prevent ponding or surface water channelization. Breaks would be installed at all known cross-drainages and trench breaker locations. Generous use of breaks would be placed along cross slopes and permafrost terrain;
- Placement of permanent slope breakers that span disturbed surfaces (trench or work side of the ROW), and at trench breaker locations;
- Removal of all ice or snow in drainages and ice bridges on ice / snow pads and frost-packed ROW areas;
- Re-contouring of cuts to match local topography as practicable, placement of salvaged organic material on restored cuts, and restoration of stream banks to original configuration (additional considerations for cuts and stream banks in permafrost are addressed in Section 3.2.3.2.2);
- Installation of permanent erosion control measures / materials on high gradient slopes in close proximity to sensitive areas (e.g., streams); and
- Installation of signage pertinent to controlling access to minimize erosion.

Reclamation crews would start immediately after breakup. Crews would access the ROW by walking to the extent practicable and use low ground pressure carriers where or if necessary; however, considerable helicopter support would be required. Other means of access would include water craft and ORV usage. Initial tasks performed by reclamation crews would include identification and prioritization of deficient or compromised areas. A more methodical and comprehensive reclamation process would occur once high priority issues have been addressed; however, this would depend on prioritized demands that include seasonal access to remote areas of the Pipeline using the methods described above. Final inspection of erosion control measures would be performed at the end of the season, and any remaining or developed erosion and settlement issues would be repaired. Specific functions of reclamation crews would include:

- Address erosion concerns with prioritization of stabilization in sensitive area which could include thaw unstable soils, waterbody crossings, and trench line and working side of the Pipeline alignment that could require low ground pressure vehicle usage;
- Removal of all excess tools, materials, and trash missed by cleanup crews;
- Installation of additional breaks in crowned trench surface completions as needed, and addressing any settlement occurrences;
- Installation of additional slope breakers as needed;
- Inspection of stream banks for erosion; and
- Revegetation of disturbed areas using seed, fertilizer, and mulch as required.

Off-ROW Facilities

Transmission Line: Specific BMPs and ESC measures associated with transmission line construction include the following:

- Cleared vegetation from the ROW would be mulched and spread for erosion control;
- Soil cuttings generated from drilling activities (augering) would be consolidated into managed stockpiles or used for construction purposes; and
- Wattles, silt fences, and/or straw bales would be placed around drill sites for soil containment, and would remain in place around the poured concrete support members until final stabilization.

Temporary Summer or All-Season Access Roads: Temporary access and shoofly roads intended for summer or all-season use would be graded or constructed of gravel. Gravel fill construction would help to minimize erosion of native soils. Grading activities could cause airborne dust along access roads and high construction areas in summer, and watering would be performed on an as-needed basis. Other ESC design features such as culverts, drainage ditches, or cut slope BMPs have not been specified for these roads, although these features are expected to be detailed in the final SWPPP and ESCP for the Pipeline.

Winter Access Roads: Ice access roads, winter shoofly roads, and other temporary roads used to access the ROW in winter construction sections would serve to protect native soils and wetlands. Construction of the three year, 46- to 50-mile long winter access road along either the Oilwell Road or Willow Landing routes would include the following elements pertinent to erosion control:

- Routes have been selected to avoid high relief topography; minimize clearing; maximize use of disturbed areas (existing roads, trails, historic stream crossings) and low relief open marshy areas that freeze readily; and minimize stream bank disturbance in developing adequate crossings for heavy equipment and loads;
- Road clearing/mulching would be conducted the winter before pipeline construction using tracked or rubber-tired vehicles. Mulch and organic debris from clearing would be left on the ground surface;
- Limited cut and fill would be required in areas where sloughing has occurred and grades are too steep for intended use;
- Road surface hardening and ice buildup at stream crossing would be accomplished by buildup of clean snow and pumping water onto the surface from significant flowing streams; and
- Road maintenance would occur in winter by packing, watering, and grading the snow/ice surface.

Camps and Storage Yards: Specific BMPs and ESC measures associated with construction camp and storage yard construction include the following:

- Areas of soil disturbance would be minimized to the extent practicable to accommodate camp, storage, and work area needs;
- Surface vegetation would be removed and infrastructure/equipment would be built or placed on stable gravel pads or temporary construction mats;
- Temporary diversion ditches along the yard/camp perimeters would be used to direct discharge to well established vegetation or flow dissipaters (rock);
- Silt fences and/or wattles would be placed along the outer edges of diversion ditches to intercept offsite erosion by sediment capture;
- Access and egress points would be minimally sized to accommodate safe movement of personnel and equipment, and coarse gravel placed as needed to reduce sediment tracking from access points; and
- Dust control in high traffic areas would be performed through surface watering on an as-needed basis.

Material Sites: Gravel and bedrock borrow pits would be sited to avoid environmentally sensitive areas, and would generally incorporate the same ESC measures described above for temporary soil stockpiles. Material would only be excavated on an as-needed basis to minimize areas of disturbance and associated potential for erosion. Anticipated Pipeline material site development and reclamation practices would also include those described for Transportation Corridor material sites (Section 3.2.3.2.3).

Airstrips: To the extent practicable, low erodibility aggregate would be used for fill at airstrips, resulting in a low potential for erosion by wind and water. Surface watering would be performed on an as-needed basis for dust control.

Valves, Pig, and Metering Stations: No ESC measures are anticipated for construction of these small facilities; however, this would be reevaluated during pipeline construction and implemented as needed.

Cleanup and Reclamation: Ancillary facilities would be decommissioned as soon as possible within the construction period when no longer needed. Cleanup and reclamation of off-ROW facilities not needed in operations would be similar to that described above under Pipeline ROW. All structures, equipment, and debris would be removed, including contaminated soils (if any) based on visual reconnaissance. Gravel pads and fill at camps, storage yards, temporary airstrips, and access roads would be left in place and revegetated. Compacted areas would be ripped and graded to blend in with surrounding topography and facilitate drainage, and any high walls at material sites would be left in a stable condition. Surfaces would be scarified for natural revegetation, mulched, or fertilized and seeded as appropriate per the SRR Plan.

Operations

Ongoing Effects from Construction: Soil erosion during Pipeline operations would primarily be associated with lingering effects associated with construction and post-construction reclamation, as new soil disturbances activities during operations would be limited (Section 3.2.3.2.1). Post-construction reclamation and ESC measures are anticipated to address most erosion concerns along the Pipeline, and ESC measures would be maintained as needed until final stabilization criteria are met; however, ongoing soil stabilization and restoration measures are likely to be a multi-year process in discrete areas. The level of intensity of effects during operations would be similar to that described under Construction. Areas that would potentially require more intensive stabilization and restoration measures would include high gradient slopes or side cuts, fine-grained soils, thermally unstable ice-rich soil, water body crossings, and wetlands. The effects of hydraulic erosion processes are anticipated to be substantially greater than the effects of wind erosion over the design life of the Pipeline due to more immediate vegetation restoration reducing wind erosion effects. Hydraulic erosion processes of concern include surface water channelization and formation of preferential flow pathways along slopes; ponding associated with thaw settlement (subsidence), and trench backfill destabilization through potential groundwater movement. The placement of salvaged organic-rich / fine-grained soils as mounded trench cap material in some areas could be susceptible to erosion on a temporary basis.

O&M Activities: Operation activities would include preventative and corrective maintenance per the O&M Plan / Manual (Appendix F). A minimum permanent ROW width would be cleared of vegetation at approximate 10-year intervals or as necessary to accommodate surveillance, monitoring, and inspection activities. Surveillance and inspections would be performed twice a year, with no inspection interval exceeding nine months. Inspection and monitoring would be performed following major rainstorms and after spring breakup. Qualitative visual inspections would be performed periodically, and quantitative inspections would be performed once per year at the end of the growing season. Final stabilization of construction-related disturbances would be achieved when a uniform vegetation area of cover of 70 percent is established (i.e., evenly distributed, without large bare areas), or the area has equivalent non-vegetation or permanent stabilization measures in place (ADEC 2011a; EPA 2007). Erosion caused by the O&M activities themselves could occur along any length of the Pipeline where follow up service is required. These activities would be performed according to the established O&M Plan / Manual and follow BMPs and directives outlined in the SRR and ESCPs.

Public Access/ORV Erosion: Long-term indirect erosion effects by recreation and ORV usage could occur along the Pipeline ROW following construction. As described in Section 3.2.2.3.3

(Erosion – Processes), authorized or unauthorized use of ORVs could result in erosion and damage to the ROW, particularly in areas with permafrost, sloping terrain, and / or organic, wet, fine-grained soils, which could potentially affect existing ESC measures or create the need for additional ESC measures. Any discharge of sediment to streams derived from streambank erosion is likely to be location specific pending ESC measures and continued monitoring and mitigation improvements as needed based on follow up inspections. Sediment discharge to streams is further described in Section 3.7, Water Quality, and Section 3.13, Fish and Aquatic Resources.

Construction of the Pipeline ROW will also result in varying degrees of soil compaction through heavy equipment operation. Although compaction reduces the volume of soil, adverse effects are primarily addressed through soil resource criteria that include soil disturbances; erosion through surface water channelization or ponded water; and productivity losses. Inferred soil productivity losses could adversely affect the temporary to long term re-establishment of pre-existing vegetative communities from disturbance, although this term generally corresponds to an agricultural attribute. Key variables that influence these soil resources of concern include the type and frequency of ORV use, operator discretion, physical attributes of affected soils, and surrounding terrain (slope). Descriptions of surface material types, terrain, and surface organics for the Pipeline corridor are presented in Appendix F.

Various aspects of soil mitigation, restoration, and reclamation measures described above and in Sections 3.2.3.2.2 and 3.2.3.2.3 would minimize the effects of soil compaction. A planned measure that addresses compaction following construction of the Pipeline ROW and reclamation of ancillary components is ripping / scarifying compacted areas and soil roughening using tracked machinery to reduce surface water runoff and facilitate infiltration and revegetation.

The Pipeline ROW corridor could result in ORV usage following construction, increasing the potential for ORV induced soil compaction. It is reasonably expected that only discrete portions of the ROW will be used due to perceived access limitations, thus limiting soil impairment concerns. Public access to the ROW would generally be limited due to the following reasons:

- No new public vehicular access will be created by Donlin;
- Areas with favorable compaction for travel would be discontinuous based on soil conditions and seasonal construction schedules (winter versus summer);
- Obstacles to passage such as wetlands and water bodies would be restored to pre-construction conditions; and
- The area is remote area and more suitable seasonal means of transportation are available (snowmachines) that are more likely to be used to access larger extents of the ROW.

Remote Pipeline ROW access points of concern include project related airstrips. With the exception of three existing airstrips (Beluga, Farewell, and Donlin) and isolated ancillary facilities (e.g., compressor station and ancillary facilities), all Pipeline construction infrastructure that could be utilized for access (if left in place) would be reclaimed. Temporary airstrips would be decommissioned in a way to prevent future use. Although the Pipeline ROW does not create an exclusive right of access by Donlin Gold, placement of large berms or other means to discourage ORV traffic along or across the ROW intersections at existing trails would be considered upon coordination with the appropriate landowners. Additional control measures to alleviate ORV effects may include public outreach / education, posted notices, signage, flagging, barricades, and retaining select ESC measures after construction (SRK 2013b).

Although snow machine-induced erosion along the ROW may occur along the portion of the Pipeline in the Matanuska-Susitna (Mat-Su) Borough from winter use in areas of wet organic soils; more significant erosion that could be induced during shoulder seasons or periods of thin snow is not anticipated due to geographic and seasonal access constraints (e.g., Susitna River and Susitna Flats State Game Refuge). However, impacts imposed by ORV traffic would likely be most extensive in the vicinity of the existing Farewell Airstrip. The Farewell Airstrip is currently used by multiple recreational user groups, and coincides with the subsistence use area for the village of Nikolai (Section 3.21, Subsistence). The subsistence use area for the village of Nikolai generally extends from MP 150 to MP 175. Access to the Pipeline ROW could be substantial through existing ORV trails, resulting in impaired portions of restored and reclaimed ROW areas, and creating access to new untouched areas off the ROW depending on terrain conditions.

Surface materials throughout this area commonly consist of silt sand mixtures overlain by organic materials (peat / muskeg) that are 0.5 to 1.5 feet thick. Gravel mixtures are common but less prevalent, and peat / muskeg thicknesses were documented at one location to reach depths up to 13 feet. Permafrost conditions are also frequently interspersed throughout this area, with notable spans of unstable permafrost segments. ROW landform slopes (longitudinal and cross) are intermittently steep from MP 150 to 154, but generally assume low gradient slope aspects thereafter to MP 175. Based on the probable increase in ORV traffic along this Pipeline ROW span, the prevalence of sand and silt surface soils with organic cover, and unstable and stable permafrost conditions, the potential for ORV soil impairments may result in acute or obvious disturbance that would affect discrete segments of the Pipeline ROW. Impacts from traffic (ORVs) could result in irreversible impairments to a resource that is usual or ordinary in context throughout this locally affected area. Overall however, the intensity of effects from ORV use would be similar to that of lingering effects from construction described above due to likely impediments restricting ORV access (summer) to the Pipeline ROW on a local basis. It is also possible that ORV impairments could be more geographically extensive (affecting larger areas of the ROW, and miles beyond the ROW depending on terrain conditions), as well as longer in duration, potentially lasting for the life of the Donlin Gold Project.

Closure

Pipeline termination activities pertinent to soil erosion would be the same as those described in Section 3.2.3.2.1. In-place abandonment of all subsurface pipes would minimize post-Closure work requiring heavy equipment; thus, the intensity of erosion effects along most of the ROW would be imperceptible. Soil erosion could occur where above-ground pipeline removal / demolition activities take place due to equipment support work and associated surface disturbances. Where applicable, closure activities would be performed from stabilized / restored work surfaces. As with the Construction and Operations phases, ESC and SRR plans would be followed during termination to achieve eventual stabilization and reclamation criteria. Thus, the intensity and duration of effects at above-ground sites would be the same as those described above for post-construction reclamation and operations. The extent or scope of effects is expected to be limited to the immediate vicinity of above-ground facility footprints. While the season of final Pipeline termination / reclamation is not specified in the current Pipeline Plan of Development (SRK 2013b), closure activities that occur during the winter season (similar to construction) would help to minimize surface disturbances to soil (Chapter 5, Impact Avoidance, Minimization, and Mitigation).

Summary of Pipeline Impacts

In terms of intensity, erosion effects along the Pipeline ROW and off-ROW facilities during all phases of Alternative 2 are anticipated to be mostly managed effectively through ESC measures, with isolated occurrences of acute or obvious erosion during ROW construction, or ORV use near discrete segments of ROW. Erosion during construction would likely be reduced such that changes in soils due to erosion may or may not be measurable or noticeable within a short period of time due to planned redundancies in ESC measures, reclamation/cleanup crew functions, and monitoring/maintenance activities. Erosion effects from ORV use would be minimized by a number of impediments restricting access. The duration of most impacts would vary and may not last longer than the span of project construction (e.g., ESC measures effective immediately following construction). In some cases, impacts would last through the life of the project (e.g., effects in erosion-susceptible soils lasting for years). The extent or scope of erosion effects would be mostly limited to the immediate vicinity of the ROW and off-ROW facility footprints. However, indirect ORV erosion effects could potentially extend for miles beyond the ROW if used to access new areas. In terms of context, erosion effects are considered usual or ordinary soil and water resources, but are also natural hazards governed by regulation.

3.2.3.2.4 SOIL QUALITY/CONTAMINATED SITES

This section describes potential effects from existing contaminated soils, as well as the effects of project activities (such as fugitive dust) on soil chemical quality. Evaluation of impacts to soil quality associated with potential project-related but unplanned and uncontrolled releases (such as diesel spills) are addressed in Section 3.24, Spill Risk.

A review of available information concerning the presence of existing contaminated sites was performed for the Mine Site, Transportation Corridor, and Pipeline components (Sections 3.2.2.1.4, 3.2.2.2.4, and 3.2.2.3.4) to identify possible impacts to the project and from project activities due to the presence of contaminated soils. Common impacts associated with pre-existing contaminated site conditions typically include management of the environmental concern to accommodate stakeholder interests, including:

- Correspondence with appropriate state, federal, or local regulatory agencies, and relevant stakeholders;
- Contaminated media characterization, remediation, or implementation of appropriate management and/or mitigation measures (e.g., institutional controls);
- Compliance with appropriate state, federal, or local regulatory agencies, including planning, reporting, and decision documents.

If conditions are unknown in advance, effects could also include inadvertent spreading or migration of contaminants beyond their initial location in areas of intrusive project work (e.g. excavations), and possible delays in project construction.

There have been no reported or suspected adverse soil conditions involving hydrocarbons or cyanide from past or current project developments, and no effects from these constituents are planned as part of the project. As noted in Section 3.2.2.1.4, no baseline data for hydrocarbons and cyanide have been collected at the Mine Site. If necessary, regulatory guidance specific to evaluation of background analyte concentrations in soil could be used in the event of a future release (described in Section 3.24, Spill Risk).

Mine Site

Construction and Operations

No pre-existing contaminated conditions of environmental concern were identified at the Mine Site; thus, effects from exposure of existing contaminated soils during construction, operations, or closure are not expected to occur.

Soil quality could be affected by fugitive dust settling on soil, or gaseous mercury emissions that wash out of the atmosphere as wet or dry deposition. Fugitive dust would be generated by processes such as drilling and blasting in the pit, waste rock and ore handling, road traffic, and wind erosion of exposed surfaces such as ore stockpiles and tailings beaches. Fugitive dust generated during Mine Site construction (pre-production) and operations could potentially result in elevated concentrations of metals in soils surrounding the Mine Site over time through dust deposition. The dust particulates would reflect the minerals in the source material. Gaseous mercury could be emitted from the mill facility, waste rock, and tailings pond water.

Potential Contaminants in Fugitive Dust

Levels of metals present in baseline soils are listed in Table 3.2-6. As described in Section 3.2.2.1.4, ADEC soil cleanup levels, which are administered through the State's Contaminated Sites Program, are also listed in 6 for comparison purposes to provide a framework for understanding existing conditions. Only arsenic exceeds this level in baseline soils for all statistical methods, and is further evaluated below along with additional constituents predicted to be present in fugitive dust. As described in Section 3.2.2.1.4, thallium is present above the ADEC soil cleanup level for the geometric mean only, but not when data is analyzed using more rigorous EPA methods, and is not further evaluated. Uncertainty surrounding the thallium cleanup level is also discussed in Appendix AB (Section AB.5.2, Soil Screening Evaluation).

Potential fugitive contaminants of concern include mercury from ore processing, as well as other metals present in mine materials that could be potential sources of dust, such as the ore stockpile and tailings solids. Other metals include 10 Hazardous Air Pollutants (HAPs) that have been estimated in various ore and waste rock fugitive dust sources. Table 3.2-6 lists the predicted concentrations of mercury in these sources, as well as additional HAPs metals that are predicted to be present in dust at concentrations exceeding ADEC soil cleanup levels protective of human health. The ADEC levels were used to identify which metals warrant further analysis of effects on soil quality.

Because there are different metals concentrations in different sources, the estimates provided for dust composites are based on a compilation of fugitive dust emissions from various sources, locations, and temporal phases of the mine. Process and fugitive dust (particulate matter (PM)) combined from all mine sources and phases is predicted to contain 97 percent waste rock and 3 percent ore (Air Sciences 2016), while 86 percent of mercury in fugitive dust is estimated to come from waste rock and 14 percent from ore (Environ 2014a, 2015; Donlin Gold 2015d).

Dust Dispersion in Air

The extent and effects of dust dispersion on air quality surrounding the mine facilities have been analyzed through particulate dispersion modeling conducted by Air Sciences (2014a) using AERMOD and Environ (2015) using CALPUFF. The AEROMOD model is recommended in the Code of Federal Regulations (CFR) for short-range dispersion analysis, using particle diameter, mass fraction and particle density inputs. The CALPUFF model was performed to estimate the potential mercury impacts from project emissions, including fugitive dust. The model selection parameters, resolution, assumptions, and boundary conditions are detailed respectively in the Air Quality Impacts Analysis Report (Air Sciences 2014a) and the Modeling of Local Impacts of Mercury Air Emissions from Stacks and Fugitive Sources Report (Environ 2015).

The Air Science results show that air quality compliance for Prevention of Significant Deterioration (PSD) particulate matter (PM) impacts would be met at the closest points of compliance in dominant downwind directions (southeast and northwest), and that PM concentrations would be well below Ambient Air Quality Standards (AAQS) at these locations. Points of compliance for air quality purposes include Calista Corporation and The Kuskokwim Corporation (TKC) property boundaries for which Donlin Gold has surface use agreements, the closest of which are located about 1 mile northwest of the pit, 1 mile south of the TSF, and 1.5 miles east of the WRF. These results are discussed in more detail in relation to air quality impacts in Section 3.8, Air Quality.

