APPENDIX AB:

Focused Risk Assessment

Appendix to Section 3.22, Human Health

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LIST OF ACRONYMS

AAQS	Ambient Air Quality Standards
ABA	acid-base accounting
ADEC	Alaska Department of Environmental Conservation
ADHSS	Alaska Department of Health and Human Services
APDES	Alaska Pollutant Discharge Elimination System
AWQC	Alaska Water Quality Criteria
AWQS	Alaska Water Quality Standards
BAF	bioaccumulation factors
CAA	Clean Air Act
CAM	Comparable Arithmetic Mean
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
cfs	cubic feet per second
CO	Carbon Monoxide
CO2	Carbon Dioxide
COPCs	chemicals of potential concern
CR	carcinogenic target risk
CSM	conceptual site model
CWA	Clean Water Act
CWD	Contact Water Dam
DW	Drinking Water
EPA	Environmental Protection Agency
EPC	exposure point concentration
EIS	Environmental Impact Statement
ELCR	excess lifetime cancer risk
ERM	Environmental Resources Management
ESC	erosion and sedimentation control
FRA	focused risk analysis
HAP	hazardous air pollutants
HCN	hydrogen cyanide
HEC	health effects categories
HHRA	Human Health Risk Assessment
HI	Hazard Index
HIA	Health Impact Assessment
HQs	hazard quotients
HUQ	Hydrologic Unit Code
IRIS	Integrated Risk Information System

IW	Irrigation Water
LNG	Liquefied Natural Gas
MACT	maximum achievable control technology
MCL	maximum containment level
MSHA	Mining Safety and Health Administration
MWMP	meteoric water mobility procedure
NAAQS	National Ambient Air Quality Standards
NAG	non-acid generating
NC	non-cancer
NEPA	National Environmental Policy Act
NO_2	nitrogen dioxide
NOx	oxides of nitrogen
O_3	Ozone
OSHA	Occupational Safety and Health Administration
PAH	polycyclic aromatic hydrocarbons
PM	particulate matter
PPRTV	Provisional Peer-Reviewed Toxicity Values
PSD	Prevention of Significant Deterioration
RME	Reasonable Maximum Exposure
ROW	right-of-way
RSL	Regional Screening Levels
SO_2	sulfur dioxide
SW	Stock Water
TDS	total dissolved solids
tpy	tons per year
TSF	tailings storage facility
UCL	Upper Confidence Limit
VOCs	volatile organic compounds
WAD	weak acid dissociable
WHO	World Health Organization
WRF	Waste Rock Facility
WTP	Water Treatment Plant

AB.1 FOCUSED RISK ASSESSMENT (FRA) INTRODUCTION

AB.1.1 FRA PURPOSE AND OBJECTIVES

The evaluation of impacts on human health is a required component of the National Environmental Policy Act (NEPA) as it pertains to negative and beneficial consequences of a proposed project on potentially affected communities. There are laws and regulations, such as the Clean Water Act (CWA), Clean Air Act (CAA) and various Alaska statutes that have been enacted to ensure protection of human health. Compliance with health laws and regulations are taken into consideration in the evaluation of health impacts.

The preparation of a Health Impact Assessment (HIA) to support a NEPA evaluation and the use of Alaska Department of Health and Social Services (ADHSS) guidelines to do so are not mandatory in Alaska, but are decisions that are made on a project-specific basis (ADHSS 2015). Once the decision to prepare an HIA under ADHSS leadership is made, it is useful to draw upon the HIA as a primary resource for the health evaluation that is required under NEPA. Section 3.22 (Human Health) of the Environmental Impact Statement (EIS) for the Donlin Gold project was developed to be consistent with NEPA practice and the ADHSS HIA methodology, and provides a comprehensive overview of health categories that are generally applicable to the evaluation of impacts related to a proposed program, project, policy, or plan under consideration by decision-makers in Alaska. The HIA developed under ADHSS leadership (Newfields 2015, 2016) was used as one of the primary resources for the Health section of the EIS.

Although the HIA (Newfields 2015, 2016) and Section 3.22 (Human Health) of the EIS describe all of the broad health effects categories (HECs) included in the ADHSS guidelines, emphasis is focused on assessing key issues and potential impacts identified during scoping (as required by NEPA) as well as health-related issues identified or expressed during public/stakeholder engagement. Numerous comments on the Draft EIS were received expressing concerns about potential risk to human health from exposure to project-related hazardous chemicals, which is tied to Health Effects Category 3 (HEC 3) in the EIS (Section 3.22.4.2.3).

The largest number of concerns were associated with consumption of chemicals in food (fish, wildlife, vegetation), and inhalation of chemicals in air. Concerns were also voiced regarding exposure to chemicals in other environmental media (surface water, sediment, groundwater, soil). While exposure to mercury was the dominant concern, concerns were also expressed about other chemicals and their release and transport mechanisms, including antimony, arsenic, cyanide, selenium, lead, potassium amyl xanthate, nitric acid, sodium cyanide, calcium oxide, copper sulfate, sulfur, diesel exhaust, “volatile airborne emissions,” “carcinogens,” “teratogens,” “hazardous chemicals,” “heavy metals,” “toxic chemicals,” “dust and vapors,” “stack emissions,” “acid,” “waste water treatment,” “groundwater as drinking water,” “spills to river,” and “spills, failures and leaks.” A focused workshop was held in December 2016 to address concerns and comments on project-related mercury impacts. At this mercury workshop, commenters expressed a preference to see all health concerns related to chemicals addressed in a single location in the EIS, rather than dispersed through multiple chapters.

To this end, a three-step focused risk analysis (FRA) was proposed to support the EIS, address these comments, and present the finding of the human health evaluation for potential chemical exposures in a single location:

- Step 1 – Identification of primary project sources of contamination, identification of chemicals of potential concern (COPCs), and exposure assessment including pathway completeness determination.
- Step 2 – Perform screening-level evaluations for complete or potentially complete exposure pathways; identification of insignificant and potentially significant pathways.
- Step 3 – Perform a quantitative risk assessment; estimation to determine whether complete and potentially significant pathways and associated chemicals represent unacceptable levels of risk relative to baseline conditions.