Table 3.2-6: Selected Metals Concentrations in Fugitive Dust Sources

Element[1]	Potential Fugitive Dust Sources at Mine Site					Potential Dust Sources along Mine Access Road	ADEC Soil Cleanup Level[7] (mg/kg)
	Ore[2] (mg/kg)	Tailings[3] (mg/kg)	Waste Rock[2] (mg/kg)	Dust Composite[4] (mg/kg)	Over-burden[5] (mg/kg)	Outcrops/ Potential Road Base Material[6] (mg/kg)	
Antimony	88	120	19	21	-	7.7	41
Arsenic	2,480	910	490	550	134	59	8.8
Mercury (total)	11.7	0.7	8.0	8.6	-	-	30/10

Notes:
1 Only metals in baseline or potential dust sources are listed to identify metals for further evaluation of effects on soil quality. Values shown are arithmetic means.
2 Average concentrations from drill core assay analyses; n = 2,269 to 41,070 (Rieser 2015b).
3 Feasibility Pilot Phase 2 Final Filtrate 2007; n = 1 (SRK 2012b).
4 Estimate for all fugitive dust sources assuming 86% waste rock/14% ore for Hg (Environ 2014a, 2015; Donlin Gold 2015d) and 97% waste rock/3% ore for As and Sb.
5 Overburden data from pit area; n = 33 (Fernandez 2014c).
6 Outcrops and rock rubble samples along mine access road, assumed similar to potential borrow pit material to be used as road base; from Fernandez (2014a), n = 2 to 54.
7 18 AAC 75: Method Two, Under 40-inch Zone, Human Health; mercury guidelines are shown as mercuric chloride/methylmercury (ADEC 2017b). Cleanup levels are shown to identify metals for further evaluation.

Abbreviations:
- data not available
n number of samples
ADEC = Alaska Department of Environmental Conservation
Shaded cell = Concentrations above ADEC soil cleanup levels to identify metals for further evaluation of effects on soil quality.

Dust Deposition on Soils

The amount of dust that is predicted to be deposited on soils at the Mine Site and along the mine access road is shown on Figure 3.2-10 and Figure 3.2-11, respectively. These figures provide annual deposition rates in terms of mass per area, as well as the total fraction of dust that is predicted to accumulate in shallow soils at the end of mine life. Calculations of dust deposition for the Mine Site are based on EPA (2005) methodology; rationale, data sources, and input assumptions for these calculations are described in detail in Appendix F.

On Figure 3.2-10, annual dust deposition rates and the dust fraction in soil at Year 35 are averaged across several watersheds, which represent USGS Hydrologic Unit Code 12 (HUC12) watersheds used in the Environ (2015) air model. Total dust deposition is predicted to be highest in the Eta-Crooked Creek watershed, where shallow soils are predicted to contain about 0.55 percent dust by the end of mine life, followed by 0.27 percent in the Donlin Creek watershed. While the Eta-Crooked Creek HUC12 watershed boundary extends from the Mine Site to the Kuskokwim River, the results for the southern portion near Crooked Creek Village are likely to be closer to those of adjacent Village and Bell watersheds and the village itself, which are an order of magnitude less, with predicted levels of dust at 0.05 to 0.06 percent.

The relatively high deposition value in the upper Crooked Creek watershed reflects the fact that the Mine Site dust sources would almost entirely be located within that HUC 12 unit. The relatively high value in the Donlin Creek watershed reflects the fact that the pit and WRF would reach or cross the watershed divide with Donlin Creek, and that these two mine components would be the source of about three-quarters of all dust from the mine.

Dust deposition for the mine access road (Figure 3.2-11) is further discussed under Transportation Corridor.

Estimated Mercury Concentrations in Soil

Estimated mercury concentrations in soil at the end of mine life were calculated using three different statistical approaches as described in Appendix F and summarized below.

Environ (2015) CALPUFF Model Results

Estimated mercury concentrations in shallow soil at Year 35 are shown on Figure 3.2-12, averaged across the HUC12 watersheds used in the Environ (2015) CALPUFF model. The results indicate that mercury concentrations could increase over the life of the mine by up to 6 percent in the northern part of Eta-Crooked Creek watershed, and from 0.1 to 1.5 percent in other nearby watersheds (ARCADIS 2014, Environ 2015, SRK 2014a). Grouse Creek watershed exhibits the highest mercury concentration at Year 35 (919 ug/kg) primarily due to higher baseline concentrations.

Reasonable Maximum Exposure Concentrations

Mercury concentrations in soil were also estimated using the watershed with the highest fraction of total dust at the end of mine life (0.55 percent, Figure 3.2-10), combined with more conservative statistics for baseline and dust concentrations (95 percent upper confidence limit [95% UCL] for baseline, and arithmetic mean for dust), to explore the upper bounds of potential average exposure concentrations. Additional information and rationale for using 95% UCL values is provided in Appendix F. The results are provided in Table 3.2-7 and discussed in comparison to the means approach below.

Comparable Arithmetic Means

An estimate of mercury in soil at the end of mine life was also calculated using arithmetic means for both baseline and dust, in order to identify the incremental contribution from the mine using comparable statistics. The site-wide population of baseline data was used for these calculations. As shown in Table 3.2-7, arithmetic mean baseline concentrations are notably lower than the 95 percent UCLs. This approach provides a more conservative estimate of the mine contribution than the other two methods, but results in a lower end concentration.

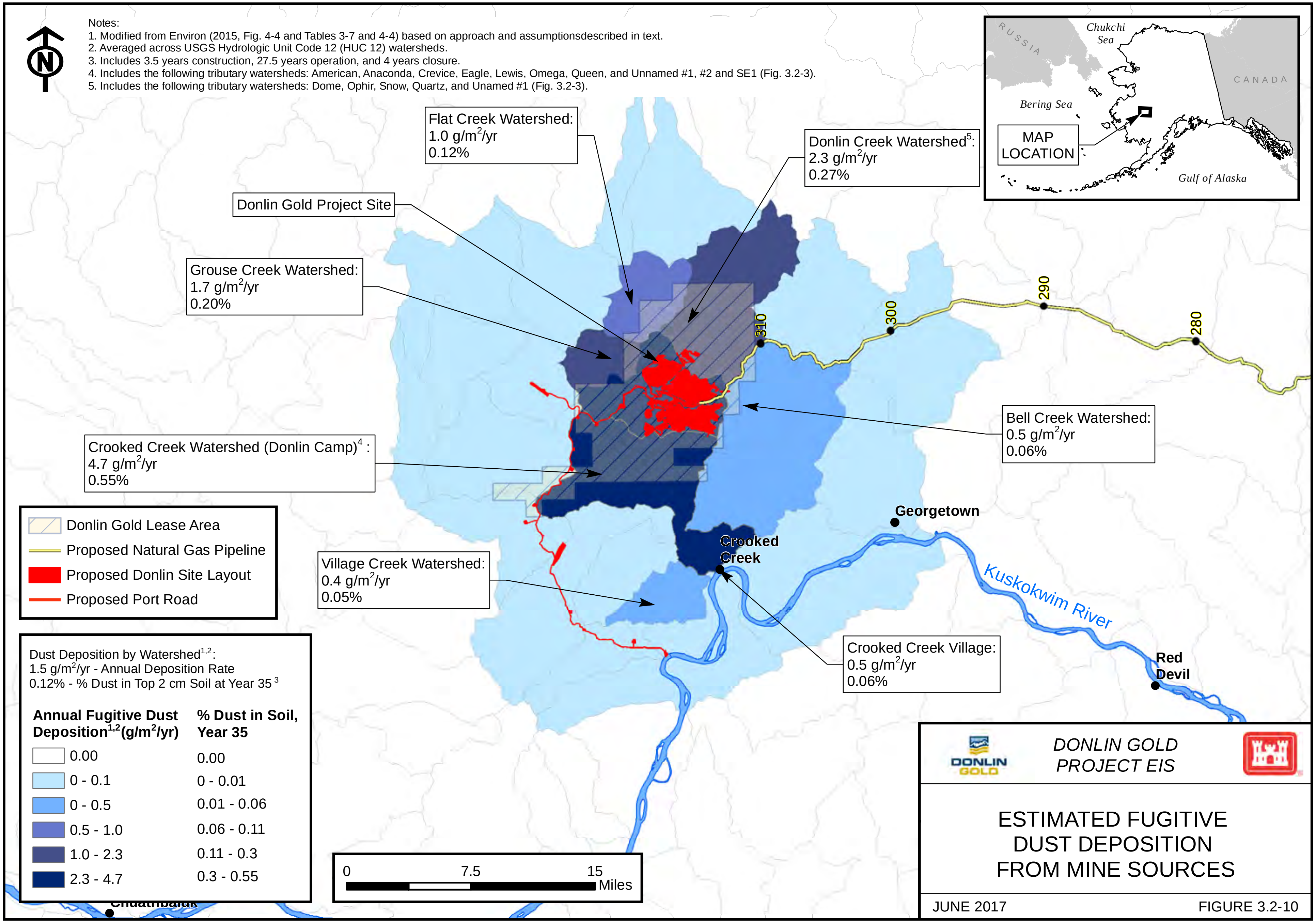
The use of the 95 percent UCL and mean baseline data, combined with the highest predicted dust fraction in soil (0.55 percent) and mean dust data, result in estimated increases in mercury concentrations in soil in the range of 11 to 22 percent. However, given the low level of mercury in baseline samples and dust compared to ADEC soil standards, these predicted increases would raise total mercury in soils to concentrations that are still one to two orders of magnitude below soil cleanup levels. In terms of intensity, these results indicate that changes in soil quality may not be measurable or noticeable with regards to effects on human health as intended by the ADEC standards. The potential effects of increased mercury that could be methylated in wetlands and bioaccumulate in biota are described in Section 3.7, Water Quality, and Section 3.12, Wildlife.

Table 3.2-7: Estimated Metals Concentrations in Mine Site Soil due to Fugitive Dust, based on Site-Wide Baseline Values

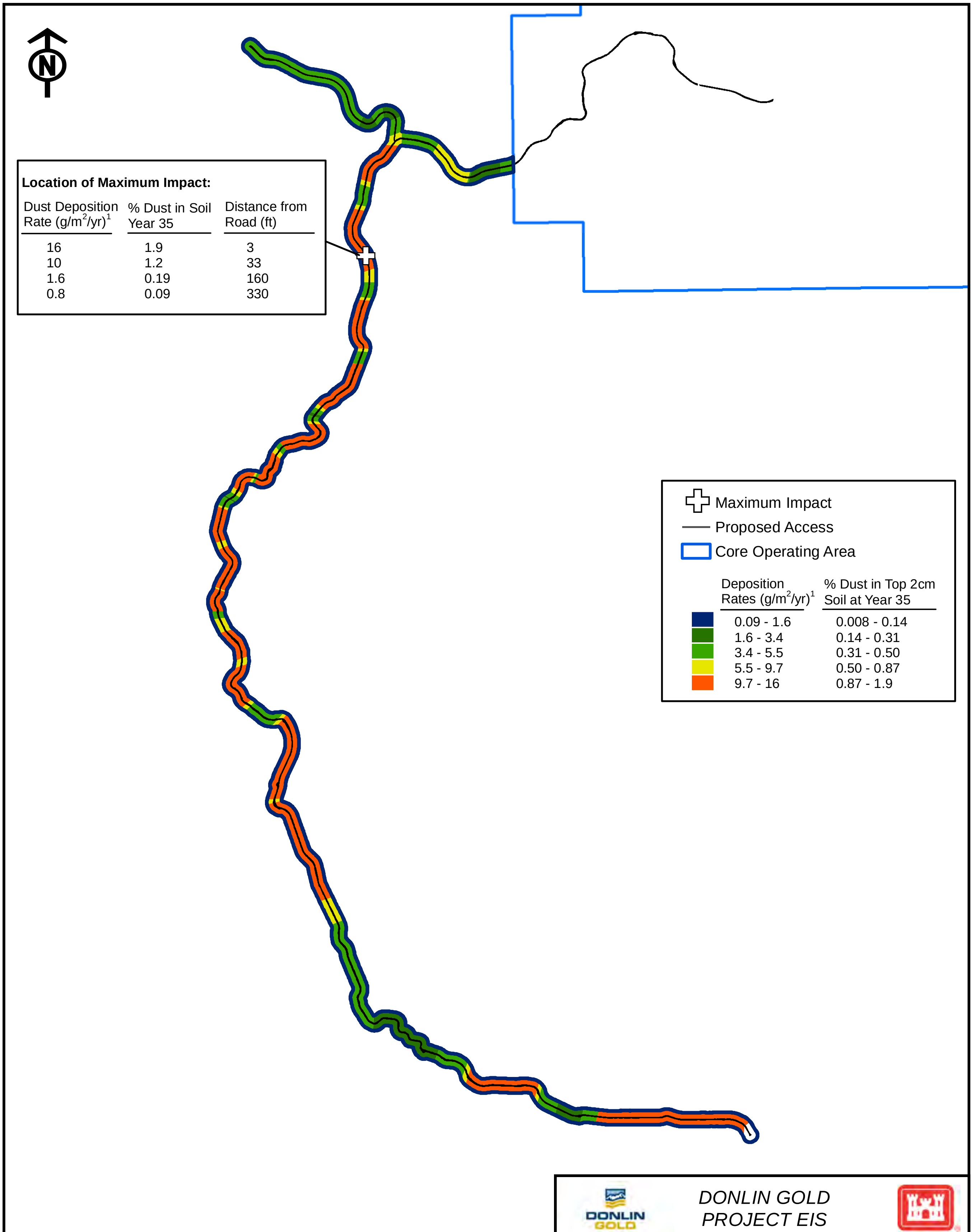
Element[1]	Current Soil Concentration[2] (mg/kg)	Dust Composite[3] (mg/kg)	% Dust in Soil, Year 35[4]	Soil, Year 35		ADEC Soil Cleanup Level[5] (mg/kg)
				Concentration (mg/kg)	% Increase above Baseline	
Antimony						
mean	5.35	21	0.55	5.44	1.6	41
95% UCL	11.1	-		11.2	0.5	
Arsenic						
mean	78.8	550	0.55	81.4	3.3	8.8
95% UCL	169	-		171	1.2	
Mercury (total)						
mean	0.212	8.6	0.55	0.258	22	30/10
95% UCL	0.415	-		0.460	11	

Notes:
1 Only metals exceeding ADEC cleanup levels in baseline or potential dust sources are listed.
2 Site-wide baseline values from Table 3.2-1 (Fernandez 2014a; ARCADIS 2007c, 2014).
3 Arithmetic mean of all fugitive dust sources at the mine assuming 86% waste rock/14% ore for Hg (Environ 2014a, 2015; Donlin Gold 2015d), and 97% waste rock/3% ore for As and Sb (Air Sciences 2016).
4 Highest watershed-based value in Figure 3.2-10, based on CALPUFF model results in Environ (2014a) extrapolated to total dust deposition (see Equations 1 and 2 in text).
5 18 AAC 75: Method Two, Under 40-inch Zone, Human Health; mercury guidelines are shown as mercuric chloride/methylmercury (ADEC 2017b).

Abbreviations:
- data not available
n number of samples
95% UCL 95 percent upper confidence limit on the mean
ADEC = Alaska Department of Environmental Conservation
Shaded cell = Concentrations exceed ADEC levels.



Notes:
1. Modified from Environ (2015, Fig. 4-4 and Tables 3-7 and 4-4) based on approach and assumptionsdescribed in text.
2. Averaged across USGS Hydrologic Unit Code 12 (HUC 12) watersheds.
3. Includes 3.5 years construction, 27.5 years operation, and 4 years closure.
4. Includes the following tributary watersheds: American, Anaconda, Crevice, Eagle, Lewis, Omega, Queen, and Unnamed #1, #2 and SE1 (Fig. 3.2-3).
5. Includes the following tributary watersheds: Dome, Ophir, Snow, Quartz, and Unamed #1 (Fig. 3.2-3).
N
RUSSIA
Chukchi Sea
CANADA
Bering Sea
MAP LOCATION
Gulf of Alaska
Flat Creek Watershed: 1.0 $g/m^2/yr$ 0.12%
Donlin Creek Watershed[5]: 2.3 $g/m^2/yr$ 0.27%
Donlin Gold Project Site
Grouse Creek Watershed: 1.7 $g/m^2/yr$ 0.20%
310
300
290
280
Bell Creek Watershed: 0.5 $g/m^2/yr$ 0.06%
Crooked Creek Watershed (Donlin Camp)[4] : 4.7 $g/m^2/yr$ 0.55%
Georgetown
Crooked Creek
Kuskokwim River
Village Creek Watershed: 0.4 $g/m^2/yr$ 0.05%
Crooked Creek Village: 0.5 $g/m^2/yr$ 0.06%
Red Devil
Donlin Gold Lease Area
Proposed Natural Gas Pipeline
Proposed Donlin Site Layout
Proposed Port Road
Dust Deposition by Watershed[1,2]:
1.5 $g/m^2/yr$ - Annual Deposition Rate
0.12% - % Dust in Top 2 cm Soil at Year 35 [3]
Annual Fugitive Dust Deposition[1,2]($g/m^2/yr$) | % Dust in Soil, Year 35
0.00 | 0.00
0 - 0.1 | 0 - 0.01
0 - 0.5 | 0.01 - 0.06
0.5 - 1.0 | 0.06 - 0.11
1.0 - 2.3 | 0.11 - 0.3
2.3 - 4.7 | 0.3 - 0.55
0 7.5 15 Miles
DONLIN GOLD
DONLIN GOLD PROJECT EIS
ESTIMATED FUGITIVE DUST DEPOSITION FROM MINE SOURCES
JUNE 2017
FIGURE 3.2-10



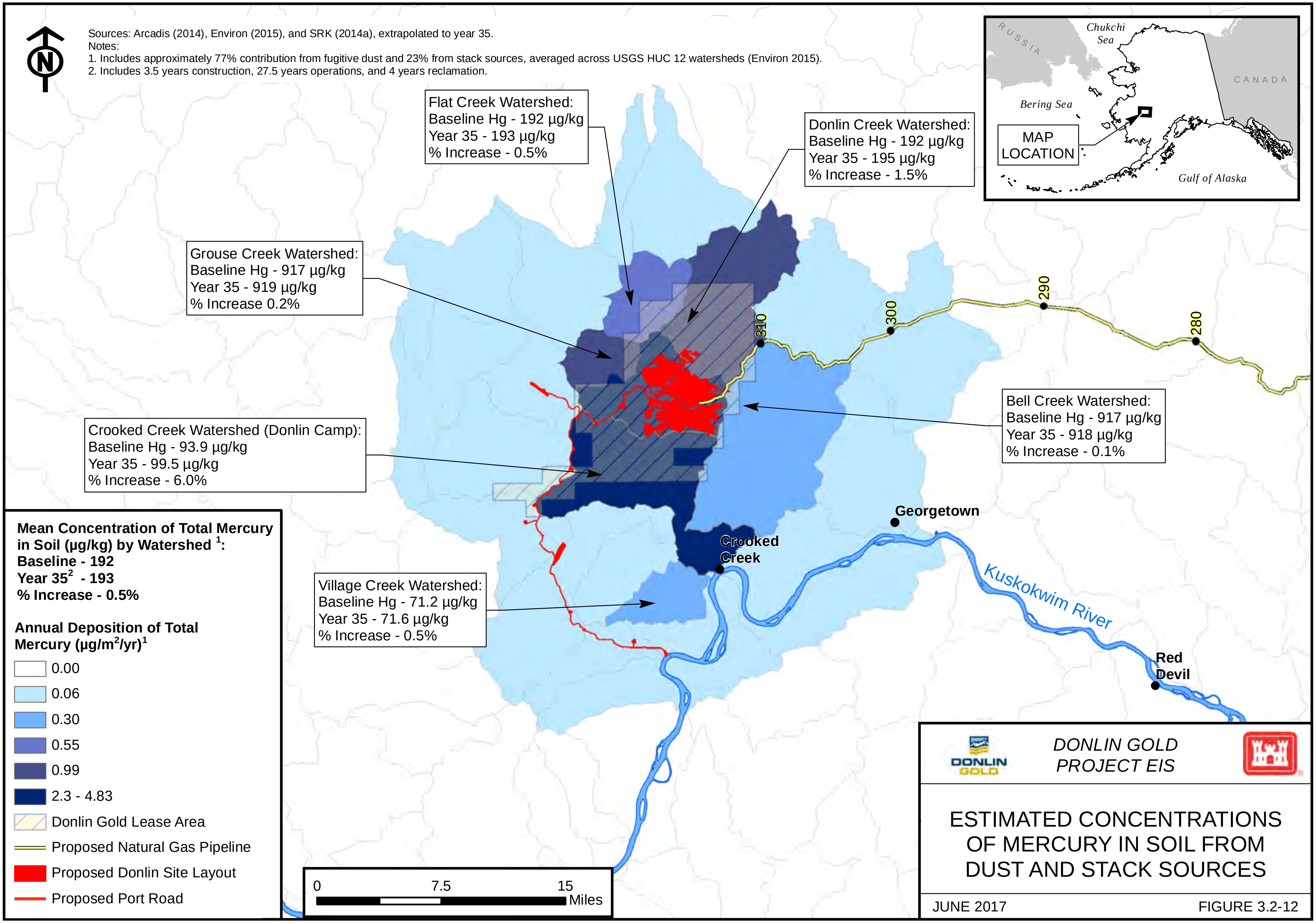
Source: Air Sciences (2015, Fig. 5)
Notes:
1. Annualized based on 110 days/year seasonal use (Donlin Gold 2015e).

0 2.5 5 Miles

DONLIN GOLD
PROJECT EIS

ESTIMATED FUGITIVE DUST DEPOSITION ALONG MINE ACCESS ROAD

JUNE 2017 FIGURE 3.2-11



ESTIMATED CONCENTRATIONS OF MERCURY IN SOIL FROM DUST AND STACK SOURCES

JUNE 2017

FIGURE 3.2-12

Estimated Concentrations of Other Metals in Soil

The geochemistry of baseline soils and potential dust sources, combined with comparisons to ADEC levels, suggest that other metals of potential concern for soil quality include antimony and arsenic. The calculation of these metals in soil at the end of mine life is described in Appendix F and summarized below. The concentrations of these elements in soil at the end of mine life were estimated based on the HUC12 watershed dust deposition rates extrapolated from Environ (2015) (Figure 3.2-10).

Baseline data for individual samples are listed in Appendix F (Table F-5a) by watershed to give an indication of the range and distribution of arsenic and antimony concentrations in the vicinity of the Mine Site. As described in Section 3.2.2.1.4 (Affected Environment, Soil Quality) and Appendix F, the highest concentrations of arsenic and antimony are present within and north of the Mine Site and generally follow trends of mineralized bedrock (Figure 3.1-3).

Year 35 soil concentrations were estimated using two of the methods described above for mercury: 1) 95 percent UCL concentrations for site-wide baseline soils, plus the arithmetic mean for dust at the highest predicted deposition rate, to identify a reasonable maximum average exposure concentration for the final soil concentration; and 2) arithmetic means for both site-wide and watershed-specific baseline data, combined with watershed-specific deposition rates, to identify more representative values for the incremental percent increases caused by the mine.

Based on site-wide baseline data combined with the highest predicted dust deposition rate, the concentration of antimony and arsenic in soil was estimated to increase by about 1 to 3 percent by the end of mine life (Table 3.2-7). The lower percent increases are associated with higher baseline and final concentrations (using 95 percent UCL for baseline), and provide a reasonably conservative estimate of final soil concentrations. The higher percent increases are associated with lower baseline and final concentrations (using means for baseline), and provide a reasonably conservative estimate of contribution from the mine.

The range of arsenic results based on individual watershed data is shown on Figures 3.2-13 and 3.2-14. Figure 3.2-13 provides results for all watersheds, and Figure 3.2-14 highlights watersheds of maximum impact based on different measures of effects (e.g., highest final concentration, highest incremental increase, and highest dust deposition area). Predicted increases in arsenic soil concentrations at the end of mine life for individual watersheds range from about 1 to 10 percent. As with the site-wide results, the final predicted concentrations are driven more by high baseline conditions than dust deposition. The final concentrations on the figures are lower than the highest values in the table, because the baseline data in the figures are based on watershed-specific averages, as compared to 95 percent UCLs in the table. The watershed with highest baseline data (Donlin Creek) is expected to experience the highest final concentration but lowest percent increase, while the highest percent increase in concentration would occur in a watershed with low baseline data close to the Mine Site (Grouse Creek). The watershed receiving the highest amount of dust deposition (North Crooked Creek) would have the largest net concentration increase (2.8 ppm), but a percent increase (6.6 percent) less than that of Grouse Creek.

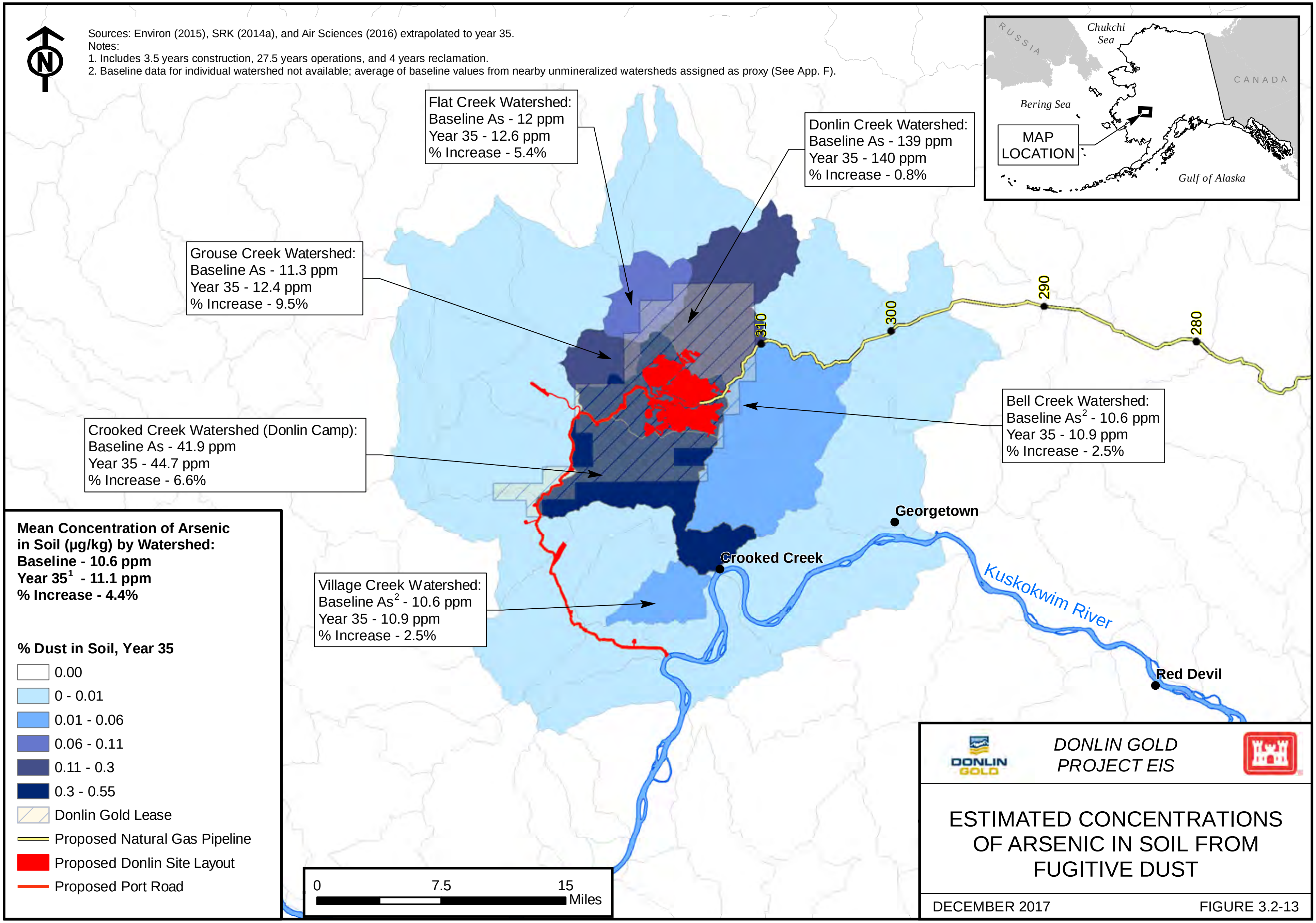
The distribution of antimony results is similar to that of arsenic (Figure 3.2-14), with the highest final concentration in Donlin Creek watershed (9.53 ppm), and the highest incremental percent and net concentration increases in Grouse and North Crooked Creek watershed (4.5 percent, 0.1 ppm).

Total concentrations of arsenic in soils outside of the footprint of the mine are likely to exceed baseline and ADEC levels over the mine life due to the relatively high concentrations in both baseline soils and dust. As described in Section 3.22 (Human Health), the human health risk associated with the incremental amount of project-related arsenic in soils does not exceed ADEC acceptable risk levels for contaminated sites, and is considered insignificant compared to baseline. ADEC cleanup levels can be modified for elevated background conditions, as is often the case for arsenic which is naturally elevated throughout western Alaska. The lateral extent of dust deposition and arsenic contributions from mine dust (Figures 3.2-10 and 3.2-13) are likely to reach negligible levels within 5 to 10 miles of the mine footprint. Potential impacts to ecological and human receptors are further analyzed in Sections 3.10, Vegetation; 3.12, Wildlife; and 3.22, Human Health.

Dust Deposition Effect on Soil Acidity

It is possible that fugitive dust deposition could cause minor changes in soil acidity from sulfide minerals in dust emitted from ore sources. About 3.5 percent of estimated fugitive dust is anticipated to be from ore sources and the remainder from waste rock sources (Air Sciences 2014a). Existing baseline soil conditions are slightly acidic, with pH averaging about 4.5 to 4.7 for wetlands and uplands soils, respectively (ARCADIS 2014), indicating little to no buffering capacity. Assuming that the sulfide content of the ore component of the dust is 1.5 percent (SRK 2011; SRK 2013b), the acid generating potential (AP) of the ore dust would be equivalent to 46.9 tonnes $CaCO_3$ / kilotonne (t $CaCO_3$ / kt). The carbonate neutralization potential (NP) of the ore is assumed to be similar to that of PAG7 waste rock or 4.6 t $CaCO_3$/kt (Enos 2013c). In contrast, the tonnage-weighted average of all waste rock types would have an AP of 11.0 t $CaCO_3$/kt and an NP of 60.5 t $CaCO_3$/kt (Enos 2013c). Applying the percentage of ore in the dust to these values, the overall net NP of the dust would be 46 t $CaCO_3$/kt, and the overall NP to AP ratio of the dust would be 4.7, meaning that the dust has the capacity to neutralize 4.7 times more acid than it can generate. In other words, the large excess of NP in the waste rock, which would comprise the majority (96.5 percent) of the dust, would be more than sufficient to counteract the AP of the ore component, and the net effect of dust deposition would be a minor increase in both the buffering capacity and the alkalinity of soils in the vicinity of the Mine Site.

Cyanide emitted from the process plant is anticipated to be primarily an air quality impact (see Section 3.8, Air Quality) and is expected to have little effect on soil quality. The atmosphere is considered the ultimate sink for almost all cyanide. Although small amounts may be present in PM, cyanide is not expected to persist in soil due to volatilization and biodegradation (ATSDR 2006).

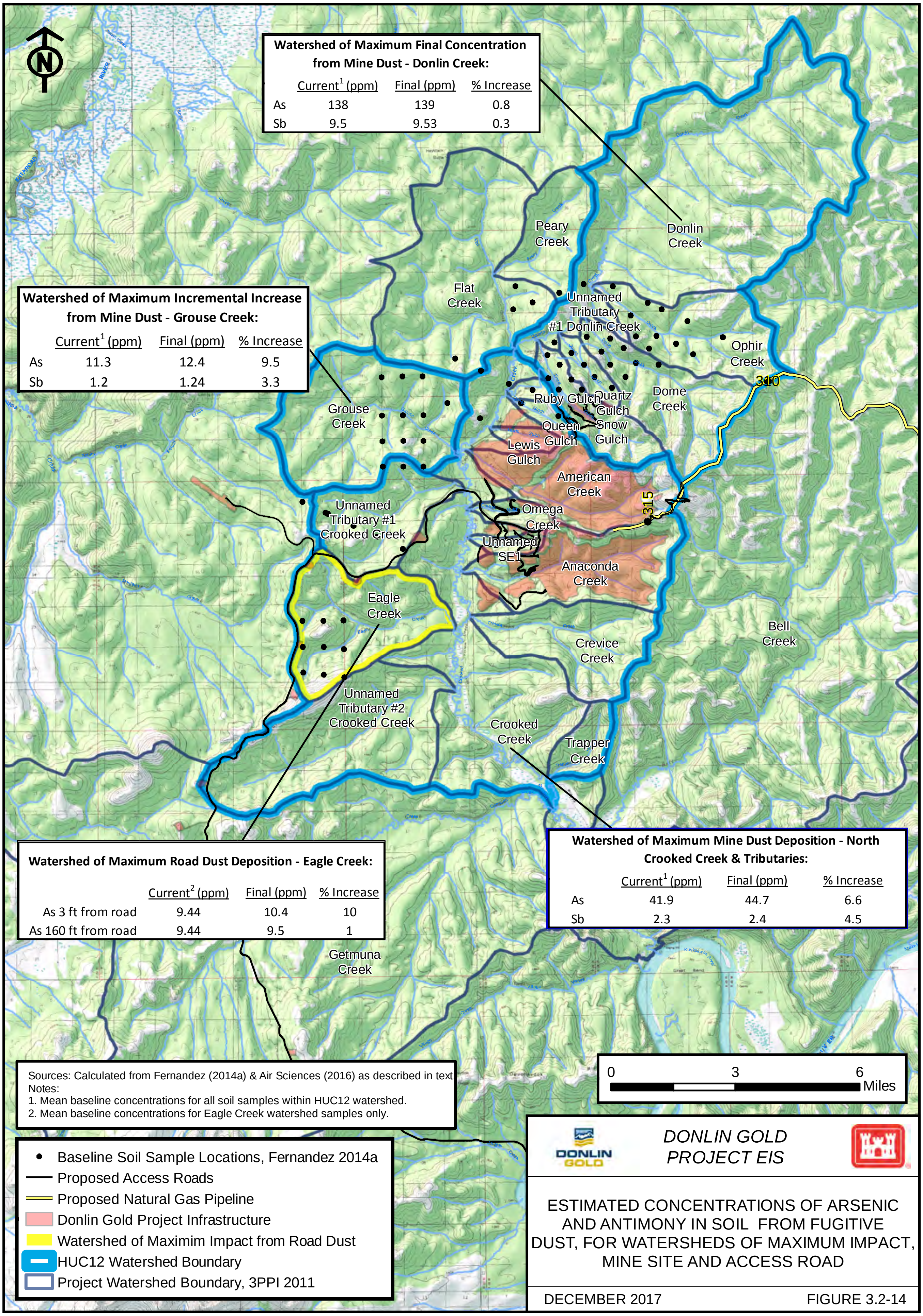


DONLIN GOLD PROJECT EIS

ESTIMATED CONCENTRATIONS OF ARSENIC IN SOIL FROM FUGITIVE DUST

DECEMBER 2017

FIGURE 3.2-13



Watershed of Maximum Final Concentration from Mine Dust - Donlin Creek:

	Current[1] (ppm)	Final (ppm)	% Increase
As	138	139	0.8
Sb	9.5	9.53	0.3

Watershed of Maximum Incremental Increase from Mine Dust - Grouse Creek:

	Current[1] (ppm)	Final (ppm)	% Increase
As	11.3	12.4	9.5
Sb	1.2	1.24	3.3

Watershed of Maximum Road Dust Deposition - Eagle Creek:

	Current[2] (ppm)	Final (ppm)	% Increase
As 3 ft from road	9.44	10.4	10
As 160 ft from road	9.44	9.5	1

Watershed of Maximum Mine Dust Deposition - North Crooked Creek & Tributaries:

	Current[1] (ppm)	Final (ppm)	% Increase
As	41.9	44.7	6.6
Sb	2.3	2.4	4.5

Sources: Calculated from Fernandez (2014a) & Air Sciences (2016) as described in text
Notes:
1. Mean baseline concentrations for all soil samples within HUC12 watershed.
2. Mean baseline concentrations for Eagle Creek watershed samples only.

DONLIN GOLD PROJECT EIS

ESTIMATED CONCENTRATIONS OF ARSENIC AND ANTIMONY IN SOIL FROM FUGITIVE DUST, FOR WATERSHEDS OF MAXIMUM IMPACT, MINE SITE AND ACCESS ROAD

DECEMBER 2017

FIGURE 3.2-14

Dust Control at Mine Site

The fugitive dust estimates described in the above analyses by Air Sciences (2014a) and Environ (2015) assume that dust suppression for emission reduction would not occur, except in the case of unpaved roads. For example, no dust suppression is assumed for the WRF, tailings beach, or pit. Unpaved roads are assumed to be controlled at 90 percent, primarily with periodic chemical application and watering (Rieser 2015b). In addition, the mercury model (Environ 2015) conservatively assumes that none of the dust from the pit, which comprises nearly half of fugitive dust mercury emissions from the Mine Site, would be redeposited in the pit.

The project design includes a number of best practical measures (BPMs) that would minimize wind erosion and fugitive dust, and limit traffic and soil disturbance during construction and operations. These measures are detailed in a Fugitive Dust Control Plan (FDCP) attached in Appendix I, and include the following: plant baghouses; enclosed structures for ore crushing and transfer; stabilization of disturbed soil by truck watering, spreading snow, or applying other approved dust suppressants; allowing natural conditions (e.g., rain and snow) to maintain dust control until use of conventional methods is necessary; the use of evaporative sprayers and sprinklers at the TSF for tailings beach dust control; and the use of a phased approach for soil disturbance and reclamation, and dozers for soil compaction, at the WRF and other reclaimed areas (Air Science 2015d, Rieser 2015b, SRK 2016c).

Closure

Dust is expected to be generated during reclamation activities. Four years of the Closure period were included in the dust estimates described above (under Construction and Operations) to provide reasonable maximum exposure concentrations at the end of mine life that include earth-moving activities in early closure. The concentrations of metals in the dust during Closure, however, would be lower than those during Operations, as the source of the dust would be mostly from overburden and growth media with concentrations closer to baseline values. Thus, the impact of dust on soil quality during reclamation is such that changes in soils may not be measurable or noticeable.

Summary of Mine Site Impacts

In terms of intensity, the effects of dust deposition on soil quality during all phases of Alternative 2 are not expected to reach levels of concern for mercury and antimony. Soil quality effects would be below regulatory limits, or within the range of baseline variation outside of the mineralized zone. Arsenic is expected to increase up to 3 percent on average across the Mine Site above naturally high baseline concentrations, and up to about 10 percent for individual watersheds with low baseline concentrations and high dust deposition rates. While baseline concentrations of arsenic near the Mine Site are more than an order of magnitude higher than ADEC levels, the additional sources of arsenic mobilized by the mine would contribute a relatively small increase in soil concentrations over the life of the mine (up to 2.8 ppm). Planned mitigation measures for dust control are expected to minimize the levels of these effects. The extent or scope of effects are expected to mostly affect nearby watersheds within Project Area boundaries, but could be measurable as far as 10 miles from the mine. Effects would potentially accumulate and persist over the life of the mine and remaining at similar levels following mine closure. In terms of context, affected soils are extensive throughout the Project Area, and it is unknown whether they would be subject to future ADEC oversight due to potential dust impacts.

Transportation Corridor

Construction

Mine Access Road: No pre-existing contaminated sites were identified along the mine access road corridor.

Dust generated during road construction and from road use during mine construction could potentially result in elevated concentrations of certain metals in soils near the road over time through dust deposition. Similar to the discussion above under Mine Site, potential contaminants of concern could include metals if present at elevated concentrations in source material (rock or overburden from material sites) used as slope fill or road base. The calculation of these metals in soil at the end of mine life is described in Appendix F and summarized below.

Dust deposition rates and dust fractions in soil are shown on Figure 3.2-11 for the mine access road. The location of maximum dust deposition along the road is in Eagle Creek watershed about 2 miles south of the airstrip spur road (Figure 3.2-11 and Figure 3.2-14). The fraction of dust that is expected to accumulate in soil at this location by the end of mine life is about 1.9 percent immediately adjacent to the road. This amount drops off by an order of magnitude (to 0.19 percent) about 160 feet from the road.

Concentrations of arsenic in soil at the end of mine life due to road dust were estimated based on baseline soil data from the Eagle Creek watershed (Figure 3.2-3 and Figure 3.2-14, Table F-5a). Antimony is not elevated with respect to ADEC levels for potential road dust sources (Table 3.2-6), thus, it was not included in this analysis. Mercury results for the road location are estimated to be the same as those described above under Mine Site, because the Eagle Creek watershed is located within the boundaries of the larger HUC12 watershed with highest predicted mine dust impacts. Year 35 soil concentrations for arsenic were estimated in Table 3.2-8 using both the arithmetic mean and 95 percent UCL concentrations for baseline soils to identify reasonable upper bound estimates associated with the incremental increase caused by road dust and final soil concentrations.