The approach used in the FRA generally follows how existing contaminated sites are evaluated under Alaska Department of Environmental Conservation (ADEC) and United States Environmental Protection Agency (EPA) guidance (ADEC 2015, 2016a; EPA 1989, 1991, 2002b, 2016) with modifications to be consistent with NEPA practice. NEPA case law and current Council on Environmental Quality (CEQ) regulations require disclosure of likely impacts (i.e., likely negative and beneficial consequences of the project), not the use of a worst-case scenario used to consider existing environmental impacts (e.g., Comprehensive Environmental Response, Compensation and Liability Act [CERCLA]). Use of worst-case scenarios in the pollutant discharge model (e.g., CERCLA) may result in forecast of contaminant levels and health impacts that are not scientifically defensible for potential impacts from this proposed project.

This Appendix focuses on the evaluations for Steps 1 and 2. Step 3 was conducted separately by Environmental Resources Management (ERM); while the Quantitative Human Health Risk Assessment (HHRA) (ERM 2017) contains sensitive information and is not available to the public, the report has been reviewed by state and federal agencies, and HHRA findings are summarized within this document to achieve the goal of having a single document to present the findings of the human health evaluations for this project.

The risks associated with potential accidental spills of oil and other hazardous substances involved in the project are evaluated in the EIS in Section 3.24, Spill Risk. The following highlights key information from Section 3.24:

- Section 3.24, Spill Risk, focuses on five hazardous substances: diesel, liquefied natural gas (LNG), cyanide, mercury, and mine tailings. Potential sources of release for diesel, LNG, cyanide and mercury would be vessels, storage containers, vehicles, transfer operations, and pipelines. Tailings could be released in the event of a partial dam failure.
- An overview of the potential spill sources, projected rates and likelihoods of occurrence, and potential spill volume, by alternative, for each of five hazardous substances is provided in Section 3.24.3, Spill Frequency and Volume.
- Table 3.24-1, Table 3.24-4, Table 3.24-5, Table 3.24-6, and Table 3.24-7 list the expected relative rates of occurrence for diesel spills, LNG spills, cyanide spills, mercury spills, and the probability of occurrence for a tailings release, respectively, from main project sources.
- Nine spill scenarios (Ocean Barge Rupture at Sea, River Barge Release, Tank Farm Release, Tanker Truck Release, Diesel Pipeline Release, LNG Release, Cyanide Release, Mercury Release, and Partial Tailings Dam Failure) are presented in Section 3.24.5 and summarize potential causes, behavior, and volumes of spills that could occur during the

transport and storage of materials, as well as potential impacts and responses. This analysis considers a variety of accidental spills, from minor to major. These scenarios are conceptual and represent possible sets of potential accidents.

- Section 3.24.6 analyzes the potential impacts of the nine spill scenarios on the 23 resources under each of the action alternatives. Overall potential impacts to natural resources from these scenarios typically range from minimal adverse impacts to a resource to resources that could be highly impacted. The likelihood of small volume releases range from very low to very high, while medium to large volume potential spills range from very low to low probability. Resources would be differentially impacted under the various scenarios; Table 3.24-26 provides a succinct summary of impacts, by resource and scenario.
- Donlin Gold design features (see Table 5.2-1 in Chapter 5, Impact Avoidance, Minimization, and Mitigation) and Standard Permit Conditions and BMPs (see Section 5.3), would be implemented for preventing and reducing impacts from potential spills. As described in Section 3.24.7 (Spill Risk), the most important design features include public outreach, double hulled vessels with isolated fuel compartments, specialized containers for cyanide and mercury transportation, and seismic fault crossings for the pipeline.
- Sections 3.24.6.6.1 and 3.24.6.7.2 (Spill Scenario Impacts, Groundwater Hydrology and Groundwater Quality, respectively) include discussion on potential effects on drinking water supplies at Crooked Creek village in the event of a partial dam failure. Additionally, Section 3.24.6.22, Spill Risk, includes discussion on how potential impacts and potential health concerns would be addressed in the unlikely event that a spill or failure were to occur (e.g., containment, monitoring, public outreach and information).

Potential exposure pathways based on accidents, spills, or failures is not further evaluated in the FRA. Although exposure could potentially be complete for human receptors were an accidental spill, leak, or release to occur, this FRA does not evaluate health impacts because these are unanticipated events, project procedures will be in place to minimize their potential for occurrence, and potential health impacts are typically short-term, acute exposures. The standard risk assessment methodology is not designed to evaluate these kinds of short-term, acute exposures.

AB.2 PROJECT BACKGROUND

As discussed in Chapter 1 of the EIS (Project Introduction and Purpose and Need), Donlin Gold is proposing a project to produce gold from ore reserves owned by Calista through open pit mining methods and milling processes suitable for application in remote western Alaska. To mine these ore reserves, Donlin Gold would develop an open pit, hardrock gold mine located in the Kuskokwim River watershed, 277 miles west of Anchorage, 145 miles northeast of Bethel, and 10 miles north of the community of Crooked Creek (see Chapter 2, Alternatives, for project maps).

The U.S. Army Corps of Engineers Alaska District (Corps) is examining the potential impacts of the Donlin Gold mine and has determined that the project could significantly affect the quality of the human and natural environment. With publication of a Notice of Intent to prepare an EIS[1] on December 14, 2012, the Corps Alaska District initiated the NEPA process for review of the Donlin Gold Project. The evaluation of impacts on human health is a required component of NEPA as it pertains to negative and beneficial consequences of a proposed project on potentially affected communities.

Although an EIS is not a regulatory decision document, it is used by agency officials to inform agency decision in conjunction with other relevant information in a permit application file, including public and agency comments.

AB.2.1 FRA COMPONENTS

The Mine Site would process ore to produce gold through crushing and grinding, flotation, pressure oxidation and cyanide leaching of the concentrate, and then stripping, electrowinning, and refining. The Mine Site and related facilities would have a total footprint of approximately 16,300 acres. Consistent with the EIS, the FRA will present the human health evaluations for each of the three major project components:

- The Mine Site component includes the excavation of an open pit, milling and ore processing, tailings storage facility (TSF), Waste Rock Facility (WRF) and overburden stockpile, dual-fuel (diesel and natural gas) 227 megawatt power plant, utilities, services and infrastructure, mine maintenance and safety controls.
- The Transportation Corridor component includes expanded port facilities at the Bethel cargo terminal, river barge traffic, a barge landing at Angyaruaq (Jungjuk), a 30-mile mine access road, a 5,000-foot airstrip, and transportation facilities.
- A 316-mile, small-diameter (14-inch), pipeline from the west side of Cook Inlet to the project site would provide energy for the power plant at the Mine Site. The Pipeline component would include a mostly buried pipeline right-of-way (ROW), aboveground facilities (compressor station, pig launcher and receiver station, and main line valves), two active seismic fault crossings, and temporary work areas outside of the ROW during construction and closure.