The results indicate that arsenic concentrations could increase by about 8 to 10 percent in soils immediately adjacent to the road, but would drop to a 1 percent increase within a distance of 160 feet from the road. Estimated final soil concentrations are less than those predicted for the Mine Site (Table 3.2-7), because arsenic concentrations at borrow sites are expected to be substantially less than those of waste rock and ore that comprise dust sources at the Mine Site. In terms of intensity, arsenic concentrations over time are not expected to substantially exceed baseline levels and would be within the range of natural variation in the site vicinity, although concentrations would slightly exceed ADEC levels protective of human health, as they are already elevated in baseline soils. Concentrations could increase towards the north end of the road where dust may be more representative of waste rock and ore data than outcrop data (Table 3.2-6). Additional evaluation of metals leaching at material sites prior to construction and planned mitigation measures for dust control (e.g., watering and use of dust suppressants) (Chapter 5, Impact Avoidance, Minimization, and Mitigation), would minimize the level and extent of effects.

Table 3.2-8: Estimated Arsenic Concentrations in Soil along Mine Access Road due to Fugitive Dust

Element[1]	Current Soil Concentration[2] (mg/kg)	Outcrop/ Rock Rubble[3] (mg/kg)	% Dust in Soil, Year 35[4]	Soil, Year 35		ADEC Soil Cleanup Level[5] (mg/kg)
				Concentration (mg/kg)	% Increase above Baseline	
Arsenic – 3 feet from road						
mean	9.44	59	1.9	10.4	10	8.8
95% UCL	11.8	-		12.7	7.6	
Arsenic – 160 feet from road						
mean	9.44	59	0.19	9.5	1.0	8.8
95% UCL	11.8	-		11.9	0.8	

Notes:
1 Only metals exceeding ADEC cleanup levels in baseline or potential road dust sources are listed.
2 Baseline samples from watershed with maximum dust deposition - Eagle Creek (Air Sciences 2015a, Fernandez 2014a). based on 95% Student's-t UCL
3 Outcrops and rock rubble samples along mine access road, assumed similar to potential borrow pit material to be used as road base; from Fernandez (2014a).
4 Maximum impact value on Figure 3.2-11, based on AERMOD results in Air Sciences (2015a) extrapolated to soil fraction at Year 35 (see Equation 2 in App. F).
5 18 AAC 75: Method Two, Under 40-inch Zone, Human Health (ADEC 2017b).

Abbreviations:
\- data not available
n number of samples
95% UCL = 95 percent upper confidence limit on the mean
ADEC = Alaska Department of Environmental Conservation
Shaded cell = Concentrations exceed ADEC levels.

Kuskokwim River Corridor: Multiple existing contaminated sites are present within ¼ mile of the Kuskokwim River, downstream from the Angyaruaq (Jungjuk) Port site, most of which coincide with established river communities (Figure 3.2-4). Petroleum hydrocarbons are the most prevalent contaminant amongst sites identified. More than half of the sites are designated as "open" by ADEC, indicating that contamination persists at concentrations above established cleanup levels, or insufficient information is available to make a determination. Established institutional controls exist for one site, which are limited to groundwater usage restrictions.

Since no project infrastructure coincides with any of the open contaminated sites along this segment, there would be no direct impacts to soil quality. The potential for indirect soil contaminant migration or dispersion to adjacent surface waters from wake-induced shoreline erosion (i.e., barge traffic) is also considered low to improbable. Any potential contribution of soil impairments to adjacent waters would require the following conditions:

- Soil contamination has sufficiently migrated through soils from inland sources to the Kuskokwim River shoreline;
- Contamination is present in vadose soils (above water table) that could potentially slough into the Kuskokwim River from wave-induced barge traffic. However, in most circumstances associated with shoreline discharge scenarios, contaminant migration to surface water bodies from inland sources is generally via groundwater seeps, or baseflow intrusion;

- Contaminant type (source) and concentrations are sufficient to have a detectable and quantifiable impact at the point of discharge (bank sloughing); and
- Wake-induced erosion can be differentiated from other on-going natural shoreline processes. As noted in Section 3.2.3.2.2 and Section 3.5, Surface Water Hydrology, natural erosion effects from ice breakup and flooding along the Kuskokwim River are likely to be substantially greater than barge wake-induced erosion.

Bethel Cargo and Fuel Terminals and Tank Farm (connected action): Although several contaminated sites exist in the vicinity of the terminals and tank farm in Bethel, only one lies within the boundary of potential port construction (Figure 3.2-4 and Appendix F). As described in Section 3.2.2.2.4, other contaminated sites in the vicinity were considered unlikely to impair soil conditions within the project boundaries due to sufficient distance, hydraulic gradients, and/or presence of permafrost. The contaminated site within the project boundary is associated with a petroleum release at the Bethel Fuel Sales facility, which ADEC gives a “cleanup complete” status. Furthermore, the site is already developed and is equipped with pads, liners, and containment to accommodate three additional tanks, indicating that intrusive construction work would be limited during tank farm expansion and discovery of additional undocumented contaminated soils unlikely. Thus, little to no impacts is expected from disturbance of contaminated soils at this site. Any actions that would occur at Dutch Harbor or the Port of Bethel at the Bethel Yard Dock are not part of the proposed action, and are considered connected actions (see Section 1.2.1, Connected Actions, in Chapter 1, Project Introduction and Purpose and Need).

Dutch Harbor Port: Fuel capacity expansion at the Dutch Harbor Port by a third party could potentially involve disturbance of areas impacted with contaminated soil or other media. A total of 17 contaminated sites are located within approximately ¼-mile of existing tank farms and docks (Figure 3.2-5 and Appendix F). Three of the sites are closed and 14 are open contaminated sites. Four of the open sites coincide with existing tank farm and dock locations, including the Delta Western bulk plant and dock pipelines, and the Rocky Point tank hill and lower tank. The nature of contamination at each of these sites is petroleum hydrocarbons derived from storage tank releases, pipeline releases, fuel handling practices, subsurface utility infrastructure, and comingling hydrocarbon contamination from WWII era operations or other historic land uses. Impacted media includes soil and groundwater. Non-aqueous petroleum product is also present in some circumstances. Groundwater is often shallow (less than 10 feet), in addition to a shallow bedrock interface. ADEC interaction with site owners/representatives is on-going (ADEC 2013a). Any actions that would occur at Dutch Harbor or the Port of Bethel at the Bethel Yard Dock are not part of the proposed action, and are considered connected actions (see Section 1.2.1, Connected Actions, in Chapter 1, Project Introduction and Purpose and Need).

Due to the present and historical complexity of environmental concerns at these sites, the effects on soil quality from construction activities largely depends on the location of the fuel expansion area, and the site-specific presence of pre-existing conditions of concern. Anticipated construction and/or fuel service provider responsibilities would likely require preparation and execution of any necessary permits or regulatory required processes, including SWPPP preparation, contaminated media investigation planning and approval by the ADEC’s Contaminated Sites Program, and remediation as appropriate. The anticipated intensity of effects from construction would depend on the presence and extent of existing soil contamination, remediation practices, and site controls employed during cleanup. Soil quality effects may be below regulatory limits, or small compared to baseline levels. The duration of pre-existing soil contamination (if any) would vary depending on certain factors. Impacts would not last longer than the span of the project construction if concurrent soil remediation is practicable and performed during construction. However, impacts could persist through the life of the project, depending on the severity of contamination and ADEC-approved remediation approach. Regardless, the duration of effects would be an ongoing responsibility of the third-party landowner, or responsible party. Resulting effects would be beneficial if required remediation results in reduced soil / water quality impairment. Due to the estimated small size of the expanded tank farm area required, the extent or scope of effects would be limited to the immediate vicinity of the tank farm expansion footprint. In terms of context, similar surface and subsurface soil conditions (soil types and / or presence of impacted soil media) exist throughout the Dutch Harbor area, and contaminated sites are governed by regulation.

Operations and Closure

Little to no incremental effects from contaminated sites are expected during operations and closure of the Transportation Corridor beyond those described above. It is possible that if remediation is required at the Dutch Harbor Port, the duration of cleanup could extend into the operations period or beyond. The level of effects though would be the same as described above.

Effects from dust generated along the mine access road during operations and closure would be the same as described above under Construction.

Summary of Transportation Corridor Impacts

Impacts to soil quality for dust along the mine access road, and from contaminated sites at the various transportation infrastructure facilities during all phases of Alternative 2 would vary in intensity. A small increase in arsenic could occur immediately adjacent to the road above slightly elevated baseline soil concentrations, with final concentrations within the range of natural variation. The intensity could be elevated on contaminated sites at Dutch Harbor, depending on site-specific presence / extent of existing soil contamination. However, additional evaluation of metals leaching at borrow sites, dust control along the road, SWPPP compliance, and remediation (Chapter 5, Impact Avoidance, Minimization, and Mitigation) are expected to be effective in controlling effects on the project, and in controlling potential third-party construction activities from spreading any pre-existing contamination. The extent or scope of effects are expected to remain within the immediate vicinity of individual facilities, and in the case of road dust, would drop to imperceptible levels within a few hundred feet from the mine access road. The duration of effects from contaminated sites would vary, and may persist through the life of the project, depending on the nature of required remediation (if any). Dust effects along the road would be irreversible, potentially accumulating over the mine life and persisting into post-Closure. In terms of context, affected soils are extensive throughout the Project Area and contaminated sites are governed by regulation.

Pipeline

Construction

Potential effects from contaminated sites are not applicable to Pipeline trenching or ROW preparation since no pre-existing contaminated conditions of environmental concern have been identified along the Pipeline ROW (Appendix F and Figure 3.2-9). Several "open" contaminated sites were identified in the vicinity of the Beluga camp and storage yard. These are unlikely to have an effect on project activities, however, because they are associated with specific Beluga Power Plant and Beluga Gas Field infrastructure that would not be disturbed by pipeline construction activities, and because construction of the camp and storage yard would not involve any cuts or subsurface excavations.

Open sites identified at one of the existing airstrips for use during pipeline construction (Farewell) could have an effect on the project if airstrip grading requirements disturb existing petroleum–contaminated soils originating from heating oil tanks and pipelines near Federal Aviation Administration (FAA) structures at the site. In this event, the type and level of effects would be similar to those described above for Dutch Harbor, with responsibility for remediation residing with FAA. Mitigation recommendations are provided in Chapter 5, Impact Avoidance, Minimization, and Mitigation, for additional investigation prior to Pipeline construction to map the specific location of potential contaminated soils compared to final grading plans, so that disturbance of these soils can be avoided if possible, and the likelihood and intensity of effects would be reduced.

Potential effects to soil from fugitive dust during pipeline construction are considered to be negligible based on design features and conservative particulate matter (PM) scaling estimates. Scaling estimates are based on the mine road dust depositional model described above and annual pipeline construction emission estimates provided in Section 3.8, Air Quality. Design features that would mitigate dust deposition include the following:

- Prevalence of moisture laden materials along the alignment;
- Predominant construction during winter months;
- Short temporal duration of construction followed by immediate stabilization and reclamation;
- Limited fetch over disturbed surfaces;
- Lack of significant mineralized sources in addition to proposed testing for PAG at materials sites and use of alternative non-PAG sources if necessary;
- Immediate access to emission controls during summer (e.g., watering); and
- Programmatic dust control and abatement measures consistent with the Fugitive Dust Control Plan (SRK 2013b).

Total dust deposition values along the Pipeline were conservatively estimated to be 0.2 and 0.01 percent dust in the top inch of soil at distances of three feet and 330 feet, respectively from the footprint after construction. These values are based on the following:

- A maximum total dust yield of 3.8 tons per mile over a two-year, 316-mile construction period (see Table 3.8-30, Section 3.8, Air Quality);
- Total PM values (48 tons per mile) over the 35-year duration of the 33-mile-long mine access road usage (see Table 3.8-27, Section 3.8, Air Quality);
- An approximate tons per mile dust deposition ratio of 4 (Pipeline) to 48 (mine access road), or conservatively 1/10; and

- Relative ratio comparison (tons per mile) of dust deposition rates and dust fractions in soil as shown on Figure 3.2-11 for the mine access road based on a model completed by Air Sciences (2015a) using AERMOD.

Small proportional increases in metal concentrations (e.g., arsenic) due to dust deposition along the Pipeline could be inferred from those shown in Table 3.2-6 (e.g., up to 1 percent increase in arsenic along the pipeline, as compared to 10 percent for the road); however, the inferred values would be conservatively high based on mineralized conditions at the Mine Site that are unlike the unconsolidated materials along most of the Pipeline alignment. Borrow site materials along the pipeline would primarily be used in the trench and on shoofly roads, not on the ROW. Dust emissions and deposition along the ROW are likely to result in a redistribution of similar concentrations as baseline soils, because the chemistry of nearby impacted soils is likely to be similar to that of the ROW soils that create the dust.

Operations and Closure

Little to no incremental effects from contaminated sites are expected during operations and closure at the Pipeline beyond those described above, as the off-ROW sites located near pre-existing open contaminated sites would not be utilized after construction. Post-construction reclamation at the Beluga camp and storage yard would not involve any intrusive actions (excavations), and the Farewell airstrip would not be reclaimed after construction.

Summary of Pipeline Impacts

Impacts from contaminated sites along the Pipeline during all phases of Alternative 2 could range in intensity due to grading of pre-existing contaminated soils at the Farewell airstrip, depending on the site-specific presence and extent of existing soil contamination. However, additional investigation during final design would likely allow disturbances of these soils to be avoided and reduce potential effects to below regulatory limits or within the range of natural baseline variation outside of the mineralized zone. Dust deposition effects along the pipeline during construction are expected to be less than 1/10th the amount that would accumulate along the mine access road during operations, and could result in up to about 0.2 percent dust in the top 1 inch of soil immediately adjacent to the ROW. These effects would be minimized by several design features (e.g., winter construction, watering, and PAG-testing of material sites). The extent or scope of effects on the project and the environment from contaminated sites and dust are expected to be limited to areas within airstrip boundaries or within a few 10s of feet of the ROW. Contaminated sites effects would last through construction only; dust effects would last beyond the life of the project. In terms of context, affected soils are extensive throughout the Project Area, but are governed by regulation.

3.2.3.2.5 CLIMATE CHANGE

Predicted overall increases in temperatures and precipitation and changes in the patterns of their distribution have the potential to influence the projected effects of the Donlin Gold Project on soils. These effects are particularly tied to changes in permafrost and increased risk of erosion as discussed in Sections 3.26.4.2.3 and 3.26.4.2.2.

3.2.3.2.6 SUMMARY OF ALTERNATIVE 2 IMPACTS

Applying the methodology defined in Table 3.2-3 to the information and data presented in this section, Alternative 2 has potential direct and indirect impacts on soils. Table 3.2-9 provides a summary of impacts by the four assessment factors.

Table 3.2-9: Summary Impacts of Alternative 2 on Soils by Project Component

Project Component	Impact Type/ Phase or Location	Magnitude or Intensity	Duration	Extent or Scope	Context
Mine Site	**Soil Disturbance**				
	Construction and Operations	Impacts would vary in intensity. Soil disturbance (e.g. compaction) would require revegetation by active methods. Impacts may result in acute or obvious changes in the resource character (e.g. complete soil removal).	Irreversible impacts on soil character. Resources would not be anticipated to return to previous levels and rehabilitation is not possible for many years after the life of the project.	Impacts limited to discrete portions of the Project area and within the footprint of the Mine Site.	Impacts would affect resources that are widely distributed in the region and/or not depleted or protected by legislation.
	Closure	Soil disturbance would require revegetation by active methods.			
	Permafrost				
	TSF, Water Dams, Stockpiles, Plants	Impacts would vary in intensity. Changes in permafrost may not be measurable or noticeable (e.g. ground settlement) and the thermal regime is maintained and rehabilitation can be accomplished through natural recolonization. Disturbance may require revegetation by active methods but the design is adequate for the expected range of permafrost hazards.	Duration of impacts would vary. Permafrost hazards may occur through the life of the project but would return to pre-activity levels after completion of the project. Impacts could result in irreversible impacts on the thermal regime.	Same as above. Estimated 130 million tons of thawed permafrost soils could lead to GHG emissions.	Same as above. (Context of GHG emissions from permafrost soils presented in Sections 3.8 and 3.26)
	WRF	Low probability[1] of disturbance requiring revegetation by active methods or acute/obvious changes with permafrost disturbance resulting in settlement that requires substantial fill for successful rehabilitation. Permafrost hazards may exceed design parameters. Toe instability may occur if deep ice-rich soils are present.			
	Erosion				

Project Component	Impact Type/ Phase or Location	Magnitude or Intensity	Duration	Extent or Scope	Context
	Construction, Operations, Closure	Impacts would vary in intensity. Changes in erosion may not be measurable and standard BMPS would be successful in preventing erosion. Disturbance may require revegetation by active methods to prevent erosion issues. Special BMPs and more frequent monitoring/maintenance may be needed for successful erosion control.	Duration of impacts would vary. Erosion may be impacted not longer than the span of the project Erosion may persist through the life of the project and return to pre-activity levels up to 100 years after completion of the project.	Same as above.	Context of impacts would vary. Affects resources widely distributed in the region but resource hazards are governed by regulation.
	Post-Closure	Changes in erosion may not be measurable or noticeable and standard BMPS would be successful in preventing erosion (after stabilization is achieved).			
	Soil Quality				
	Fugitive Dust Deposition	Soil quality effects are below regulatory limits or within the range of natural baseline variation outside of the mineralized zone (1 to 3% arsenic increase above naturally high baseline, averaged across large watershed).	Irreversible impact on soil quality and persisting in soils after Closure.	Extent or scope of impacts would vary. Impacts to soils would mostly be limited to areas within the property boundaries. Could affect soils potentially with the locality or region 10 miles away.	Impacts would affect resources that are widely distributed in the region and/or not depleted or protected by legislation.

Project Component	Impact Type/ Phase or Location	Magnitude or Intensity	Duration	Extent or Scope	Context
Transportation Corridor	**Soil Disturbance**				
	Construction and Operations	Intensity of impacts would range from compaction and grading in previously disturbed port areas that may not be measurable or noticeable to acute or obvious changes in the resource character from the complete removal of native soils at road cuts.	Irreversible impact on soil character. Resource would not be anticipated to return to previous levels and rehabilitation is not possible for many years after the life of the project.	Impacts to soil would be limited to discrete portions of the Project Area and within footprints of individual facilities.	Same as above.
	Closure	Intensity of impacts would range from changes in soils that may not be measurable or noticeable to disturbances that require revegetation by active methods.			
	Permafrost				
	All Facilities (where permafrost present)	Same as above.	Duration would range from impacts lasting throughout the life of the project (e.g., road settlement reaches equilibrium within several years) to irreversible impacts where restoration of permafrost is not expected.	Same as above. Estimated 6.9 million tons of thawed permafrost soils could lead to GHG emissions over life of mine.	Same as above. (Context of GHG emissions from permafrost soils presented in Sections 3.8 and 3.26)
	Erosion				
	Project Facilities: Construction, Operations, Closure	Same as above.	Duration of most erosion effects would range from several months for individual locations or events, to port reclamation or effects potentially lasting for years until soils are re-stabilized.	Same as above.	Context of impacts would vary. Affects resources widely distributed in the region but resource hazards are governed by regulation.
	Project Facilities: Post-Closure	Changes in soils and erosion may not be measurable or noticeable after stabilization is achieved.			
	Soil Quality				

Project Component	Impact Type/ Phase or Location	Magnitude or Intensity	Duration	Extent or Scope	Context
	Contaminated Sites	Impacts would vary in intensity. A small increase in arsenic could occur immediately adjacent to the road above slightly elevated baseline soil concentrations, with final concentrations within the range of natural variation. The intensity could be elevated on contaminated sites at Dutch Harbor, depending on site-specific presence/extent of existing soil contamination.	Same as above.	Same as above.	Impacts would affect usual or ordinary resources that are widely distributed in the region and/or not depleted or protected by legislation.
Transportation Corridor (continued)	Fugitive Dust Deposition (mine Access Road)	Soil quality effects would be within the range of natural baseline variation outside of the mineralized zone (8 to 10% increases in arsenic above slightly elevated baseline immediately adjacent to road).	Changes would persist in soils after closure.	Same as above.	
Pipeline	**Soil Disturbance**				
	Construction	Impacts would range from compaction of frozen native soils along winter roads that may not be measurable or noticeable to acute or obvious changes in the resource character from cuts and fills along ROW, roads, and airstrips. Soil disturbance area would be slightly greater under North Option.	Same as above.	Same as above.	Same as above.
	Post-Construction Reclamation, Operations, and Closure	Intensity reduced through reclamation.			