AB.2.2 FRA GEOGRAPHIC BOUNDARIES

The Donlin Gold Project covers a relatively large geographical distance and considers effects to broad rural areas within the vicinity of the project components. As discussed in Section 1.4 (Project Introduction and Purpose and Need, Scope of Analysis), the NEPA scope of analysis for the project is defined by the summation of the resource study areas. The study areas for each resource are described within the resource subchapters of Chapter 3, Environmental Analysis. For most resource areas, the geographic scope of analysis, or the EIS Analysis Area, extends outside the project component boundaries, with distances dependent on the resource and the reach of the potential impacts (e.g., wind dispersion).

[1] Federal Register/Vol. 77, No. 241/Friday, December 14, 2012/Notices.

In this FRA, several terms are used to describe the spatial boundaries and include: "EIS Analysis Area", "Project Site / Area", "Core Operating Area", and "HHRA Study Area". These are defined as follows:

- Project Site or Project Area – spatial boundary of the Proposed Donlin Gold Mine Site Layout, including the core operating area with mine facilities and mine camp (i.e., EIS Mine Site project component, see Figure 2.3-3)
- EIS Analysis Area – includes the three project components: Mine Site, Transportation Corridor, and Pipeline; analysis spatial boundaries may extend outside the project component boundaries, with distances dependent on the resource and the reach of the potential impacts (e.g., wind dispersion)
- Core Operating Area – spatial boundary that includes the Mine Facilities and Mine Camp (i.e., equivalent to the EIS Mine Site, see Figure 3.15-3).
- HHRA Study Area – spatial boundary based on the extent of the mercury air deposition model for the project (Environ 2015), encompassing a 20-mile radius outside the Core Operating Area and representing the highest exposure area for subsistence populations that could harvest wild food in the project area (inclusive of the EIS Mine Site Analysis Area and the portions of the EIS Transportation Corridor and Pipeline Analysis Areas nearest the Core Operating Area / Mine Site).

Consistent with the EIS and NEPA practice, the scope of the FRA is limited to "outside of the fence." Consistent with ADHSS (2015), this assessment does not include a direct evaluation of the anticipated project workforce safety and health issues (i.e., "inside the fence"). Therefore, the health and safety of project worker and contractor populations, including use of potable water wells at the construction camp, are expected to be adequately addressed by compliance with Donlin Gold's health and safety plans The project is governed by the regulations of the Occupational Safety and Health Administration (OSHA) and the Mining Safety and Health Administration (MSHA), and occupational health and safety regulations. For "inside the fence" mine worker safety information and considerations, including groundwater as potable water and health safety measures at the mine and at mine camps, see Table 3.6-1 (Applicable Regulations under Groundwater Hydrology), Sections 2.3.2 (Description of Alternatives), 3.6.1.5.1 (Groundwater Hydrology), 3.6.2.2.1, 3.6.2.2.2 (Groundwater Hydrology), 3.7.1.1, 3.7.2.1, 3.7.3.2.3 (Water Quality), and 5.0 (Impact Avoidance, Minimization, and Mitigation).

Consistent with Section 3.7, Water Quality, this FRA uses a watershed approach for evaluating human health exposure to surface water "outside the fence" that could be potentially impacted by project-related activities. Although, none of the surface water bodies in the vicinity of the Mine Site are known to be used for potable water supply purposes, including Crooked Creek, they could be periodically be used as potable water sources by subsistence consumers of other multi-day outdoor recreationalists. The closest known use of surface water for potable water purposes is at the Kuskokwim River, which is generally protected for all uses (including drinking water) downstream from its confluence with Crooked Creek, eight miles downstream of the Mine Site (see Section 3.7.2.1, Surface Water Quality, and Section 3.5, Surface Water Hydrology). This watershed approach is conservative because dilution within creeks (from upstream inputs) and at the confluence with the Kuskokwim River would occur.

AB.2.3 FRA TIME SCALES

Each of the project components are evaluated in relation to three active phases. The project would require approximately 3 to 4 years for the Construction Phase, approximately 28 years for the Operations Phase, and 3 to 4 years for the Closure Phase. However, as discussed in Section 1.4 (Scope of Analysis), the NEPA scope of analysis for the Dolin Gold EIS looks approximately 85 years into the future. This is based on the anticipated duration of the project and the more extended post-closure monitoring period (expected to take place over 55 years after active mining ends). The 55 year post-closure monitoring period was established based on current estimates of the length of time required to fill the pit lake and construct a water treatment plant (five years prior to pit fill). For the water treatment system, modeling and NEPA scope of analysis for the project was performed through 99 years after closure. The FRA evaluates all three project phases (Construction, Operations, Closure), but places emphasis on the approximately 28 years of mine operations, the end of which represents the cumulative potential environmental impacts from mine site operations and when project-related releases of chemicals are most likely to occur, as well as other important periods (e.g., post-operation pit effluent).

AB.3 OVERVIEW OF FRA APPROACH

As noted in Section AB.1.1, the approach used in the FRA generally follows the approach used to evaluate existing contaminated sites under ADEC and EPA guidance (ADEC 2015, 2016a; EPA 1989, 1991, 2002b, 2016), with modifications to be consistent with NEPA practice. NEPA case law and current CEQ regulations require disclosure of likely impacts (i.e., likely negative and beneficial consequences of the project). NEPA case law and current CEQ regulations do not require the use of a worst-case scenario used in the pollutant discharge model (e.g., CERCLA), which could result in forecast of contaminant levels and health impacts that are not scientifically defensible for potential impacts from this proposed project.

Modifications to the general HHRA approach used in the FRA include:

- Use of estimated future concentrations, when available, in conjunction with a qualitative evaluation for exposure scenarios without estimated future concentrations in the Screening Level Evaluation (Step 2)
- Use of both potential upper-bound reasonable and average estimated concentrations in the Screening Level Evaluation (Step 2)
- Use of individual-chemical promulgated screening criteria for the Screening Level Evaluation (Step 2)
- Evaluation of cumulative, multi-chemical exposure in the quantitative HHRA (Step 3)

The following subsections detail the approach used for the exposure pathway analysis (Step 1), the screening level evaluation (Step 2), and the quantitative HHRA (Step 3).

AB.3.1 EXPOSURE PATHWAY ANALYSIS

The potential for adverse health effects associated with exposure to hazardous chemicals is a common and legitimate concern expressed by communities in the EIS Analysis Area. As noted in Section 3.22.3.2 (Human Health) and Section AB.1 of this FRA, members of the affected communities expressed concerns about exposure to hazardous materials associated with the

Donlin Gold Project and the potential for these constituents (e.g., air pollutants, processing reagents, heavy metals in non-acid generating [NAG] waste rock) to be released to the environment and affect human health.

A complete exposure pathway is created when chemicals released to the environment come into contact with human or ecological receptors (any human, plant, or animal individual or population that are present or could potentially be exposed to the release or migration of contaminants). An effective way to understand the potential for health risks related to hazardous constituents in the environment is to understand two critical concepts: first, there has to be exposure to the chemical, and second, the exposure has to be high enough that adverse health effects may be a concern (EPA 1989).

An exposure pathway includes the following components:

- A source of contamination (e.g., release of mercury due to the Donlin Gold Project);
- A mechanism of release and transport pathway to an affected medium (e.g., roadway runoff to offsite creeks and food-web uptake by fish);
- A receptor (e.g., subsistence fisher); and
- An exposure route (e.g., ingestion of fish).

An exposure pathway is considered complete when, and only when, all of the above component elements are present. If any of these elements are missing, then the exposure pathway is considered incomplete. In addition, some pathways may be complete, but inconsequential since the level of exposure may not be high enough to be a health concern.

This source to receptor exposure pathway framework is used to evaluate the potential impacts of project-related hazardous constituents on human health in affected communities since it provides a comprehensive and transparent approach to identifying and evaluating health issues related to hazardous constituents. A schematic representation of this exposure pathway analysis is called a conceptual site model (CSM) and is used to illustrate the complete and incomplete exposure pathways for a site.

AB.3.2 MEDIA-SPECIFIC SCREENING-LEVEL EVALUATION

Step 2 of the FRA is the media-specific screening level evaluation for complete and potentially complete pathways, including those that are expected to be insignificant. This step evaluates and verifies whether the complete pathways may pose a risk, relative to risk-based screening levels, and warrants further evaluation. The screening of site COPCs is used to identify compounds at a site that need further analysis (ADEC 2015). The general steps typically used to screen for human health COPCs are summarized below, with modifications to be consistent with NEPA practice for disclosure of likely impacts (see FRA approach description n AB.1.1 and AB.3):

- Establish media-specific exposure point concentrations (EPCs).
  - o Consistent with the EIS, baseline concentrations and risk represent current conditions (i.e., the No Action Alternative). The baseline concentrations were obtained from the relevant media sections of the EIS.
  - o Calculation of the EPCs for all contaminants in each environmental medium is typically performed in screening-level evaluations; however, this is not a

contaminated site under CERCLA and future estimated media modeling of COPCs is not required for the Donlin Gold EIS. Therefore, limited media modeling (i.e., estimation of media concentrations) was conducted to support the EIS and permitting for representative COPCs that are expected have the greatest impact. The estimations were performed, as summarized in the media screening-level evaluation (see Sections AB.5.1 through AB.5.3), and included one or both of the following per media:

- Reasonable Maximum Exposure (RME) concentrations were calculated to explore the upper bounds of potential EPCs, and / or
- Comparable Arithmetic Mean (CAM) concentrations were calculated to identify the potential average EPCs

- RME is defined as the highest exposure that is reasonably expected to occur at a site and is usually represented by an upper-bound estimate of the mean such as 95 percent upper confidence limits on the mean (EPA 1989, 1991), when available. For this project, the RME was sometimes a combination of the 95 percent UCL and mean concentrations (e.g., predicted future soil concentrations using 95 percent UCL baseline and mean estimated project-related increases). The CAM is defined as the potential average exposure concentration using comparable mean statistics. Determine contaminant-specific human health screening level.
  - o Air screening level values included Alaska Ambient Air Quality Standards (AAQS) (ADEC 2016b) and National Ambient Air Quality Standards (NAAQS) (EPA 2013a), as well as EPA Integrated Risk Information System (IRIS) guidelines (EPA 2014b), World Health Organization (WHO) guidelines (WHO 2003), and EPA Air Regional Screening Levels (RSL) (EPA 2016).
  - o Soil screening level values included Alaska Soil Cleanup Levels for Method 2, under 40-inch zone (ADEC 2017a) and EPA Soil RSL (EPA 2016).
  - o Water screening levels included Alaska Water Quality Criteria (AWQC) (ADEC 2008), Alaska Water Quality Standards (AWQS) (ADEC 2017b), and EPA Tapwater RSLs (EPA 2016).
  - o Sediment screening levels included Washington Sediment Criteria (Ecology 2017), as well as Alaska Soil Cleanup Levels (ADEC 2017a) and EPA Soil RSLs (EPA 2016).
- Compare baseline concentrations and the estimated RME and / or CAM concentrations to abiotic media screening levels (i.e., air, soil, water, sediment screening levels; see Sections AB.5.1 through AB.5.3).
- Compare the RME and CAM to baseline concentrations.
- Eliminate compounds from further analysis that:
  - o Do not exceed the abiotic screening levels (i.e., unlikely to pose a threat to human health in that exposure medium) and are not considered bioaccumulative.
  - o Do not exceed the abiotic screening levels and do not exceed background concentrations, regardless of bioaccumulation potential.

- Identify compounds not eliminated as COPCs that warrant further evaluation in Step 3 for each abiotic medium, as well as those COPCs that warrant evaluation in Step 3 for potential bioaccumulation in tissue for subsistence dietary pathway.
- Identify uncertainties in the screening level assessment.