Project Component	Impact Type/ Phase or Location	Magnitude or Intensity	Duration	Extent or Scope	Context
	Permafrost				
	Construction, Operations, Closure	Impacts would range from ground settlement that may not be measurable or noticeable, to more severe impacts, but the design is adequate for the expected range of permafrost hazards.	Most permafrost thaw effects would range in duration from areas where settlement reaches equilibrium within several years, to irreversible changes in permafrost where restoration of permafrost is not expected.	Same as above. Estimated 37 million tons of thawed permafrost soils could lead to GHG emissions.	Same as above. (Context of GHG emissions from permafrost soils presented in Sections 3.8 and 3.26)
	Post-Closure	Impacts would range from ground settlement or thermal erosion that may not be measurable or noticeable, to acute or obvious changes in permafrost (site-specific settlement post-SRR plan).			
	Erosion				
	Project Facilities: Construction and Post-Construction Reclamation	Impacts mostly managed through ESC measures, with isolated occurrences of acute or obvious erosion during ROW construction, or ORV use near discrete segments of ROW. Erosion during construction would likely be reduced such that changes in soils due to erosion may or may not be measurable or noticeable within a short period of time due to planned redundancies in ESC measures, reclamation/cleanup crew functions, and monitoring/maintenance activities.	Duration of most erosion effects would range from several months for individual locations or events, to port reclamation or effects potentially lasting for years until soils are re-stabilized.	Same as above.	Context of impacts would vary. Affects resources widely distributed in the region but resource hazards are governed by regulation.
	Project Facilities: Operations and Closure	Changes in soils may not be measurable or noticeable after stabilization is achieved.			

Project Component	Impact Type/ Phase or Location	Magnitude or Intensity	Duration	Extent or Scope	Context
Pipeline (continued)	ORV Access (Indirect Effects)	Most impacts would result in disturbance that requires revegetation by active methods to prevent erosion issues. Discrete areas may experience acute or obvious changes in the resource character (potential heavy seasonal use near Farewell).	Duration of impacts would vary. Impacts would persist through the life of the project and may result in irreversible impacts on soil character.	Extent or scope of impacts would vary. Impacts to soils would mostly be limited to areas within the property boundaries. Could affect soils potentially beyond the ROW if used to access new areas.	
	Soil Quality				
	Contaminated Sites	Impacts would range in intensity from soil quality below regulatory limits or within the range of natural baseline variation, to small effects compared to baseline resulting from grading of pre-existing contaminated soils at the Farewell airstrip.	Impacts would last through the construction phase only.	Impacts to soil quality would be limited to discrete portions of the Project Area and within footprints of individual facilities.	Same as above.

Direct impacts to soils from ground disturbances, permafrost degradation, erosion, and fugitive dust at the Mine Site under Alternative 2, as well as impacts from permafrost hazards on man-made structures, would vary in intensity. Impacts would range from changes in the resource character that may or may not be measurable, to acute or obvious changes. However, the intensity for most effects would be reduced through reclamation or additional mitigation. Soil removal would result in the irreversible alteration of a total of roughly 9,000 acres of soil and discontinuous permafrost, and an estimated 120 million tons of thawed soils that could lead to GHG emissions. Likewise, the duration of dust effects would be irreversible, potentially accumulating and persisting over the life of the mine and remaining at similar levels following mine closure. However, the duration of erosion effects would range from not longer than the span of the project, to impacts lasting through the life of the project, with impacts potentially lasting for months or years until stabilization is achieved. The extent or scope of soil disturbance, permafrost, and erosion effects would be limited to areas within the mine footprint and project property boundaries; whereas fugitive dust effects could be measurable as far as 10 miles from the mine. The context of soil and permafrost effects would range from usual or ordinary resources that are widely distributed in the region, to effects that are governed by regulation (e.g., erosion).

Transportation Corridor impacts to soils from ground disturbances, permafrost degradation, erosion, fugitive dust, and contaminated sites under Alternative 2, as well as impacts from permafrost hazards on man-made structures, would also vary in intensity similarly to the Mine Site. Impacts would range from changes in the resource character that may or may not be measurable, to acute or obvious changes, although the intensity for most effects would be reduced through reclamation or other mitigation (e.g., remediation preventing spread of existing soil contamination, or ORV access restrictions). Soil disturbances under Alternative 2 would result in the irreversible alteration of a total of roughly 900 acres of surface soil and associated erosion and permafrost effects (where present). The total amount of thawed permafrost soils would be roughly 6.9 million tons over the life of the mine, and roughly 62,000 tons/year in Closure (Bethel site only). The extent or scope of impacts would mostly be limited geographically to areas within the footprints of the individual infrastructure components. The duration of dust effects along the road would have irreversible impacts on soil character, potentially accumulating and persisting over the life of the mine and into post-Closure; whereas the duration of erosion effects could range from several months to irreversible impacts on soil character. The extent or scope of dust and contaminated sites effects would be limited to areas within the vicinity of individual facility footprints (e.g., dust on order of 1/10th mile from road). The context of impacts would be the same as described above for the Mine Site.

Impacts to soils from ground disturbances, permafrost degradation, erosion, and contaminated sites along the Pipeline ROW and associated facilities under Alternative 2, as well as impacts from permafrost hazards on the Pipeline, would vary in intensity. Impacts would range from changes in the resource character that may or may not be measurable, to acute or obvious changes, although the intensity for most effects would be reduced through effective design, reclamation, access limitations, or other mitigation. Soils and permafrost would be irreversibly altered in areas of elevated intensity effects. The duration of most effects following reclamation would range from not longer than the span of the project, to impacts lasting through the life of the project until stabilization criteria are met. Effects from contaminated sites on the project (e.g., at Farewell airstrip) would last only through the construction phase. Soil disturbances under Alternative 2 would impact a total of 8,350 to 14,100 acres, depending on the amount of additional ROW space needed in areas of challenging ground conditions, and the total amount of thawed permafrost soils would be roughly 37 million tons. While the Pipeline would cross several regions of Alaska, the extent of soil disturbance, erosion, and contaminated sites effects would be limited to areas within the footprint or immediate vicinity of the ROW and individual infrastructure components. Indirect ORV erosion effects could range from discrete segments of ROW to potentially extending for miles beyond the ROW if used to access new areas. The extent or scope of permafrost effects would be limited to areas along intermittent ice-rich areas, mostly occurring along the north flank of the Alaska Range. The context of soil and permafrost effects would be the same as described above for the Mine Site and Transportation Corridor.

3.2.3.2.7 MITIGATION AND MONITORING FOR ALTERNATIVE 2

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

Design features important for reducing impacts to soils include:

- Areas of disturbed bedrock and surficial deposits along the pipeline ROW, roads, and material sites would be contoured to match existing landforms as feasible, ripped to mitigate compaction effects, covered with growth media as needed and revegetated, and would support the overall drainage of the site, the long-term geotechnical stability, and post-mining land use;
- The mine plan incorporates the concept of design for closure. This incorporates methods for safe and efficient closure of the mine as an integral part of the planned mine design and operations. Implementing design for closure can have the effect of minimizing disturbance and the re-handling of materials;
- A detailed Mercury Management Plan would be developed that describes mercury control systems, storage areas, inspections, training, hazard communication, and procedures for off-site transport and disposal (Donlin Gold 2015d). Implementation of this plan would minimize the potential for release of mercury to the environment through normal ancillary activities;
- A Fugitive Dust Control Plan and air quality permit requirements would be followed that describe BACTs and source testing for PM emissions, BMPs for controlling dust from site activities (including roads) and wind erosion, and training and performance assessment procedures (ADEC 2017i);
- Approximately 68 percent of the total pipeline length would be constructed during frozen winter conditions to minimize wetland and soil disturbances from support equipment. Areas selected for summer or fall construction would be based on geotechnical, terrain, safety, and continuity considerations;
- Construction would employ design measures to preclude extended soil compaction;
- The project design includes in-place abandonment of all subgrade pipeline; avoiding impacts that would occur if the pipe were removed; and
- Monitoring of bank erosion immediately upstream and downstream of Angyaruaq (Jungjuk) port would continue, with measures applied, as warranted, for streambank

protection as part of adaptive management (as a Standard Operating Procedure). If warranted, this may include installation of geotextile matting, riprap armoring or methods from the ADF&G Streambank Revegetation and Protection Manual (Walter et al. 2005), such as willow staking, to reduce the effects of eddy formation, scour, and bank erosion during flood events (BGC 2014e).

Standard Permit Conditions, BMPs, and mandated spill prevention and response plans important for reducing impacts to soils are discussed above in Section 3.2.3, and some examples are presented below:

- Implementation of Stormwater Pollution Prevention Plans (SWPPPs) and/or Erosion and Sediment Control Plans (ESCPs) and use of industry standard BMPs for sediment and erosion control;
- Development and maintenance of Oil Discharge Prevention and Contingency Plans (ODPCPs), Spill Prevention, Control and Countermeasure Plan (SPCCs), and Facility Response Plans (FRP);
- Use of BMPs such as watering and use of dust suppressants to control fugitive dust; and
- Preparation and implementation of a Stabilization, Rehabilitation, and Reclamation Plan (SRRP).

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

- The need for monitoring and rehabilitation in Post-Closure should be addressed in the revised Stabilization, Rehabilitation, and Reclamation Plan prior to Closure; include discussion of additional financial assurance to cover these activities.

3.2.3.3 ALTERNATIVE 3A – REDUCED DIESEL BARGING: LNG-POWERED HAUL TRUCKS

3.2.3.3.1 SOIL DISTURBANCE/REMOVAL

Mine Site

Effects on soil disturbance/removal under Alternative 3A would be the same as discussed for Alternative 2 for the Mine Site component, as facility footprints would be identical between alternatives.

Transportation Corridor

The reduction in barging associated with Alternative 3A would reduce effects associated with Kuskokwim River bank soils due to potential disturbances at relay points along the river. During rare low water barging periods, temporary barge moorage along the riverbank may be required at relay points to accommodate reduced barge tows or loads for transit conditions (i.e., draft depth). Temporary riverbank moorage alternatives may include infrequent access to soils above the river bank for rigging securement. Rigging securement would preferably use nonintrusive methods; however, minimal soil disturbances may be required on a case-by-case basis. Under Alternative 3A, the reduction of barge traffic by about one-third of the level under Alternative 2 nearly eliminates the need for barge travel during low water conditions to meet cargo and fuel shipping requirements at the Mine Site. Thus, potential soil disturbances at the relay points would range from imperceptible to changes in soils that may not be measurable or noticeable, occurring very infrequently.

The reduction in fuel trucking along the mine access road under Alternative 3A would result in a slight reduction in dust effects from the mine access road which would result in the same intensity of impacts as described for Alterative 2, due to concentrations in dust similar to baseline.

Because the Bethel and Dutch Harbor ports would not require as much expansion, if any, under Alternative 3A, total soil disturbances could be reduced by about 10 to 20 acres. There would be a related reduction of permafrost degradation at the Bethel port. However, this is a small amount compared to overall soil disturbances for transportation infrastructure (about 900 acres), and the range of effects would be the same as Alternative 2, due to minor grading to blasting, with some reductions in intensity through reclamation (Section 3.2.3.2.1). Any actions that would occur at Dutch Harbor or the Port of Bethel at the Bethel Yard Dock are not part of the proposed action, and are considered connected actions (see Section 1.2.1, Connected Actions, in Chapter 1, Project Introduction and Purpose and Need).

Pipeline

Effects on soil disturbance/removal under Alternative 3A would be the same as discussed for Alternative 2 for the Pipeline component, as facility footprints and Pipeline route would be the same as Alternative 2.

3.2.3.3.2 PERMAFROST

Mine Site

Anticipated effects on permafrost for the Mine Site under Alternative 3A would be the same as those described under Alternative 2.

Transportation Corridor

Permafrost does not occur in the Dutch Harbor area, and is unlikely to occur at the Kuskokwim River relay points due to the likely presence of a thaw bulb close to the river. The reduction of fuel storage expansion at the Bethel dock under Alternative 3A could reduce the extent of permafrost effects by several acres if permafrost is present. However, the intensity of effects from Alternative 3A would be the same as Alternative 2 due to the need for the cargo terminal at Bethel. Any actions that would occur at Dutch Harbor or the Port of Bethel at the Bethel Yard Dock are not part of the proposed action, and are considered connected actions (see Section 1.2.1, Connected Actions, in Chapter 1, Project Introduction and Purpose and Need).

Pipeline

Impacts to permafrost associated with the Pipeline component of Alternative 3A would be the same as discussed under Alternative 2.

3.2.3.3.3 EROSION

The types of erosion impacts and mitigation measures under Alternative 3A are expected to be the same as those described under Alternative 2 for the Mine Site, Transportation Corridor, and Pipeline. While less Transportation Corridor upland soils and riverbank areas would be subject to erosion under Alternative 3A, these areas are small compared to the project as a whole. The intensity of impacts for erosion at remaining project components would be the same as described for Alternative 2, and the extent of impacts would be limited to areas within the immediate vicinity of the remaining component footprints.

3.2.3.3.4 SOIL QUALITY/CONTAMINATED SITES

Contaminated sites conditions, and activities that cause fugitive dust impacts on soil quality, would the same under Alternative 3A as Alternative 2. Thus, direct and indirect effects would be the same as described for Alternative 2.

3.2.3.3.5 SUMMARY OF IMPACTS FOR ALTERNATIVE 3A

Effects at the Mine Site and along the Pipeline from soil disturbance, permafrost degradation, erosion, and fugitive dust deposition under Alternative 3A would be the same as discussed for Alternative 2, as facility footprints and activities that create dust emissions would be essentially the same between alternatives. Impacts associated with climate change would also be the same as those discussed for Alternative 2.

Under Alternative 3A, there would be a small reduction in impacts to Kuskokwim River bank soils at relay points due to less low water travel, a reduction in soil and permafrost disturbance at ports by about 10 to 20 acres (out of a total of about 900 acres for the Transportation Corridor as a whole), and a slight reduction in fugitive dust from less fuel truck traffic on the mine access road. The overall intensity of impacts for Alternative 3A would be the same as described under Alternative 2.

Design features, Standard Permit Conditions and BMPs most important for reducing impacts to soils would be similar to those described for Alternative 2. Examples of additional measures being considered that are applicable to this resource are listed under Alternative 2.

3.2.3.4 ALTERNATIVE 3B – REDUCED DIESEL BARGING: DIESEL

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

- Port MacKenzie Option: The Port MacKenzie Option would utilize the existing Port MacKenzie facility to receive and unload diesel tankers instead of the Tyonek facility considered under Alternative 3B. A pumping station and tank farm of similar size to the Tyonek conceptual design would be provided at Port MacKenzie. A pipeline would extend northwest from Port MacKenzie, route around the Susitna Flats State Game Refuge, cross the Little Susitna and Susitna rivers, and connect with the Alternative 3B alignment at approximately MP 28. In this option, there would be no improvements to the existing Tyonek dock; a pumping station and tank farm would not be constructed near Tyonek; and the pipeline from the Tyonek tank farm considered under Alternative 3B to MP 28 would not be constructed.

- Collocated Natural Gas and Diesel Pipeline Option: The Collocated Natural Gas and Diesel Pipeline Option (Collocated Pipeline Option) would add the 14-inch-diameter natural gas pipeline proposed under Alternative 2 to Alternative 3B. Under this option, the power plant would operate primarily on natural gas instead of diesel as proposed under Alternative 3B. The diesel pipeline would deliver the diesel that would be supplied using river barges under Alternative 2 and because it would not be supplying the power plant, could be reduced to an 8-inch-diameter pipeline. The two pipelines would be constructed in a single trench that would be slightly wider than proposed under either Alternative 2 or Alternative 3B and the work space would be five feet wider. The permanent pipeline ROW would be approximately two feet wider. This option could be configured with either the Tyonek or Port MacKenzie dock options.

3.2.3.4.1 PIPELINE

3.2.3.4.2 SOIL DISTURBANCE/REMOVAL

Mine Site

With the exception of a reduced fuel storage capacity at the Mine Site, soil disturbance activities for Alternative 3B are generally the same as Alternative 2 for construction, operation, and closure. The decreased fuel storage capacity would likely reduce the required fuel storage footprint by roughly 75 percent in comparison to Alternative 2 (from 15 tanks down to four), resulting in roughly 10 acres less fuel storage under Alternative 3B at the Mine Site, although the site lies within the contiguous plant area and may be disturbed for other purposes (e.g., laydown). The reduction in fuel storage footprint under this alternative is small compared to overall soil disturbance areas for the Mine Site as a whole (roughly 9,000 acres).

Transportation Corridor

The area of soil disturbance at the Angyaruaq (Jungjuk) Port site would likely be similar under this alternative to that of Alternative 2, as fuel storage capacity would be needed at this site for the construction period. Thus, the site footprint would be similar to that of Alternative 2.

Expansion of the existing North Foreland Barge Facility dock in Tyonek under Alternative 3B would require soil disturbances during construction of a temporary barge landing adjacent to the dock to support dock extension and pipeline construction. The temporary barge landing area would disturb/compress an area of previously disturbed soils, and localized temporary fill placement may be necessary for barge off-loading. Soils in the barge landing area (mostly intertidal zone) may or may not require revegetation (upland soils are described below under Pipeline). Applicable Corps and ADEC permit stipulations would be followed for any fill placement. The anticipated intensity of effects to soil disturbances from this shoreline component would result in disturbances/fill in area of previously disturbed soils that may or may not be measurable or noticeable, and would add a small amount of soil disturbance to those under the Alternative 2 Transportation Corridor (900 acres).

Pipeline

Soil disturbances for the diesel Pipeline ROW include those described for Alternative 2, plus up to roughly 700 additional acres for the construction ROW from Tyonek to Beluga (Alternative

3B, or Alternative 3B Collocated Natural Gas and Diesel Pipeline Option) or 740 net additional acres for the construction ROW between Port MacKenzie and MP 28 Alternative 3B Port MacKenzie Option), for a total of 12,200 to 12,240 acres for the entire construction ROW under Alternative 3B, depending on the selected option (Table 3.2-10). Cut and fill construction along the Tyonek-Beluga or Port Mackenzie to MP 28 segments would be minimal due to low relief topography in these areas; thus, it is unlikely that the full construction ROW would be disturbed. Soil types in these areas (Figure 3.2-6 and Appendix F) consist primarily of peat, silt loam, loess, glacial till, and alluvium that are common in the lower lying Cook Inlet region of Alaska.

Table 3.2-10: Soil Disturbance Comparisons for Pipeline Alternatives

Soil Disturbance Estimates[1]	Alternative 2 (Proposed Action)	Alternative 3B (Diesel Pipeline and Options)	Alternative 6A (Dalzell Gorge)
Surface Disturbance Length (miles)	316	334	313
Potential Construction ROW Surface Disturbance (acres)[2,3]	11,500	12,200	11,300
Off-ROW Soil Disturbance (acres)	2,600	2,800	4,100
Total ROW + Off-ROW (acres)	14,100	15,000	15,400

Notes:

1. Comparisons are for total Pipeline routes, including alternate segments in Beluga-Tyonek and Port MacKenzie areas and Alaska Range (SRK 2012i, 2013b; Polaris 2014).
2. For maximum 300-foot wide construction ROW.
3. Areas not reduced by undisturbed soils above potential horizontal directional drilling (HDD) segments in Alaska Range. Alternative 6A would include 2.3 miles of HDD through Dalzell Gorge and under Happy River. Alternative 2 (and 3B) may include HDD and/or deep bedrock trenching along Threemile Creek/Jones River portion; length(s) and construction technique(s) to be determined in later design phase (Fueg 2014).

Soil disturbances at off-ROW facilities under either option of Alternative 3B would be roughly 200 acres higher than Alternative 2 to accommodate three additional new Hercules-capable airstrips (at Puntilla, Tatlawiksuk, and George River) required to support potential oil spill response (OSR) activities; as well as an uplands facility near the North Foreland dock consisting of an operations center, fuel storage area, living quarters, OSR warehouse, and access road (Figure 2.3-39) (Polaris 2014). Some cut and fill may be required to construct at least one of the airstrips (George River). Gravel and concrete foundations would be required at the North Forelands tank storage area.

The types of construction used in the additional ROW and off-ROW areas under Alternative 3B would be similar to that of Alternative 2, and would affect relatively small additional areas compared to overall soil disturbances under Alternative 2. Thus, the intensity of effects would be similar to Alternative 2, with reductions achieved through reclamation. The additional soil disturbance impacts under Alternative 3B would be limited to areas within the Pipeline component footprints. The duration of soil disturbances at some off-ROW facilities, such as airstrips and shoofly roads that would remain in usable condition during operations to support spill response needs, would be longer term than under Alternative 2, and beneficial effects of reclamation at these facilities would be delayed until the closure period. Specific infrastructure remaining during operations would be finalized during preparation of the spill response plan.

3.2.3.4.3 PERMAFROST

Anticipated effects on permafrost for the Mine Site, Transportation Corridor, and Pipeline components under Alternative 3B would be the same as those described under Alternative 2. Geotechnical investigations and available information indicate that the area along the additional 19-mile segment of Pipeline from Tyonek to Beluga is free of permafrost (Section 3.2.2.3.2).