For human health evaluations, chemicals are typically evaluated on the basis of whether they are considered to be carcinogenic or non-carcinogenic. For a chemical that have both carcinogenic and non-carcinogenic modes of action, then the mode of action with the most stringent (i.e., lowest) screening level (typically carcinogenic) is used for the screening level evaluation.

For the FRA, the screening levels selected were the promulgated human health-protective values from the sources noted above and are presented in the media screening-level evaluation sections (see Sections AB.5.1 and AB.5.3). For non-carcinogenic screening values, the individual-chemical promulgated values were selected (i.e., hazard quotient [HQ] = 1) to be consistent with the approach used in the EIS (i.e., Sections 3.2, 3.7, 3.8), for identification of individual metals elevated in baseline data, and to identify those chemicals that are more likely to have potential human health impacts to be consistent with NEPA practice (i.e., disclosure of likely impacts). Carcinogenic screening values were selected as promulgated (i.e., excess lifetime cancer risk [ELCR] = $1x10^{-5}$ for ADEC and $1x10^{-6}$ for EPA values). In addition, the cumulative and multi-media human health evaluation was conducted at the quantitative HHRA step. This approach maintains consistency with the EIS and NEPA practice, and avoids the worse-case, maximum approach typical of CERCLA that may lead to an over-estimate of COPCs at the screening step for the proposed project.

AB.3.3 QUANTITATIVE HHRA

Step 3 is the multi-media quantitative HHRA for COPCs determined to warrant further evaluation. This step quantifies the risk to human receptors from multi-chemical and multi-media exposure to the retained COPCs to evaluate the likelihood of adverse effects to potentially exposed populations (i.e., subsistence residents).

Step 3, the quantitative HHRA, was conducted separately by ERM. The following summarizes the general steps of the quantitative HHRA:

- Selection of COPCs.
- Development of a CSM to describe the relationship between sources of COPCs and potential exposure to human populations; including selection of temporal and spatial boundaries, identification of primary sources and transport pathways, and evaluation of exposure pathways, media, and populations.
- Present the data sources used in the HHRA and describe data usability.
- Present the HHRA exposure assessment, which determines the magnitude, frequency, duration, and route of exposure to COPCs.
- Present the toxicity assessment, which weighs the available and relevant evidence regarding the potential for constituents to cause adverse health effects in exposed individuals and provides a quantitative estimate of the relationship between the magnitude of exposure and the likelihood of adverse effects.

- Risk characterization integrates the exposure assessment and toxicity information, and includes:
  - o Both a baseline estimate of potential risk and an incremental risk estimate from future project-related sources; that is, what is the added human health exposure and associated incremental risk due to predicted future concentrations of certain metals (i.e., antimony, arsenic, mercury) in soil, sediment, surface water, wildlife, and fish that may be harvested and eaten near the project as well as from inhalation associated with air emissions.
  - o The potential for adverse health effects other than carcinogenic effects (i.e., non-carcinogenic effects) is characterized by dividing estimated constituent doses or exposure concentrations in air, by constituent-specific reference doses or reference concentrations. The resulting ratio is the non-cancer HQ. However, a toxic effect can only occur if the metal is absorbed into the blood. EPA has developed a recommended soil arsenic relative bioavailability factor, which was incorporated into the non-cancer HQs (i.e., multiplying the arsenic relative bioavailability factor with the estimated dose, then dividing by the reference dose). An HQ or HI less than 1 indicates a non-cancer effect is highly unlikely. Incremental changes in risk were considered substantial if non-cancer risks (i.e., HQs or HIs) changed from less than 1 to greater than 1.
  - o The potential for carcinogenic effects is evaluated by estimating the probability of developing cancer over a lifetime based on exposure assumptions and constituent-specific toxicity criteria. The increased likelihood of developing cancer from exposure to a particular constituent is defined as the excess cancer risk. Excess cancer risk is the risk in excess of a background cancer risk for subsistence residents. Of the COPCs evaluated in the HHRA, arsenic (in the inorganic form) was recognized as a potential human carcinogen. Cancer risk estimates for ingestion exposures are the product of exposure assumptions (i.e., intake dose) and the constituent-specific oral cancer slope factor, while cancer risk estimates for inhalation exposures are the product of exposure concentrations and cancer inhalation unit risk factors. For cancer risk, the "target range" is defined as "an excess upper-bound lifetime cancer risk to an individual of between 1×10^{-4} and 1×10^{-6}," or 1 in 10,000 to 1 in 1,000,000. Incremental changes in risk were considered substantial if cancer estimates increased in the risk assessment by 10-fold or more.
  - o Identification of COCs, if any.
- Identify uncertainties in the HHRA.

AB.4 STEP 1 - EXPOSURE PATHWAY ANALYSIS

This section describes Step 1 of the FRA, the exposure pathway analysis. This step includes identification of primary project sources of contamination, identification of contaminants of potential concern, and the exposure pathway assessment. The exposure pathway assessment includes identification of COPC release and transport mechanisms, exposure media and routes, potentially exposed human receptors, and exposure pathway completeness determination. Consistent with the EIS, the foundation of the FRA is the EIS Proposed Action, Alternative 2, with inclusion of other alternatives only if they substantively differ from Alternative 2.

The exposure pathway determination may identify pathways as incomplete under current and future conditions based on the Donlin Gold project description and location of receptors in relation to the project component, nature of chemicals and pathway, and other information. Pathways that are determined to be incomplete (i.e., human exposure will not occur; therefore, there are no health concerns) do not warrant further evaluation. Pathways that are complete or potentially complete are carried forward into Step 2 of the FRA: screening level evaluation.

Consistent with the EIS and NEPA practice, the FRA evaluates potential exposure pathways to chemicals used or released from the project activities by presenting baseline exposure, combined baseline and predicted project-related exposure, and incremental exposure (e.g., percent increase from baseline). In order to evaluate potential project-related health impacts, the FRA evaluation focuses on the findings related to predicted health consequences for exposure to hazardous chemicals due to potential project-related impacts to abiotic media and potential bioaccumulation in biota, but also summarizes how these predicted project-related exposures relate to baseline exposures.

AB.4.1 PRIMARY PROJECT SOURCES AND PRELIMINARY COPCS

As noted in Section 3.22.3.2 (Human Health) and Section AB.1 of this FRA, members of the affected communities expressed concerns about exposure to hazardous materials associated with the Donlin Gold Project and the potential for these chemicals to be released to the environment and affect human health. A list of preliminary COPCs was developed for further evaluation in the FRA, by reference to the project description and project activities.