Similarly, the diesel Pipeline response to permafrost-related ground deformation is expected to be comparable to that described for the natural gas Pipeline. Like Alternative 2, the temperature of the diesel would be within a few degrees of ambient ground conditions. The pipeline is not expected to freeze surrounding soils, and any thaw settlement would be more attributable to clearing and surface disturbances than product-induced thaw (Michael Baker Jr. 2013a). Thus, thaw settlement estimates would be similar to those described under Alternative 2 (Section 3.2.3.2.2).

3.2.3.4.4 EROSION

The types of erosion impacts and mitigative ESC measures under Alternative 3B for the Mine Site, Transportation Corridor, and Pipeline are expected to be the same as those described under Alternative 2. While a larger soil area would potentially be subject to erosion under Alternative 3B, the intensity levels would be the same, and extent of impacts would be limited to areas within the immediate vicinity of the component footprints.

3.2.3.4.5 SOIL QUALITY/CONTAMINATED SITES

Mine Site

Effects on soil quality from fugitive dust and existing contaminated soils at the Mine Site under Alternative 3B would be the same as Alternative 2.

Transportation Corridor and Diesel Pipeline

Effects on soil quality from mine access road dust under Alternative 3B would be the same as Alternative 2. Impacts from existing contaminated site conditions at or near the transportation and Pipeline facilities are primarily the same as Alternative 2; however, additional conditions exist. Six open contaminated sites are present within about a ¼ mile of the ROW between the existing Tyonek dock and Beluga (Figure 3.2-9 and Appendix F). The nature of contaminants at these sites is related to petroleum hydrocarbons present in soil and/or groundwater. In addition, petroleum-contaminated soils are reported at the FAA Puntilla Lake Station, which may coincide with the Puntilla airstrip for use under Alternative 3B (Polaris 2014).

The contaminated site near the Tyonek dock is listed in the ADEC Contaminated Sites database as partly "open" and partly "cleanup complete." While the site is located about ¼ mile southwest of the dock, depending on the size of the Alternative 3B temporary barge landing site, it is possible that soil disturbances during barge landing could encounter contaminated soils.

Most of the contaminated sites in the Beluga area are unlikely to impact soil conditions along the ROW based on the nature of the releases and general groundwater flow direction. Groundwater in the Beluga area is generally shallow, reported at 13 feet below ground surface, and the local direction of flow is generally to the east, which is opposite of the Pipeline corridor located to the west of most open sites. Of three sites where institutional controls exist in the Beluga area, no offsite migration of contaminants has been reported (ADEC 2013a). However, because one of the open sites is located upgradient of the ROW and three are very close to it, it is possible that soil disturbances during trenching could encounter contaminated soils.

In the event that contaminated soils are encountered at the above sites, the type and level of effects would be similar to those described in Section 3.2.3.2.4 for Dutch Harbor, with responsibility for remediation being that of the landowners/operators. Mitigation recommendations are provided in Chapter 5, Impact Avoidance, Minimization, and Mitigation, for additional investigation at the Tyonek barge landing site, Beluga area ROW, and Puntilla airstrip prior to Pipeline construction to map the specific location of potential contaminated soils compared to final construction plans, so that disturbance of these soils can be avoided if possible, and reduce the likelihood and intensity of impacts.

3.2.3.4.6 SUMMARY OF IMPACTS FOR ALTERNATIVE 3B

Effects at the Mine Site and the Transportation Corridor from soil disturbance, permafrost degradation, erosion, and fugitive dust under Alternative 3B would be the same as discussed for Alternative 2. Impacts associated with climate change would also be the same as those discussed for Alternative 2. The small decrease in fuel storage footprint under Alternative 3B lies within the contiguous plant area, and is likely to be disturbed for other purposes (e.g., laydown). Additionally, the small increase in soil disturbance at the North Foreland port would be in an area of already disturbed soils, and would not change the range of impacts and overall effects from those of Alternative 2. There could be a small increase in contaminated soils encountered during construction near the Tyonek dock, under Alternative 3B or Alternative 3B Collocated Natural Gas and Diesel Pipeline Option.

Up to 900 to 940 additional acres of soil would be disturbed under Alternative 3B associated with the Pipeline due to the increased length of ROW and associated facilities, depending on the selected option. There would be no change in permafrost effects (no permafrost is reported between Beluga and Tyonek or Port MacKenzie and MP 28), and erosion effects would occur and be managed at the same levels of intensity as those under Alternative 2. There could be an increase in contaminated soils encountered during construction in the Beluga-Tyonek area and at Puntilla airstrip.

Design features, Standard Permit Conditions and BMPs most important for reducing impacts to soils would be similar to those described for Alternative 2. Examples of additional measures being considered that are applicable to this resource are listed under Alternative 2.

3.2.3.5 ALTERNATIVE 4 – BIRCH TREE CROSSING (BTC) PORT

3.2.3.5.1 SOIL DISTURBANCE/REMOVAL

Mine Site

Soil disturbance/removal effects for the Mine Site under Alternative 4 would be the same as described under Alternative 2.

Transportation Corridor

Soil disturbance impacts associated with transportation components that are different under Alternative 4 as compared to Alternative 2 are described below.

BTC Mine Access Road and Port: The 73-mile long BTC mine access road would be about 43 miles longer than the mine access road under Alternative 2, or 2.43 times longer. The total estimated area of soil disturbance/removal associated with the road is approximately 900 acres, which is more than three times that of the mine access road under Alternative 2. The BTC Port site would occupy a footprint of about 65 acres, more than twice the size of the Angyaruaq (Jungjuk) Port site under Alternative 2.

Alternative 4 would employ similar port and road construction techniques as those described for Alternative 2, as well as similar maintenance and post-mine disposition. The intensity and extent of impacts would be the same as described under Alternative 2. Gravel fill construction would be used over approximately 75 percent of the alignment, and the remaining 25 percent (roughly 20 miles) would use cut and fill construction methods, which is slightly longer than cut and fill lengths for the mine access road. In most circumstances, fill would range from three to five feet thick, and be placed over a generally thin surface layer of organic mat and peat, which is prevalent along most surfaces of the alignment. Geofabric would be placed along approximately 26.5 miles of the alignment in addition to three miles of geogrid, primarily in permafrost and wetland areas (Section 3.2.3.5.3).

As in Alternative 2, construction at the BTC Port would require disposal of approximately 10,000 cy of dredge materials derived from development of shoreline infrastructure (sheetpile wall and berthing). All dredge materials would be used as reclamation media for material borrow sites. For this reason, no additional soil disturbances are associated with dredged materials.

Effects from operations and closure activities for the BTC mine access road and Port are generally the same as those described for Alternative 2. Approximately 1,200 cy of dredge materials generated annually from berth maintenance activities would continue to be placed in material borrow sites as reclamation material.

Soil map units that would be impacted from construction activities along the BTC mine access road and Port are shown on Figure 3.2-1 and listed in Appendix F. More than 90 percent of areas disturbed by road and port construction would impact map units associated with colluvium and frozen loess along low mountains and glaciated uplands. These soil types are prevalent throughout the Project Area, extending well beyond the alignment corridor. Less prevalent soil types within the construction corridor, include those associated with alluvium in floodplains and terraces.

Temporary Ice Road: Simultaneous construction of the BTC Port mine access road from opposing ends would require the development of a single-season temporary ice road from Crooked Creek village to the Mine Site along Crooked Creek valley for a distance of about 12 miles. Ice roads are commonly used in arctic and sub-arctic environments for overland transport of heavy loads and are intended to minimize physical and thermal impact to underlying vegetation or tundra. Established guidelines exist for ice roads constructed on state and federal lands, and include permitting and planning processes that can involve multiple regulatory agencies and restrict travel to a limited time in late winter.

Impacts to soils from ice road construction could occur through vegetation degradation and runoff, depending on slope angle. Minimal disturbance to surface vegetation can be achieved when using methods following state and federal management practices. Previous studies on the North Slope of Alaska have shown that complete recovery of vegetation is attainable within a 24-year period for a single-season ice road (BLM 2005b). More recent improvements in BMPs that can minimize vegetation and soil impacts include ice road route selection (landscape characteristics), construction methods, equipment operators, and period of use (one season versus consecutive season usage) (ADNR 2010). Based on limited information on permafrost conditions at the BTC Port site, the anticipated levels of effect are expected to range in intensity from changes in permafrost that may not be measurable or noticeable, to changes requiring revegetation, but the design is adequate for the expected range of permafrost hazards.

In general, upland vegetation and soils are more sensitive to ice road construction than wetlands, and impacts generally decrease with increased surface moisture content/saturation (ADNR 2010; BLM 2005). While wet soils are generally more resilient and better suited for ice road construction, increased slope gradients in these conditions can facilitate erosion (Kidd 2010). More than 90 percent of the ice road alignment under Alternative 4 is located within soil map units that represent alluvium and colluvium along floodplains, terraces, and lower slopes of Crooked Creek valley (Figure 3.2-1). Vegetation types associated with these soils (e.g., taiga, scrub, forest) are not ideal with respect to ice road construction impacts. The anticipated intensity of effects may or may not be noticeable. Although the potential for soil degradation exists within discrete portions of the Project Area and through the life of the project, the short single season of use would minimize the duration of surficial impacts.

Kuskokwim River Corridor: The BTC Port site would reduce barge travel distances along the Kuskokwim River by approximately 25 percent in comparison to Alternative 2. In doing so, several critical sections upstream of the BTC Port site (Aniak, Holokuk, Upper Oskawalik), where barges would need to be relayed during low water periods, would be avoided (AMEC 2014). Like Alternative 2, the intensity of soil disturbance effects from relay activities at the Nelson Island critical section below BTC Port site may not be measurable or noticeable from infrequent soil compaction.

Pipeline

Soil disturbance/removal impacts associated with the Pipeline under Alternative 4 would be the same as described under Alternative 2.

3.2.3.5.2 PERMAFROST

Mine Site

Permafrost effects for the Mine Site under Alternative 4 would be the same as described under Alternative 2.

Transportation Corridor

Permafrost impacts associated with transportation components that are different under Alternative 4 as compared to Alternative 2 are described below. Estimates of the amount of permafrost soils that would be impacted under Alternative 4 are provided in Table 3.2-5. The total amount of thawed permafrost soils is estimated to be 30 million tons over the life of the mine, and roughly 62,000 tons/year in Closure (Bethel site only). This is about 23 million tons more than Alternative 2, due mostly to the higher occurrence of permafrost along the BTC road alignment. Evaluation of GHG emissions resulting from permafrost degradation under Alternative 4 is presented in Section 3.8, Air Quality.

BTC Mine Access Road: Permafrost was encountered in about two-thirds of geotechnical borings drilled along the BTC mine access road alignment (Recon 2007b), which extend along roughly 40 to 50 miles of the road corridor, although substantial visible ice is only present in a limited number of borings located in the Owhat River drainage, and intermittently from the east side of Tor Creek to the road terminus at the BTC Port site. Field observations also report thermokarst terrain along this road corridor, which inconsistently coincides with visible ice in soil borings. Prominent thermokarst terrain was observed immediately west of the Iditarod River; and limited segments were observed in the Cala Poco Creek area, west of Cobalt Creek, west of the Lithos Creek floodplain, east of Kaina Creek, at Tor Creek flats, and Aurum Creek flats. Much of the permafrost along the BTC mine access road alignment appears to be associated with thaw stable soil conditions; however, multiple segments of the alignment contain thaw unstable silt. Permafrost conditions in this area are predominantly warm (31° to 32° Fahrenheit) based on studies performed at the Mine Site, adding to the likelihood of thaw degradation when soils are disturbed.

Impacts to permafrost from the BTC mine access road would be similar to those described for the mine access road under Alternative 2, with several notable differences in the intensity and extent of impacts. The intensity of impacts in thaw stable soils would result in changes in soils that may not be measurable or noticeable. In thaw unstable soils and thermokarst terrain, the intensity of impacts would be elevated and may result in acute or obvious changes in the resource character, and thaw settlement during operations and beyond would likely require more frequent maintenance and fill repairs than the mine access road.

The use of geotextile reinforcement along some road segments is expected to be effective in minimizing road surface deformation and embankment sloughing from thaw settlement (e.g., Alfaro et al. 2006) and reduce most effects, although isolated areas requiring multiple fill repairs over time could remain. The extent of unstable soil conditions due to thawing are greater along the BTC mine access road alignment; therefore, the potential for thermal degradation and associated effects are likely to be greater, although impacts would still remain within the immediate vicinity of the road footprint. The duration of impacts would range from subsidence repaired over several years to irreversible impacts, since permafrost degradation is not expected to recover, and the road would remain in perpetuity to support monitoring and water treatment at the Mine Site.

BTC Port Site: Limited geotechnical information is available for the BTC Port site. The closest borings to the port, located about ½ to 1 mile northeast of the port site along the BTC mine access road, encountered both frozen and unfrozen silt, which suggest a range of conditions could be present at the port site, ranging from no permafrost to thaw unstable permafrost. Frozen soils in these borings contain up to 10 percent visible ice. No thermokarst terrain was noted as coinciding with the BTC Port site terminus. These discontinuous permafrost conditions are similar to the Angyaruaq (Jungjuk) Port site under Alternative 2. About one-third of borings at the Angyaruaq (Jungjuk) Port site contain permafrost with substantial visible ice (up to 50 percent) in similar soil types. In addition, active thermokarst and ongoing thaw degradation was observed in the vicinity of the Angyaruaq (Jungjuk) Port site. NRCS soil types that are generally associated with common permafrost are present at both BTC and Angyaruaq (Jungjuk) Port sites.

Based on limited information on permafrost conditions at the BTC Port site, the intensity of impacts would range from changes in permafrost and soils that may or may not be measurable or noticeable, with effects likely to be reduced in intensity through typical planned mitigation in design and construction practices, such as further geotechnical investigation and possible permafrost excavation if needed.

Temporary Ice Road: Although no detailed permafrost studies have been performed along the Crooked Creek temporary ice road alignment, permafrost occurrence and distribution is likely similar to that documented at the Mine Site near Crooked Creek, where discontinuous permafrost is common (Figure 3.2-2). Permafrost thaw from ice road construction (if any) could occur from compaction or degradation of insulative surficial organic materials. North Slope case studies indicate that increases in thaw depth of several inches can occur along ice roads, but with little visible change in existing thermokarst features where slow vegetation recovery exists (Kidd 2010).

Although the potential for permafrost impacts exists from ice road construction, effects may or may not be noticeable if construction methods incorporate State of Alaska (ADNR) and BMPs applicable to the selected route, and no inadvertent scraping of vegetation occurs. Any permafrost degradation from construction is likely to be undifferentiated from naturally occurring processes. Effects are expected to vary in duration, depending on the rate of vegetation recovery.

Pipeline

Permafrost effects for the Mine Site under Alternative 4 would be the same as described under Alternative 2.

3.2.3.5.3 EROSION

Mine Site

Erosion effects for the Mine Site under Alternative 4 would be the same as described under Alternative 2.

Transportation Corridor

Erosion impacts associated with transportation components that are different under Alternative 4 as compared to Alternative 2 are described below.

BTC Mine Access Road and Port: Like the soil types along the mine access road under Alternative 2, erosion ratings for soil types along the BTC mine access road and Port range widely, from slight to severe for both water and wind erosion (Appendix F). Culverts and bridges installed at stream crossings and other drainages along the road are expected to be largely effective in controlling runoff and stream bank impacts that would otherwise lead to erosion. Anticipated erosional effects and construction activities along the BTC mine access road would be similar to those described under Alternative 2, except that there would be longer road sections along slopes requiring cut and fill construction, greater thermal erosion potential, and more major stream crossings requiring bridges under Alternative 4, which would generally require more robust ESC measures, monitoring, and maintenance to manage erosion effects. Potential erosion effects from waste soils generated during berth excavation at the BTC Port site could potentially be less than that of Alternative 2, as these materials are proposed to be used in material site reclamation, as opposed to construction of a waste soil stockpile under Alternative 2.

Like Alternative 2, the intensity of erosion effects for the BTC mine access road and Port under Alternative 4 are expected to be managed through the use of BMPs and ESC design features. Other than bridges and culverts, specific ESC details or stabilization measures have not been specified for the road or road material sites (under either Alternative 2 or 4), but are expected to be addressed in final design as part of SWPPP permitting, and during final reclamation and closure planning.

Temporary Ice Road: As described above (Sections 3.2.3.5.1, Soil Disturbance/Removal and 3.2.3.5.2, Permafrost), ice roads can trigger erosion if vegetation and permafrost degrades, depending on runoff and slope gradient. Soil erosion effects associated with the temporary ice road under Alternative 4 may or may not be noticeable if appropriate management practices are followed and no inadvertent scraping of vegetation occurs. The extent or scope of effects would be limited to areas within the immediate vicinity of the ice road corridor. The duration would range from impacts lasting not longer than the span of the project construction, to impacts lasting through the life of the project, depending on the rate of vegetation recovery.

Pipeline

Erosion effects for the Pipeline under Alternative 4 would be the same as discussed under Alternative 2.

3.2.3.5.4 SOIL QUALITY/CONTAMINATED SITES

Mine Site

Soil quality and contaminated sites impacts for the Mine Site under Alternative 4 would be the same as described under Alternative 2.

Transportation Corridor

No documented contaminated sites exist in the vicinity of the BTC mine access road alignment or the Village of Crooked Creek. There would be about 10 fewer contaminated sites located along the Kuskokwim River as a result of the shorter transportation corridor under Alternative 4 (Figure 3.2-4). There would be less potential for small indirect effects from wave-induced shoreline erosion on contaminated sites.

The effects of dust on soil quality along the BTC mine access road are expected to be similar to those described for Alternative 2. While the analysis of dust impacts under Alternative 2 is based on rock samples collected along the mine access road (Section 3.2.3.2.4 and Figure 3.2-1), effects are expected to be similar along the BTC mine access road as the area of greatest concern would be borrow sites in the eastern part of the BTC mine access road corridor shared by the mine access road corridor, where rock types are most similar to mineralized bedrock at the mine (Cretaceous sedimentary rock). Additional evaluation to confirm metals concentrations at material sites along the BTC mine access road would be completed in final design (Chapter 5, Impact Avoidance, Minimization, and Mitigation).

<u>Pipeline</u>

Soil quality and contaminated sites impacts for the Mine Site under Alternative 4 would be the same as described under Alternative 2.

3.2.3.5.5 SUMMARY OF IMPACTS FOR ALTERNATIVE 4

Effects at the Mine Site and for the Pipeline component from soil disturbance, permafrost degradation, erosion, and fugitive dust under Alternative 4 would be the same as discussed for Alternative 2.

For the Transportation Corridor under Alternative 4, the extent of soils and permafrost that would be irreversibly altered (thawed, total removal, buried by fill, thaw settlement) would cover about 40 more miles of road length and 39 more acres of port site, resulting in about 23 million cy more permafrost soils thawed than under the proposed action. While most impacts would be such that the thermal regime is maintained with site-specific design, there could be acute or obvious changes with permafrost disturbance resulting in settlement requiring substantial fill for successful rehabilitation, in thermokarst areas along the BTC mine access road that could require repeated fill repairs over time. In addition, there could be low to medium intensity soil compaction and permafrost degradation effects (i.e., may or may not be noticeable) beneath 12 miles of ice road that would not occur under Alternative 2. Direct erosion effects would be managed at the same levels of intensity (due to SWPPPs and BMPs) as those under Alternative 2, although erosion at the BTC Port site could be of lower intensity due to reuse of berth construction soils in material site reclamation. There would be less disturbance of riverbank soils due to fewer relay points along the Kuskokwim River under Alternative 4, and less potential for indirect effects from shoreline erosion on contaminated sites. Road dust effects on soil quality along the road would be similar to Alternative 2, as material site concentrations are expected to be similar to baseline. Impacts associated with climate change would be the same as those discussed for Alternative 2.

Design features, Standard Permit Conditions and BMPs most important for reducing impacts to soils would be similar to those described for Alternative 2. Examples of additional measures being considered that are applicable to this resource are listed under Alternative 2.

3.2.3.6 ALTERNATIVE 5A – DRY STACK TAILINGS

This alternative includes two options:

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

3.2.3.6.1 SOIL DISTURBANCE

Mine Site

Disturbances to soil under the dry stack tailing alternative (for both lined and unlined options) are slightly greater than those for Alternative 2; however, they are not considered to be drastically different. The overall soil disturbance footprint from the dry stack tailings alternative (either lined or unlined) in the Anaconda Valley is approximately 2,461 acres, as compared to the Alternative 2 TSF that would impact 2,384 acres, or an increase of 77 acres (BGC 2014a).