AB.4.1.1 ANTICIPATED PROJECT SOURCES AND PRELIMINARY COPCS

As illustrated on the CSMs for each of the Donlin Gold Project components: Mine Site (Figure AB.4-1), Transportation Corridor (Figure AB.4-2), and Pipeline (Figure AB.4-3), the primary anticipated project sources of potential contamination are from hazardous chemicals used, released, or present during the Construction, Operation, and Closure Phases. Specific project sources are summarized below, along with their project-associated preliminary COPCs:

- Mine Site air emissions during Construction, Operations, and Closure from stationary sources, mobile sources, and fugitive sources. Preliminary COPCs include criteria pollutants (e.g., carbon monoxide, lead, ground-level ozone (O_3), nitrogen dioxide, particulate matter [PM], and sulfur dioxide) and hazardous air pollutants (HAPs; e.g., antimony, arsenic, lead, mercury, and hydrogen cyanide).
- Mine Site use of NAG waste rock for construction at the mine. Preliminary COPCs include heavy metals (e.g., antimony, arsenic, lead, mercury).
- Mine Site Water Treatment Plant (WTP) effluent discharges to Crooked Creek during Operations and post-Closure (influent from overland flow from NAG waste rock used for construction / roadway and groundwater / leaching at site excavations). Preliminary COPCs include heavy metals and weak acid dissociable (WAD) cyanide.
- Mine Site pit water flow into depressurized deep bedrock groundwater (>600 feet below grade) when pit dewatering is stopped after Closure. Preliminary COPCs include sulfate and heavy metals, and decreased pH (SRK 2012b) (see also Section 3.6, Groundwater

Hydrology).

- Mine Site use of processing reagents during Operations. Specific process use and estimated annual consumption of these process reagents is presented in Table 2.3-3 (Estimated Annual Consumption of Reagents used at the Mine Site) in Section 2.3 (Description of Alternatives) of the EIS. Preliminary COPCs include nitric acid, sodium cyanide, potassium amyl xanthate, calcium oxide, copper sulfate, and sulfur.
- Transportation Corridor air emissions during Construction, Operations, and Closure from stationary sources, mobile sources, and fugitive sources. Preliminary COPCs include criteria pollutants and hazardous air pollutants.
- Transportation Corridor NAG waste rock from the mine used for roadway construction (e.g., overland flow). Preliminary COPCs include heavy metals (e.g., arsenic, antimony, mercury).
- Pipeline air emissions during Construction, Operations, and Closure from stationary sources, mobile sources, and fugitive sources. Preliminary COPCs include criteria pollutants and HAPs (e.g., metals).

AB.4.2 EXPOSURE ASSESSMENT

As discussed in Section AB.3.1, an exposure pathway is considered complete when, and only when, all of component elements (source of contamination, release mechanism and transport to affected media, a receptor, and an exposure route) are present. If any of these elements are missing, then the exposure pathway is considered incomplete. Some pathways may be complete, but inconsequential since the level of exposure may not be high enough to be a health concern. The exposure pathway assessment includes identification of COPC release and transport mechanisms, exposure media and routes, potentially exposed human receptors, and exposure pathway completeness determination, which are detailed below. The CSMs for the Mine Site (Figure AB.4-1), Transportation Corridor (Figure AB.4-2), and Pipeline (Figure AB.4-3) illustrate the exposure assessment, including identification of the complete and incomplete exposure pathways for the Donlin Gold Project.

AB.4.2.1 COPC RELEASE AND TRANSPORT MECHANISMS

The primary anticipated project sources and associated preliminary COPCs were identified in Section AB.4.1.1, above. Potential COPC release and transport mechanisms are illustrated or footnoted on the project CSMs and include the following:

- Mine Site - Air emission COPCs entrained in wind, resulting in COPCs in ambient air and deposition of COPCs to surface soil and surface water bodies outside the mine. Also potential for subsequent leaching of COPCs in surface soil to groundwater and infiltration of COPCs in surface water bodies to groundwater. These mechanisms are either expected to occur (e.g., entrained in ambient air) or may potentially occur (e.g., leaching to groundwater) during Construction, Operations, and/or Closure.
- Mine Site – Overland flow/erosion of COPCs in mine surfaces (e.g., NAG waste rock used for construction at the mine) to surface soil, which has the potential to subsequently leach to groundwater. These mechanisms are not expected to occur. NAG waste rock used for mine construction will be tested prior to use; NAG with metal

leaching potential will only be used for construction of the Lower Contact Water Dam (CWD), where runoff and seepage would be treated prior to discharges into Crooked Creek (see next bullet; also see Section 3.7.3, Water Quality, and Section 3.2.3, Soils). Operations BMPs and erosion and sedimentation control (ESC) mitigation measures would be expected to ensure containment of mine surface water runoff and Mine Site impacted groundwater to "inside the fence" (see next bullet; also see Section 3.7.2.1, Surface Water Quality, and Section 3.7.2.3, Sediment Quality). Therefore, no overland flow / erosion of COPCs at the Mine Site is expected to be released / transported "outside the fence" (i.e., the active work environment where only occupational exposures would occur and community residents or subsistence consumers would not be present).