Minor variations in soil disturbance quantities include additional areas associated with infrastructure requirements, and overburden stockpile acreage. An additional eight acres would be required to accommodate a filter plant for tailings processing. Although an additional eight acres would be disturbed from this infrastructure, the rock generated from construction activities would be appropriated for dam construction. Overburden stockpiles generated under this alternative would generate a slightly larger total overburden stockpile footprint. Alternative 5A is anticipated to result in a slightly increased stockpile footprint of 45 acres, or a 12 percent increase from Alternative 2. Stockpiles would be similarly located, designed, and managed as those described under Alternative 2 (BGC 2014a).

More notable soil disturbance deviations from Alternative 2 would occur during the closure and reclamation phase of the operating pond, which represents approximately 40 percent of the TSF area under this alternative. The operating pond would be similarly constructed as the TSF impoundment under the proposed action. Unlike the proposed action, however, the operating pond water and liner would be removed once all off-spec tailings are pumped to the open pit, and the main dam and downstream face of the upper tailings dam regraded to 3H:1V slopes. Although soils would be disturbed during operating pond construction, with the exception of the reclaimed main dam, post-reclamation topography under the pond would more closely resemble pre-development landforms. The dry stack landform remaining in the post-Closure period under Alternative 5A would be situated higher in the valley and reach a higher final elevation (950 feet) than the remaining landform under Alternative 2 (830 feet), which would cover the entire TSF footprint.

Under this alternative, tailings would be dewatered to produce a filter cake that is trucked, spread, and compacted in controlled lifts on the drystack. Reclamation of the dry stack would include grading to establish positive drainage and an LLDPE liner incorporated into the closure cover (BGC 2015d, 2015e). Like Alternative 2, reclamation of the dams would include placement of overburden and slope flattening.

While BGC (2014a) does not detail how the ground surface beneath the operating pond would be reclaimed after liner removal, it is assumed that the same methodology used for the dams and other reclaimed soil surfaces would be employed (Section 3.2.3.2.1).

Since disturbed soil acreages under this alternative are comparable to the proposed action, the same effects on soil are anticipated. Although the reclaimed operating pond landscape would more similarly resemble the pre-construction landscape, surface soils would still have to be stripped to accommodate operating pond construction and would result in irreversible alteration of soils. For this reason, there would be minimal soil disturbance differences between Alternative 5A and Alternative 2.

Transportation Corridor and Pipeline

Soil disturbance/removal impacts associated with the Transportation Corridor and natural gas Pipeline components of Alternative 5A would be the same as described under Alternative 2.

3.2.3.6.2 PERMAFROST

Mine Site

Disturbances to permafrost during construction of the TSF would be similar to the proposed action with minor exceptions. Although the dry stack impoundment area may not require installation of a liner, excavation of ice-rich overburden would be required to prevent excessive thaw-induced slope deformation (BGC 2014a). The quantities of stripped thaw unstable, ice-rich overburden removed during construction of the operating pond and dry stack impoundment areas would be similar to the proposed action, based on similar acreages of disturbance. The volume of ice-rich overburden excavated to bedrock beneath the upper and main dams, however, could be greater under this alternative, due to the larger combined dam footprints.

Thermal property variations between Alternative 2 and Alternative 5A tailings could result in less permafrost degradation during initial operation of the dry stack impoundment. Although both alternatives will produce tailings comparable to a silt material, the dry stack tailings are expected to have a lower heat capacity and potentially lower thermal conductivity than slurried tailings. This rationale is based on the lower moisture content associated with the dry stack tailings (i.e., filter cake). At a minimum, tailings under both Alternatives will be elevated above freezing temperatures to facilitate conveyance and placement under either TSF Alternative. Since the dry stack tailings are less likely to result in heat transference, it is possible that less permafrost degradation could result during initial operation of the impoundment in comparison to Alternative 2. However, diminished permafrost degradation during operation could be minimal based on other significant conditions common with Alternative 2. Common conditions would include bedding material placement (lift) over cleared substrates; progressive increase of overburden pressures, and installation of modified underdrains and/or water flux management from the TSF base.

Any variations of physical characteristics between Alternative 5A and Alternative 2 tailings would diminish with progressive TSF expansion. Tailings under Alternative 2 would become less saturated at depth (TSF base) due to consolidation from overburden pressure and porewater expulsion. Tailings under Alternative 5A (unlined) are likely to become more saturated at depth (TSF base) from sidewall (i.e., unlined) and/or or surface infiltration (i.e., lined and unlined) resulting in internal water mounding. These progressive changes during TSF operation and eventual closure would reduce any thermal variability between dry stack and slurried tailings and resulting permafrost losses. The tailings under either Alternative would become physically comparable following post closure.

Although a reduced permafrost degradation could potentially exist during the initial stages of dry stack impoundment operation, the overall impacts to permafrost would likely be comparable to Alternative 2 due to greater permafrost disturbances during construction of the dam footprints; common basal design features with Alternative 2, and diminished variation in physical characteristics of tailings throughout operation and closure of the TSF under either

Alternative. The duration of eventual disturbances to permafrost under this alternative are also expected to be similar to those described for the proposed action.

While the total amount of permafrost thaw is expected to be similar under Alternatives 2 and 5A, the amount of thawed permafrost leading to GHG emissions could be different under the different liner scenarios, as the liner may trap emissions and keep them from being released to the atmosphere. The total amount of thawed permafrost soils emitting GHGs is estimated to be about 150 million tons under the Alternative 5A-Lined Option, about 20 million tons greater than Alternative 2 due to removal of the operating pond liner in Closure; and a total of about 170 million tons under the Unlined Option, about 40 million tons greater than Alternative 2 due to lack of a liner under the dry stack. Estimates of GHG emissions from thawed permafrost are presented under Section 3.8, Air Quality.

Transportation Corridor and Pipeline

Permafrost effects for the transportation and natural gas Pipeline components under Alternative 5A would be the same as described under Alternative 2.

3.2.3.6.3 EROSION

Mine Site

Construction

Erosion during the construction phase would be mostly similar between Alternatives 2 and 5A (both options) based on the following:

- The TSF is located in the Anaconda Valley in generally the same footprint and acreage as the proposed action.
- Similarly timed seasonal construction stages will incorporate a variety of similar construction methodologies and design features as the proposed action. This would include water management practices that incorporate fresh and contact water diversion channels, and overburden stockpile design and management.
- Removal of ice-rich overburden would be required to prevent thaw-induced slope deformation and related erosion throughout most of the operating pond and dry stack footprint.
- Erosional processes and mechanisms would be the same as Alternative 2 (i.e., hydraulic and wind); however, these processes could result in different erosional outcomes based on physical property differences at the time of tailings deposition (dry versus slurried). At a minimum, plans and programs related to control and mitigation of erosion at the Mine Site throughout construction to closure activities would also be the same as Alternative 2.
- Existing soil types and corresponding erosional susceptibilities would also be the same as the proposed action since both alternatives generally share the same TSF footprint.

Operations

Notable differences during operations that could result in different erosion effects between Alternatives 2 and 5A include the following:

- Unlike the proposed action where the entire TSF would be lined, the lack of a liner beneath the dry stack could conceivably result in increased suspended sediment in subsurface flow. It is estimated that collection of TSF-affected water at the end of operations and throughout closure would be 53 percent higher than the proposed action. However, the dam filter zones and geotextile wrapping around underdrains are expected to keep sediment from moving downgradient.
- Overburden generated from TSF construction would result in a 12 percent increase in overburden stockpile volume (45 acres) compared to the proposed action. The increased volume would increase the potential for erosion; however, similar design and erosion mitigation features would likely result in no appreciable erosional differences.
- Hydraulic and wind erosion at the TSF (dry stack) would be more prevalent during the operational period under Alternative 5A in comparison to the proposed action. This is largely attributed to an increase in the amount of sloped topography, increased dry stack surface area exposed to erosional processes, and limited opportunity for progressive reclamation during operation. Exposed surfaces subjected to erosional processes would range from 220 acres after the first year of construction to 1,500 acres at the end of mine operation, which represent an increase of 47- to 60-percent above the area of the exposed tailings beach under Alternative 2.
- A variety of measures would be implemented to mitigate dry stack erosional processes:
  - Dewatering of tailings to within three percent of the optimum moisture content prior to placement to facilitate compaction to a minimum of 90 percent maximum dry density in one foot lifts;
  - Freshwater diversion channels constructed around the perimeter of the dry stack in three separate phases as the elevation progressively increases with continued tailings deposition. Diversion channels would be constructed to minimize erosion and improve surface flow efficiency;
  - Grading and sloping of dry stack surfaces to the south to minimize surface infiltration. Sloped dry stack surfaces would direct contact water to a water collection channel located on the south face of the dry stack, and eventually discharge to the operating pond;
  - Silt fencing along inactive dry stack surfaces to reduce hydraulic and wind driven erosional processes;
  - Management of snow clearing practices during winter months to minimize exposed dry stack surfaces; and
  - Aerial application of polymer dust suppression and soil stabilizer solutions on the entire dry stack surface for every three foot rise in tailings deposition. Although no specific polymer has been selected for use, a potential equivalent includes Entac Dust Control and Soil Stabilizer Solution by KBM Resources© for comparative purposes. The polymer is an organic, tall oil pitch emulsion that is a non-toxic, non-

corrosive, non-water soluble compound used for a variety of dust control and surface stabilization applications. During periods of high wind conditions, however, erosion could occur during tailings placement between polymer applications. Additional discussion of fugitive dust issues is presented in Section 3.2.3.2.4.

- In general, the above ESCs and BMPs are more complex than erosion control required under Alternative 2, and may be more difficult to manage during periods of high winds or rainfall.

- Potential dry stack instability during operations could cause related erosion concerns. Conditions that could result in instability include inadequate tailings dewatering, unsuitable compaction of tailings, and variable moisture contents within the dry stack. Deposition of tailings during winter months would include frozen lifts of material that may result in inadequate compaction, or increased pore pressure and subsequent liquefaction potential when thawed. Furthermore, mounding of groundwater within the dry stack is expected, some of which could occur as small individual perched water layers between lifts. Water table mounding is expected to have a limited effect on dry stack stability, however, due to bottom-up construction in controlled lifts (BGC 2014a). Additional discussion regarding dry stack instability issues is presented in Section 3.3, Geohazards and Seismic Conditions.

Closure

Erosion associated with closure of the dry stack could be less than the proposed action for the following reasons:

- Both alternatives would require a closure cover area of approximately 2,500 acres; however, the dry stack would support vehicle traffic upon completion for cover placement.
- The dry stack alternative is estimated to require approximately one-sixth the earthwork effort of the proposed action in a much shorter time period. Comparatively reduced material handling and expedited closure proceedings would result in a diminished erosion potential.

Restoration measures under Alternative 5A that are similar to Alternative 2 include the following:

- Completed surfaces would eventually direct surface runoff via a spillway to Crevice Creek after Year 10 of closure.
- Surface runoff during the reclamation process (five years), and for an additional five years thereafter, would be directed to a new SRS established downstream of the upper dam, and eventually to the open pit.

Reclamation of the dry stack would include an LLDPE liner incorporated into the closure cover to provide for minimum potential infiltration into the dry stack. The LLDPE has a saturated hydraulic conductivity of 3.0×10^{-13} cm/s (BGC 2015d, 2015e). While this is potentially more protective of the environment because of reduced seepage flow (discussed in Section 3.3, Geohazards), placement of a protective layer of soil on top of the cover could result in more erosion control issues than that of the engineered soil cover for the TSF under Alternative 2.

It is also possible that increased activity involved in removing the operating pond would increase erosion. After water and off-spec tailings from the operating pond are pumped to the open pit, the liner would be removed, and the main dam and downstream face of the upper dam regraded to 3H:1V slopes. An interim sediment pond may be required to address suspended sediment issues during vegetation establishment on reclaimed surfaces.

Summary of Mine Site Impacts

Comparison of erosional impacts between Alternative 5A and the proposed action indicates similar conditions during the construction phase; increased erosion potential during the operational phase; and both reduced and increased erosion potential during closure at the dry stack and operating pond, respectively. Although some effects would likely offset each other, erosional increases inherent to the operational phase from the large exposed dry stack surface area, together with the general increased complexity of earthwork activities at the TSF under Alternative 5A, are anticipated to result in a net increase in the intensity of erosion effects.

The intensity of effects in most areas of the Mine Site would be the same as described for Alternative 2 if uncontrolled, with BMPs expected to result in most effects being reduced in intensity. However, because the size of the dry stack is unprecedented, there would be an increased difficulty in controlling wind erosion in particular, potentially resulting in intermittent acute or obvious effects (i.e., effects in which planned BMPs and ESC measures are unsuccessful). The duration of effects would range from lasting not longer than the span of the project construction phase, to lasting through the life of the project (e.g., intermittent wind erosion from the dry stack could continue over years, but effects would be shorter in closure due to more favorable conditions resulting in less earthwork). Extent or scope of erosion effects would be limited to discrete portions of the Project Area, assuming planned dust control mitigation measures are effective in limiting dust dispersion. However due to the higher position of the dry stack relative to surrounding topography, wind erosion would likely be greater under Alternative 5A than Alternative 2.

Transportation Corridor and Natural Gas Pipeline

Erosion effects for the Transportation Corridor and natural gas Pipeline components under Alternative 5A would be the same as described under Alternative 2.

3.2.3.6.4 SOIL QUALITY/CONTAMINATED SITES

Mine Site

Soil quality impacts under Alternative 5A are comparable to those of Alternative 2, with the exception of fugitive dust. It is anticipated that tailings under Alternative 5A (both options) would exhibit the same chemical constituents of concern in fugitive dust as those described for the proposed action (Section 3.2.3.2.4 and Table 3.2-9). There would be limited addition of reagents to the filtration process stream, primarily a flocculant used during the thickening process (BGC 2014a). The flocculant, known by the trade name Entac, is a tall oil pitch emulsion which is a by-product of pine tree pulping. Entac is non-lethal to aquatic organisms, naturally decomposes over a period of months, and is not expected to impact soil quality (Rieser 2015b).

Due to the quantity and nature of exposed tailings surfaces under this alternative, a greater potential for fugitive dust generation and dispersion is anticipated than under Alternative 2.

Exposed surfaces (tailings) after the first year of operation for the dry stack alternative and the proposed action (TSF tailings beach) are 220 acres and 150 acres, respectively. Corresponding exposed surfaces for the dry stack alternative and the proposed action at the end of mine operation are 1,500 acres and 940 acres, respectively, a 60 percent increase for this facility under Alternative 5A. It is estimated that the increase in surface area and material handling under Alternative 5A would cause a 6.6 percent increase in total fugitive dust emissions at the Mine Site over that of Alternative 2 (Rieser 2015b). This percent increase is less than the increase in surface area at the TSF, because other major sources of dust would not change under this alternative (e.g., pit).

Processed filter cake will have a reduced moisture content of 19.7 percent by mass (%m) to accommodate planned deposition and compaction practices (BGC 2014a). The reduced moisture content could potentially increase fugitive dust mobilization from wind in comparison to slurried tailings under the proposed action. Activities associated with the immediate transport and placement of dewatered tailings by heavy equipment are not likely to generate appreciable quantities of fugitive dust since placed materials exhibit some stickiness (cohesiveness) at 20% moisture (BGC 2014a). However, surfaces exposed for prolonged periods between successive lifts would be most susceptible to disturbances by heavy equipment and atmospheric conditions (i.e., desiccation, wind). These surfaces are most likely to result in fugitive dust generation during the operational period. Little if any fugitive dust is anticipated following TSF closure since exposed surfaces would be capped and reclaimed as described in Section 3.2.3.2.4. Variables that are likely to influence fugitive dust generation during mine operation include operational controls and mitigation measures, seasonal weather conditions (i.e., temperature, humidity, wind, precipitation), and concurrent reclamation activities (to the extent practicable).

Fugitive dust mitigation is anticipated throughout the TSF operational period. Fugitive dust effects are anticipated to be most intense during dry summer conditions (May to October), and least intense during April and winter months due to wet or frozen conditions. Potential mitigation measures to minimize fugitive dusts include wind breaks, snow removal activities, dust suppression, and to a lesser extent concurrent reclamation. Silt fence windbreaks along inactive dry stack surfaces would reduce erosion by hydraulic and wind driven processes. Snow clearing practices during winter months would be limited to active areas to minimize exposed dry stack surfaces. Most important, however, would be the application of polymer dust suppression and soil stabilizer solutions on dry stack surfaces. Polymers would be aerially distributed over dry stack tailings surfaces following every 3-foot lift (BGC 2014a). Concurrent reclamation would reduce exposed dry stack surfaces and fugitive dust mobilization; however, this would be limited to the south- and west-facing slopes as the tailings raises advance.

While fugitive dust dispersion modeling has not been conducted for this alternative, transport mechanisms and metals concentrations are expected to be similar to those described for the proposed action. The concentration and extent of fugitive dust dispersion and deposition could be measurably greater than the proposed action, and could include an increase in the concentration and dispersion to the closest points of compliance in prevailing wind directions (Section 3.2.3.2.4), although the increase is expected to be relatively small in the context of other major sources of fugitive dust that would not change under this alternative. Additional discussion of impacts to air quality is discussed in Section 3.8, Air Quality.

Despite the potential for increased deposition (mass and extent) of fugitive dust in soils over the life of the mine, concentrations of mercury are likely to be below ADEC soil standards protective of direct contact and inhalation pathways for human health (see Section 3.12, Wildlife, for effects on biota). This is based on low levels expected in ore and tailings samples and corresponding ADEC soil standards (one to two orders of magnitude). For these reasons, mercury would continue to have effects under this alternative. The lateral extent of mercury deposition under this alternative is likely to be similar to that of the proposed action (Figure 3.8-5 in Section 3.8, Air Quality), as dust emissions would be dominated by other major sources that would not change under this alternative.

At a minimum, concentrations of arsenic in soil from dust deposition would be similar to the proposed action, predicted to be about a one to five percent increase in soil concentration over the mine life. Compared to Alternative 2, arsenic could be slightly greater in concentration and extent outside the footprint of the dry stack based on assumed fugitive dust scenarios associated with this alternative, which predict about a 6.6 percent increase in dust compared to Alternative 2. Like Alternative 2, while the added arsenic in soils from dust falling outside of the footprint of the dry stack are likely to exceed both baseline and ADEC levels over the mine life and would remain in soils beyond closure, the intensity of potential health effects may not be perceptible (Section 3.22, Human Health).

Summary of Mine Site Impacts

Similar to Alternative 2, the intensity of impacts to soil would include arsenic-bearing dust deposition resulting in small increases in soil concentration above a naturally high baseline. Like Alternative 2, the extent or scope of effects is expected to extend from nearby watersheds within Mine Site property boundaries to as far as 10 miles away. A slightly broader distribution of soil impacts is possible under this alternative due to a small increase in the amount of dust (6.6 percent more than Alternative 2) due to lower moisture content, heavy equipment use, and higher terrain (greater wind exposure) at the dry stack. Incremental effects compared to the proposed action would be small; however, as dust emissions at the Mine Site are dominated by major sources other than the dry stack (e.g. pit) that do not change under this alternative. Soil impacts would be irreversible, potentially accumulating and persisting over the life of the mine and beyond closure. Planned mitigation measures for the dry stack could be partially effective in controlling these effects.

Transportation Corridor and Pipeline

Soil quality and contaminated sites impacts for the Transportation Corridor and the natural gas Pipeline under Alternative 5A would be the same as described under Alternative 2.

3.2.3.6.5 SUMMARY OF IMPACTS FOR ALTERNATIVE 5A

Under Alternative 5A (lined or unlined), there would be a slightly greater area of soil disturbance (about 85 acres more than Alternative 2 for TSF and filter plant) and permafrost removal beneath dams (due to their larger combined footprints under Alternative 5A); however, the increases in permafrost removal could potentially be off-set by thermal properties of the dry stack tailings. The amount of thawed permafrost soils emitting GHGs is estimated to be greater under Alternative 5A than Alternative 2 due to removal of the operating pond liner in Closure (both options) and lack of a liner under the dry stack (Unlined Option only).

There would likely be an increase in the intensity of erosion effects due to increased surface area (up to 60 percent more than Alternative 2) exposed to wind and water erosion, and complexity of ESCs and BMPs at the dry stack. The increase in stockpile surface area (12 percent) is expected to be manageable with BMPs similar to Alternative 2. Similar to Alternative 2, irreversible impacts to soil from dust deposition would involve arsenic-bearing dust deposition resulting in small increases in soil concentration exceeding naturally high baseline levels, although a slightly broader distribution of impacts is possible under Alternative 5A due to a small increase in the amount of dust for the Mine Site as a whole (6.6 percent more than Alternative 2). Impacts associated with climate change would be the same as those discussed for Alternative 2. Planned mitigation measures regarding dust control are provided in Chapter 5, Impact Avoidance, Minimization, and Mitigation.