- Mine Site – Desorption / leaching of COPCs at excavations and infiltration to shallow groundwater "outside the fence." This mechanism is not expected to occur because Operations water management measures are expected to ensure containment and impacted shallow groundwater is not expected to flow "outside the fence." As discussed in Section 3.7.3.2.3, Groundwater Quality, groundwater that could potentially be contaminated by inputs of WRF and tailings storage facility (TSF) seepage would flow towards the CWD pit, and the spatial extent of the impacts would be limited because the contaminated groundwater would be intercepted by the pit and the pit dewatering system. According to the Donlin Gold Water Resources Management Plan, all groundwater removed from the pit via the dewatering system is considered mine drainage and must be treated to meet AWQC (ADEC 2008) and AWQS (ADEC 2017b); this groundwater would be piped directly to the WTP and treated prior to discharge to Crooked Creek. Upon discharge, further dilution would occur with surface water. Therefore, treated WTP effluent impacts are expected to be insignificant.
- Mine Site - Pit water flow of COPCs into depressurized deep bedrock groundwater (>600 feet below grade) when pit dewatering is stopped after Closure. As discussed in Section 3.7.3.2.3, Groundwater Quality, modeling analysis indicates that this flow would last for the full period of time that it takes for the pit lake to fill after Closure; however, flow rates would be highest during the approximately 8 years following the cessation of pit dewatering. COPC concentrations in groundwater would increase over time in the vicinity of the pit ("inside the fence") and would likely exceed AWQC / AWQS. After the pit lake fills to its highest managed level (after approximately 52 years), groundwater would then flow back into the pit lake radially from all directions (BGC 2014c) during the remainder of the period of closure and throughout the post-closure period under anticipated management (BGC 2014c; SRK 2012b). This would limit the extent of migration of the contaminated groundwater and restrict the extent or scope of the impact. Impacts to groundwater quality outside the Mine Site are expected to meet water quality regulatory limits; therefore, any impacts to groundwater immediately "outside the fence" would be expected to be insignificant.
- Mine Site – Use of processing reagents and release / transport to environmental media. This mechanism would not be expected to occur because most of the reagents used would be expected to be oxidized during the metallurgical process and breakdown of residual reagents would be expected during the neutralization step at the process facilities (see Section 3.7, Water Quality). Operations procedures are expected to adequately shield the public, including chemical-specific containerization and double-

hulled vessels (see Section 3.24). Therefore, under anticipated operations, process reagents would not be expected to be released / transported to exposure media.

- Transportation Corridor - Air emission COPCs entrained in wind would be expected to result in COPCs in ambient air and deposition of COPCs to surface soil and surface water bodies adjacent to the corridor. Although there is the potential for subsequent leaching of COPCs to groundwater, as noted in Section 3.7.3.2.3, Groundwater Quality, the Transportation Corridor activities under Alternative 2 would not be expected to have measurable effects on groundwater quality.
- Transportation Corridor - Roadway NAG waste rock erosion / overland flow of COPCs to adjacent surface soil and surface water bodies; also potential for subsequent leaching of COPCs in surface soil to groundwater. These mechanisms may potentially occur during Construction, Operations, and / or Closure.
- Pipeline – Air emission COPCs entrained in wind, resulting in COPCs in ambient air. Impacts to other media along the ROW would not be expected to be measurable; with the exception of the dust generation and deposition during Construction that would have a negligible 1 percent increase of arsenic in adjacent soils (see Section 3.2.3.2.4, Soils). These mechanisms range from expected to occur (i.e., entrained in ambient air, dust deposition to soil) to may potentially occur but are not measureable (i.e., ambient air deposition to soil / surface water bodies).

AB.4.2.2 EXPOSURE MEDIA AND ROUTES

For those COPC releases with complete transportation pathways identified in Section AB.4.2.1, affected communities could then potentially be exposed either directly or indirectly to media potentially impacted by project COPCs through:

- Inhalation of ambient vapors / dust and soil dust
- Direct contact (incidental ingestion and dermal contact) with soil
- Direct contact (ingestion and dermal contact with surface water and sediment)
- Direct contact (ingestion and dermal contact) with and potential inhalation of vapors from potable water (e.g., groundwater)
- Indirectly though consumption of fish, wildlife, and vegetation that has taken up COPCs from impacted media (e.g., soil, surface water, sediment)

The specific exposure media for each project component and complete release / transport pathway are depicted in their respective CSMs (see Figures AB.4-1, AB.4-2, and AB.4-3).

AB.4.2.3 POTENTIALLY EXPOSED HUMAN RECEPTORS

Potentially affected communities are identified in relation to the three components of the Donlin Gold Project, as described in Section 3.22.3 (Human Health) and Section AB.3 of this FRA, and illustrated in their respective CSMs (Figures AB.4-1 to AB.4-3). Potential human receptors for all three components include residents in villages near the project area (Crooked Creek is the nearest village, 10 miles from the Mine Site), recreationalists, and subsistence consumers (i.e., foragers, hunters, and fishers who may conduct subsistence activities in the general vicinity but outside the active mine site during the active project phases, and includes residents with whom harvests may be shared). For the Transportation Corridor, commercial/industrial workers not related to the project (e.g., other workers at the Transportation Corridor ports) are also potential receptors. Although residential exposure to harvested biota shared by subsistence hunters/foragers/fishers could potentially occur, this exposure pathway is already captured and evaluated under subsistence consumers. Therefore, the biota consumer evaluation is not duplicated for potential residential exposure. Any potential health impacts to residents from ingesting biota harvested and shared by subsistence receptors is covered under the subsistence consumer exposure scenario.

After the active phases of the project (i.e., post-Closure), the Mine Site land use would be designated as wildlife habitat and recreation as prescribed by the Reclamation Standards (AS 27.19.020; see Section 2.3.2.1.12). Therefore, post-closure potential human receptors both in the general vicinity and within the Mine Site include residents and subsistence consumers (including nearby residents with whom harvests may be shared). Since soil, surface water, and sediment impacts were estimated for the entire Study Area (both "inside" and "outside" the fence), the subsistence consumer and resident evaluations conducted during the active phases of the project are protective of post-closure subsistence consumers and recreational users. Potential post-closure exposures may even be less after completion of reclamation activities (although quantitative estimation would not be possible at this time). The Mine Site WTP pit and any impacted shallow groundwater in the vicinity of the pit would be part of the Donlin Gold Project post-Closure continued management and monitoring, and measures would be in place to preclude human exposure via water ingestion within this area (e.g., signs; see Sections 2.3 and 5.0); therefore, post-Closure subsistence and recreationist exposure to potentially impacted Mine Site groundwater is incomplete. Evaluation of post-closure receptors would be duplicative and was, therefore, not separately conducted. Consistent with the EIS and NEPA practice, and as noted in Section AB.2.2, Donlin Gold Project employee health is covered by the Donlin Gold Mine's Plan of Operations, which includes an occupational health and safety plan and monitoring, and is governed by OSHA and MSHA regulations. Therefore, this FRA assessment does not include an evaluation of the anticipated project workforce safety and health issues (i.e., "inside the fence"). The health and safety of project worker and contractor populations would be expected to be adequately addressed by compliance with site health and safety plans and occupational health and safety regulations (see Section AB.2.2).