Effects on the Transportation Corridor and along the Pipeline from soil disturbance, permafrost degradation, erosion, dust deposition, and contaminated sites under Alternative 5A would be the same as discussed for Alternative 2.

Design features, Standard Permit Conditions and BMPs most important for reducing impacts to soils would be similar to those described for Alternative 2. Examples of additional measures being considered that are applicable to this resource are listed under Alternative 2

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

3.2.3.7.1 SOIL DISTURBANCE/REMOVAL

Mine Site and Transportation Corridor

Soil disturbance/removal impacts associated with the Mine Site and Transportation Corridor under Alternative 6A are the same as those described under Alternative 2.

Pipeline

Differences in soil disturbance impacts under Alternative 6A, compared to Alternative 2, are primarily based on comparative estimates of the footprint areas required for construction (Table 3.2-11). The total Pipeline length of the Dalzell Gorge route is very similar to Alternative 2, being approximately two miles shorter. However, the Dalzell Gorge route has a greater estimated area of off-ROW surface disturbance (e.g., airstrips, access roads), resulting in a total of roughly 1,300 acres or nine percent more surface disturbance for both ROW and off-ROW areas combined.

The Dalzell Gorge is more likely to require the use of the full construction ROW width due to a greater proportion of steep unstable slopes than Alternative 2 (discussed in Section 3.3, Geohazards and Seismic Conditions). The amount of ROW soils that would remain undisturbed in the Alaska Range due to the use of HDD techniques is expected to be roughly similar between Alternative 2 and 6A. Alternative 6A would include 2-mile HDD through Dalzell Gorge and 0.3 mile HDD under Happy River (SRK 2012i). Alternative 2 may include HDD and/or deep bedrock trenching along the Threemile Creek/Jones River portion, the lengths of which would be determined in later design phase (Fueg 2014).

Because the increased amount of acreage under Alternative 6A is relatively small compared to total area of surface disturbance (about 15,400 acres), and because the types of construction activities would be similar for both alternatives, the levels of intensity would be the same as Alternative 2.

The duration of effects on soil disturbance could be slightly longer under Alternative 6A compared to Alternative 2, as the construction schedule for Alternative 6A calls for an additional winter season beyond the two proposed under Alternative 2 (SRK 2012i, 2013b). However, this would not change the assessment of the duration of impacts from that of Alternative 2.

Only one additional soil map unit is exclusive to the Alternative 6A route in comparison to Alternative 2. Soil map unit E28MT5 (Interior Alaska Mountains), associated mostly with loess over gravelly colluvium and debris flow deposits, extends outside the Pipeline corridor and is present throughout the Alaska Range (USDA-NRCS 2013). The remainder of soil types crossed by Alternative 6A is the same as those along the Alternative 2 route through the Alaska Range (Figure 3.2-7). The context of impacts would be the same as described under Alternative 2.

3.2.3.7.2 PERMAFROST

Mine Site and Transportation Corridor

Permafrost impacts associated with the Mine Site and Transportation Corridor under Alternative 6A are the same as those described under Alternative 2.

Pipeline

Permafrost appears to affect about a 10-mile longer length of the Pipeline under Alternative 6A than Alternative 2. Most of the additional permafrost length under Alternative 6A is considered stable permafrost. The length of unstable permafrost, and number of transitions between unstable permafrost and either stable or non-permafrost soils, are estimated to be slightly more for Alternative 6A than Alternative 2 (Table 3.2-11). The amount of thawed permafrost soils would be roughly 12 million tons greater than Alternative 2. Estimates of GHG emissions from this source are presented in Section 3.8, Air Quality.

Table 3.2-11: Permafrost Comparisons for Pipeline Alternatives

Permafrost Estimates	Alternatives 2 and 3B (Proposed Action and Diesel Pipeline)	Alternative 6A (Dalzell Gorge)
Overall Route Comparisons		
Total Permafrost (miles)	31	41
Thaw Stable Permafrost (miles)	19	28
Thaw Unstable Permafrost (miles)	12	13
Number of Unstable Permafrost Transitions	258	264
Amount permafrost soils thawed (million tons)	37	49
Thaw Settlement Comparisons, Alaska Range		
Predicted Thaw Settlement at Ground Surface (feet)	0 - 21.1	0 - 6.8
Predicted Thaw Settlement Below Pipe (feet)	0 - 20	0 - 6.7
Number of Borings Used in Modeling	93	37

Table 3.2-11: Permafrost Comparisons for Pipeline Alternatives

Permafrost Estimates	Alternatives 2 and 3B (Proposed Action and Diesel Pipeline)	Alternative 6A (Dalzell Gorge)
Stream Crossing Comparisons		
Number of Crossings in Permafrost Terrain	82	68
Number of Crossings in Permafrost with Erodible Soil Types	31	23
Number of Crossings with Permafrost/Erodible Soils and Potential Fish Habitat	21	16
Number of Crossings with Permafrost/Erodible Soils and Confirmed Fish Presence	8	7

Sources: BGC (2013c); CH2MHill (2011b); Fueg (2014); SRK (2012i, 2013b); Zarling (2011); Appendix F.

Thaw settlement over the life of the project, however, is estimated to be less for the Alaska Range section of Alternative 6A than that of Alternative 2, predicted to reach a maximum of 6.8 feet at the ground surface under Alternative 6A (CH2MHill 2011b; Zarling 2011) compared to a maximum of 21.1 feet under Alternative 2 (Donlin Gold 2014c). Permafrost differences between the two alternatives are based on assessments of varying data quantities, methods, and confidence. Permafrost estimates along the Alternative 2 Alaska Range segment are based on many more borings (93) than the Alternative 6A Alaska Range segment (37), and updated thaw modeling was conducted for Alternative 2 borings that has not been performed on the Alternative 6A borings. In addition, many of the Alternative 2 Alaska Range borings specifically targeted ice-rich areas to further evaluate pipeline design parameters and areas requiring special design. Based on general terrain conditions between the Alaska Range segments of the two alternatives, it is likely that if similar drilling and modeling programs were conducted in the Alaska Range section of Alternative 6A, similar thaw settlement results would be identified.

The number of stream crossings that occur in permafrost terrain was compared between Alternatives 2 and 6A (Appendix F and Table 3.2-11) in an effort to identify potential impacts from thermal erosion triggered by pipeline construction on sensitive waterbodies. There are fewer pipeline stream crossings in permafrost terrain with erodible soil types under Alternative 6A than under Alternative 2 (Table 3.2-11), although the number of crossings with confirmed fish presence is roughly the same between the two alternatives (Section 3.13, Fish and Aquatic Resources).

3.2.3.7.3 EROSION

Mine Site and Transportation Corridor

Erosion impacts pertaining to the Mine Site and Transportation Corridor under Alternative 6A are the same as those described under Alternative 2.

Pipeline

A relative comparison of soil type prevalence and corresponding USDA soil erosion values along the Alaska Range portions of Alternatives 2 and 6A is presented in Table 3.2-12. Ranges of values for erosion factor K_w (K-factor), soil loss tolerance (T) Factor, and WEG are provided for major soil components within each map unit. Higher K-factors indicate a greater susceptibility to particle erosion and runoff. Greater T-factor values generally correspond with soils that can tolerate more soil loss in terms of vegetation productivity. Higher values generally indicate deeper, more erosion-resistant soils; and lower values indicate thinner, more erosion-susceptible soils. Greater WEG values are less susceptible to wind erosion, whereas lesser values are more susceptible to erosion.

Table 3.2-12: Soil Erosion Comparison for Pipeline Alternatives in Alaska Range

Soil Map Unit	Alternative 2 (miles)	Alternative 6A (miles)	K-Factor (unitless)[1,2]	T-Factor (tons/acre)[2,3]	WEG[2,4]
E28MT5	0	2.3	0.20-0.43	3 to 5	2 to 5
E23M5	11.2	13.1	0.24-0.37	2 to 3	1 to 6
E28GV	16.1	9.8	0.43	1 to 3	2 to 5
E28GP2	5.7	5.4	0.37-0.43	1 to 3	2 to 8
E28FP1	3.1	2.1	0.02-0.32	1 to 3	7 to 8
E28V	9.4	12.8	0.37-0.43	1 to 2	2 to 8
E23M7	0.3	0	na	na	na
E28RC	0.5	0	na	na	na
Total Miles	46.1	45.4			

Notes:

1 Maximum Kw for shallow soils up to 18 inches deep, unitless; higher numbers = more erosion susceptible.
2 Range of values given for major components of soil map unit.
3 Soil loss tolerance; lower numbers = soils less tolerant of erosion; higher numbers = soils more tolerant of erosion.
4 Dimensionless number representing resistance to soil blowing in cultivated areas; lower numbers = less resistant to erosion; higher numbers = more resistant to erosion.

Abbreviations:

na = not applicable (e.g., outcrops, rubble, glacier)
K-Factor = erosion factor $K_{w(max)}$
T-Factor = soil loss tolerance
WEG = wind erodibility group

Source: USDA-NRCS 2011, 2013

While notable differences in route lengths exist for the different soil types, the USDA K- and T-factor values are generally comparable between soil types. The route lengths having the highest K-factor values for particle erodibility (units E28MT5, E28GV, E28GP2, E28V) are roughly similar between Alternative 2 (31.2 miles) and Alternative 6A (30.3 miles). The two soil types with the highest range of soil loss tolerance are more prevalent along Alternative 6A (E28MT5 and E23M5), which has an additional 4.2 miles of these two soil types combined in comparison to Alternative 2. Conversely, Alternative 6A has approximately 3.4 additional miles of the least tolerant soil type (E28V).

Differences in route length also exist for different WEG values. Alternative 2 has an additional 1.0 mile of the least susceptible soil to wind erosion (E28FP1), and Alternative 6A has an additional 1.9 miles of soil with the lowest WEG value that is potentially the most susceptible to wind erosion (E23M5). Thus, Alternative 6A appears slightly more susceptible to wind erosion.

Other indicators of erosion susceptibility warrant consideration, including total area of surface disturbance and permafrost prevalence. As described in this section under Soil Disturbance/Removal, Alternative 6A would have a larger overall area of surface disturbance;

therefore, erosion effects could be considered proportionally greater, and could represent greater post-construction restoration challenges and uncertainty associated with surface restoration success. The potential for thermal erosion of frozen soils is also potentially greater along Alternative 6A due to more prevalent thaw unstable permafrost; however, the location of these soils in relation to sensitive receptors at stream crossings is similar (Table 3.2-11).

The ESC measures and BMPs employed for the Dalzell Gorge route would be the same as under Alternative 2. Like Alternative 2, the intensity of erosion effects under Alternative 6 are anticipated to be mostly managed effectively through ESC measures, with isolated occurrences of acute or obvious erosion that would likely be reduced in intensity within a short period of time due to planned redundancies in ESC measures, reclamation / cleanup crew functions, and monitoring / maintenance activities.

3.2.3.7.4 SOIL QUALITY/CONTAMINATED SITES

No documented contaminated sites or pre-existing conditions of environmental concern were reported along the Dalzell Gorge route. Thus, impacts to soil quality and from contaminated sites would be the same as Alternative 2.

3.2.3.7.5 SUMMARY OF IMPACTS FOR ALTERNATIVE 6A

Effects at the Mine Site and the Transportation Corridor from soil disturbance, permafrost degradation, erosion, and fugitive dust under Alternative 6A would be the same as discussed for Alternative 2.

Up to an additional 1,300 acres of soil (about 9 percent more than Alternative 2) would be disturbed for the Pipeline under Alternative 6A due to the greater area of off-ROW surface disturbance. Alternative 6A has a greater lateral extent of permafrost, particularly unstable permafrost, along the ROW (about 10 miles more), but Alternative 2 has a higher amount of modeled vertical thaw settlement at specific locations than Alternative 6A; however, the amount of geotechnical data and thaw modeling conducted for Alternative 2 is substantially more than Alternative 6A and likely accounts for much of these apparent differences. There are slightly fewer stream crossings along Alternative 6A in permafrost terrain with erodible soil types. Alternative 6A is roughly similar to Alternative 2 with respect to hydraulic erosion susceptibility, and has a slightly higher susceptibility to wind erosion, although both would be mitigated through ESCs and BMPs, and the impacts criteria ratings for erosion would be the same as Alternative 2. There would be no differences in contaminated soils encountered along Alternative 6A and Alternative 2. Impacts associated with climate change would be the same as those discussed for Alternative 2.

Design features, Standard Permit Conditions and BMPs most important for reducing impacts to soils would be similar to those described for Alternative 2. Examples of additional measures being considered that are applicable to this resource are listed under Alternative 2.

3.2.3.8 ALTERNATIVES IMPACT COMPARISON

A summary of impacts between alternatives by project component is presented in Table 3.2-13. While there are differences among alternatives that would affect soils, they are mostly small in comparison to each component as a whole. This is because all alternatives involve disturbance of large amounts of soil, with such impacts being necessary for construction and operation of the Mine Site, Pipeline, and supporting facilities. Notable differences include 6 to 9 percent more soil disturbance under Pipeline Alternatives 3B and 6A, a greater extent (about 40 more miles) of permafrost effects along the mine access road under Alternative 4, and greater susceptibility to erosion for the dry stack under Alternative 5A, than under the proposed action.

Table 3.2-13: Comparison by Alternative* for Soils

Impact-causing Project Component	Alternative 2 – Proposed Action	Alternative 3A LNG-Powered Haul Trucks	Alternative 3B – Diesel Pipeline	Alternative 4 – BTC Crossing	Alternative 5A – Dry Stack Tailings	Alternative 6A – Dalzell Gorge Route
Mine Site						
Soil Disturbance/ Removal	Irreversible alteration of 9,000 acres of surface soil, with 2,400 acres for TSF.	Same as Alternative 2 (LNG plant within same soil disturbance footprint as Alternative 2).	Same as Alt 2 (slightly smaller fuel storage footprint likely disturbed for other uses).	Same as Alternative 2.	85 acres > Alternative 2 for TSF and filter plant.	Same as Alternative 2.
Permafrost	Degradation of 9,000 acres discontinuous permafrost, with 2,400 acres for TSF. About 130 million tons thawed soils could be source of GHG emissions. Impacts would vary in intensity: - Changes in permafrost may not be measurable or noticeable (e.g. ground settlement) and the thermal regime is maintained and rehabilitation can be accomplished through natural recolonization. - Disturbance may require revegetation by active methods but the design is adequate for the expected range of permafrost hazards. - Low probability of disturbance requiring revegetation by active methods or acute/obvious changes with permafrost disturbance resulting in settlement that requires substantial fill for successful rehabilitation. Permafrost hazards may exceed design parameters. Toe instability may occur if deep ice-rich soils are present.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Slightly greater permafrost removal due to larger dam footprints. About 170 million tons thawed soils could be source of GHG emissions under Unlined Option, and150 million tons under Lined Option.	Same as Alternative 2.
Erosion	Impacts would vary in intensity: - Changes in erosion may not be measurable and standard BMPS would be successful in preventing	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Dry stack surface area 60% > Alternative 2;	Same as Alternative 2.

Table 3.2-13: Comparison by Alternative* for Soils

Impact-causing Project Component	Alternative 2 – Proposed Action	Alternative 3A LNG-Powered Haul Trucks	Alternative 3B – Diesel Pipeline	Alternative 4 – BTC Crossing	Alternative 5A – Dry Stack Tailings	Alternative 6A – Dalzell Gorge Route
	erosion. - Disturbance may require revegetation by active methods to prevent erosion issues. Special BMPs and more frequent monitoring and/or maintenance may be needed for successful erosion control.				greater erosion susceptibility and ESC complexity. Slightly larger overburden stockpile (12% > Alternative 2) with BMPs similar to Alternative 2.	
Soil Quality/ Contaminated Sites	Soil quality effects are below regulatory limits or within the range of natural baseline variation outside of the mineralized zone (1 to 5% arsenic increase above naturally high baseline, averaged across large watershed).	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Slightly greater potential for fugitive dust generation/ dispersion (6.6% more than Alternative 2).	Same as Alternative 2.
Transportation Corridor						
Soil Disturbance/ Removal	Irreversible alteration of 900 acres (including 30-mile mine access road, and 26-acre Angyaruaq (Jungjuk) Port site).	Reduced disturbance of Kuskokwim River bank soils at relay points. Less soil disturbance at ports by 10 to 20 acres.	Small additional disturbance of already disturbed soils at North Foreland dock.	Soil removal increased by 43 miles of road and 39 acres at BTC Port site. Additional minor compaction along 12-mile ice road. Less riverbank disturbance at Kuskokwim relay points.	Same as Alternative 2.	Same as Alternative 2.
Permafrost	Intensity of impacts would range from changes in soils and permafrost that may not be measurable or noticeable to disturbances that require revegetation by active methods (degradation and thaw settlement hazards) for short road segments and at 2 ports. About 6.9 million tons thawed soils	Slightly less permafrost effects at Bethel port.	Same as Alternative 2.	Permafrost effects over about 40 more miles of mine access road; greater potential for repeated fill repairs in localized thermokarst areas. Low intensity effects over 12 miles of ice road. Ports similar to	Same as Alternative 2.	Same as Alternative 2.

Table 3.2-13: Comparison by Alternative* for Soils

Impact-causing Project Component	Alternative 2 – Proposed Action	Alternative 3A LNG-Powered Haul Trucks	Alternative 3B – Diesel Pipeline	Alternative 4 – BTC Crossing	Alternative 5A – Dry Stack Tailings	Alternative 6A – Dalzell Gorge Route
	over the life of the mine could be source of GHG emissions.			Alternative 2. About 30 million tons thawed soils over the life of mine could be source of GHG emissions.		
Erosion	Intensity of impacts would vary: - Could range from changes in soils that may not be measurable or noticeable to disturbances that require revegetation by active methods, but managed through BMPs and ESCs. - Localized disturbances that require revegetation by active methods (such as seeding or sod replacement) to prevent drainage/erosion issues and for successful site rehabilitation. - Occasional acute or obvious indirect effects.	Slightly less erosion effects at relay points and ports.	Same as Alternative 2.	Effects managed through BMPs mostly same as Alternative 2. Less erosion effects at relay points. Slightly less intensity at BTC Port site (reclamation reuse of berth soils).	Same as Alternative 2.	Same as Alternative 2.
Soil Quality/ Contaminated Sites	Impacts would vary in intensity: - Small increase in arsenic could occur immediately adjacent to the road above slightly elevated baseline soil concentrations, with final concentrations within the range of natural variation. - Intensity could be elevated on contaminated sites at Dutch Harbor, depending on site-specific presence/extent of existing soil contamination.	Slightly less dust effects along road.	Possible additional contaminated soils near Tyonek dock.	Similar fugitive dust effects. Slightly lower potential effects from contaminated sites along Kuskokwim River.	Same as Alternative 2.	Same as Alternative 2.
Pipeline						
Soil Disturbance/ Removal	316-mile ROW; up to 14,100 acres of surface disturbance. North Option: essentially the same soil disturbance area as main	Same as Alternative 2.	334-mile ROW, up to 15,000 acres of surface disturbance (6%	Same as Alternative 2.	Same as Alternative 2.	313-mile ROW, up to 15,400 acres of surface disturbance (9% > Alternative 2)

Table 3.2-13: Comparison by Alternative* for Soils

Impact-causing Project Component	Alternative 2 – Proposed Action	Alternative 3A LNG-Powered Haul Trucks	Alternative 3B – Diesel Pipeline	Alternative 4 – BTC Crossing	Alternative 5A – Dry Stack Tailings	Alternative 6A – Dalzell Gorge Route
	route.		> Alternative 2).			
Permafrost	31 miles of permafrost soils. Predicted thaw settlement up to 21 feet. Estimate 37 million tons thawed soils.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	41 miles of permafrost soils. Predicted thaw settlement up to 6.8 feet (although Alternative 6A based on less data). Estimate 49 million tons thawed soils.
Erosion	Intensity of impacts would vary: - Impacts mostly managed through ESC measures, with isolated occurrences of acute or obvious erosion during ROW construction, or ORV use near discrete segments of ROW. - Erosion during construction would likely be reduced such that changes in soils due to erosion may or may not be measurable or noticeable within a short period of time due to planned redundancies in ESC measures, reclamation and/or cleanup crew functions, and monitoring/maintenance activities.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Effects managed through BMPs mostly same as Alternative 2. Stream crossings in erodible permafrost 1 < Alternative 2; slightly more wind erosion than Alternative 2; hydraulic erosion similar to Alternative 2.
Soil Quality/ Contaminated Sites	Impacts would range in intensity from soil quality below regulatory limits or within the range of natural baseline variation, to small effects compared to baseline resulting from grading of pre-existing contaminated soils at the Farewell airstrip.	Same as Alternative 2.	Trenching could encounter contaminated soils in Beluga-Tyonek area.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.

Notes: *Alternative 1 (No Action Alternative) would have no new impacts to soils.