AB.4.2.4 EXPOSURE PATHWAY COMPLETENESS DETERMINATION

This section takes the information from the preceding sections (Sections AB.4.2.1 through AB.4.2.3), and the detailed information from the preceding sections of the Exposure Pathway Assessment (Sections AB.4.2.1 through AB.4.2.3), and determines if complete or incomplete exposure pathways exist. As illustrated in the CSMs (Figures AB.4-1 to AB.4-3) exposure pathways for the project include those identified as incomplete, complete but insignificant, and complete.

The following summarizes the complete exposure pathways, including those identified as complete but likely insignificant, that will be carried forward into Step 2 – Screening Level Evaluation:

- Mine Site - Exposure to COPCs in ambient outdoor air, soil, and biota would be expected to be complete for subsistence consumers (including any residents with whom harvests are shared). The abiotic exposure pathways (i.e., ambient outdoor air and soil) would be complete but insignificant for residents (including recreationists) due to their distance from the active mine site.

- Mine Site – Exposure to COPCs in surface water and sediment (from treated WTP effluent and air deposition) would be expected to be complete but insignificant for both subsistence consumers and community resident receptors due to the air pollution permit controls and planned WTP treatment program, as well as dilution within the water bodies. As described in Section AB.2.2, surface water is not known to be used as a potable water supply in the vicinity of the Mine Site or in the individual streams prior to their confluence with the Kuskokwim River; although periodic use of these water bodies as potable water sources by subsistence consumers of other multi-day outdoor recreationalists could occur. The closest known potable use of surface water is in the Kuskokwim River, which is generally protected for all uses (including drinking water) downstream from its confluence with Crooked Creek, eight miles downstream of the Mine Site (see Section 3.7.2.1, Surface Water Quality, and Section 3.5, Surface Water Hydrology). Also see Sections 3.7.1.1 (Regulatory Framework), 3.7.2.1 (Surface Water Quality), and 3.7.2.2 (Groundwater Quality) for details on water quality regulations and programs.
- Transportation Corridor - Exposure to COPCs in ambient outdoor air would be expected to be complete but insignificant for residents, subsistence consumers, and non-project commercial / industrial workers due to the planned controls on emissions.
- Transportation Corridor – Exposure to COPCs in soil and biota would be expected to be complete for subsistence consumers (including any residents with whom harvests are shared).
- Transportation Corridor – Exposure to COPCs in soil, surface water and sediment would be expected to be complete but insignificant for residents. Although these direct exposure pathways are expected to be typically incomplete for residents since the footprint of the Transportation Corridor would not be located in residential areas, it is possible that residential recreationists may venture within the footprint of the Transportation Corridor.
- Transportation Corridor – Exposure to surface water and sediment would also be expected to be complete but insignificant for subsistence consumers.
- Pipeline – Exposure to COPCs in outdoor air would be expected to be complete but insignificant for residents and subsistence consumers due to the remoteness of the pipeline.

The following summarizes the incomplete exposure pathways that will not be carried forward into Step 2:

- Mine Site – Many of the rural communities lack municipal water and sanitation systems, and water for potable use is drawn from wells and from the Kuskokwim River. There may be groundwater sources (wells or springs) that are in use associated with residences or public camps (e.g., subsistence camps). In many areas near streams, groundwater is shallow enough to be accessed with small-diameter driven point wells that would be unlikely to be registered in public databases. A community water supply well is located in the village of Crooked Creek about 10 miles downstream of the Mine Site and 0.5 mile southwest of the confluence with the Kuskokwim River. The typical depth from which groundwater is drawn in the wells is unknown. Any effects to human health related to groundwater quality would only occur if project-related contamination were to migrate “outside the fence” and to where groundwater usage may be occurring. As discussed in Section AB.4.2.1, impacted shallow groundwater would be contained “inside the fence,” any impacted deep bedrock groundwater (>600 feet) immediately “outside the fence” after Closure would be expected to meet water quality regulatory limits and future development of groundwater wells in this area is not reasonably anticipated, especially not deep bedrock groundwater wells. As a result, exposure to COPCs in impacted shallow and deep bedrock groundwater as potable water is incomplete for all human receptors.

- Mine Site - Exposure to COPCs from use of processing reagents would be incomplete because they would not be expected to be released/transported to exposure media under anticipated Operations as discussed in Section AB.4.2.1.
- Transportation Corridor – Exposure to COPCs in soil, surface water, sediment, and biota would be expected to be incomplete for non-project commercial/industrial workers (e.g., at port locations). As presented in Section 3.2.3.2.4 (Soils), along the Kuskokwim River Corridor and at various transportation infrastructure facilities, the primary source of potential soil quality impacts are from possible spreading of pre-existing contamination due to disturbance caused by project-related activities. Although multiple existing contaminated sites are present in close proximity to the project Transportation Corridor, only one open contaminated site is within potential project infrastructure at Bethel Port and one open contaminated site at Dutch Harbor Port. The one at Bethel Port is related to a petroleum release, has an ADEC “cleanup complete” status, has been redeveloped, and little to no impacts are expected. The Dutch Harbor Port contaminated site could be impacted by third party fuel tank expansion, but BMPs, Storm Water Pollution Prevention Plan compliance and likely required remediation by the third party are expected to be effective in controlling effects on the project and protecting human health.
- Transportation Corridor – Exposure to COPCs in groundwater as potable water would be incomplete for all receptors because the transport of COPCs to groundwater would not be expected to result in any measurable changes from air deposition to soil or from the NAG waste rock used for construction since it would be tested prior to use and only non-leaching NAG rock would be used. In addition, the mine access road is too distant from residents to be a potable water source.
- Pipeline – Exposure to COPCs in soil, surface water, sediment, and biota would be expected to be incomplete for all receptors. Almost the entire length of the pipeline would be located in remote areas, distant from residential communities or other areas of frequent human use. It is noted that portions of the pipeline ROW would intersect with or be collocated with the Iditarod National Historic Trail. This collocation is not expected to introduce a human health concern due to the nature of the proposed facilities. The following summarizes why each of these media exposure pathways are incomplete:
  - Soil - As discussed in Section 3.2.3.2.4 (Soils), potential effects to soil from

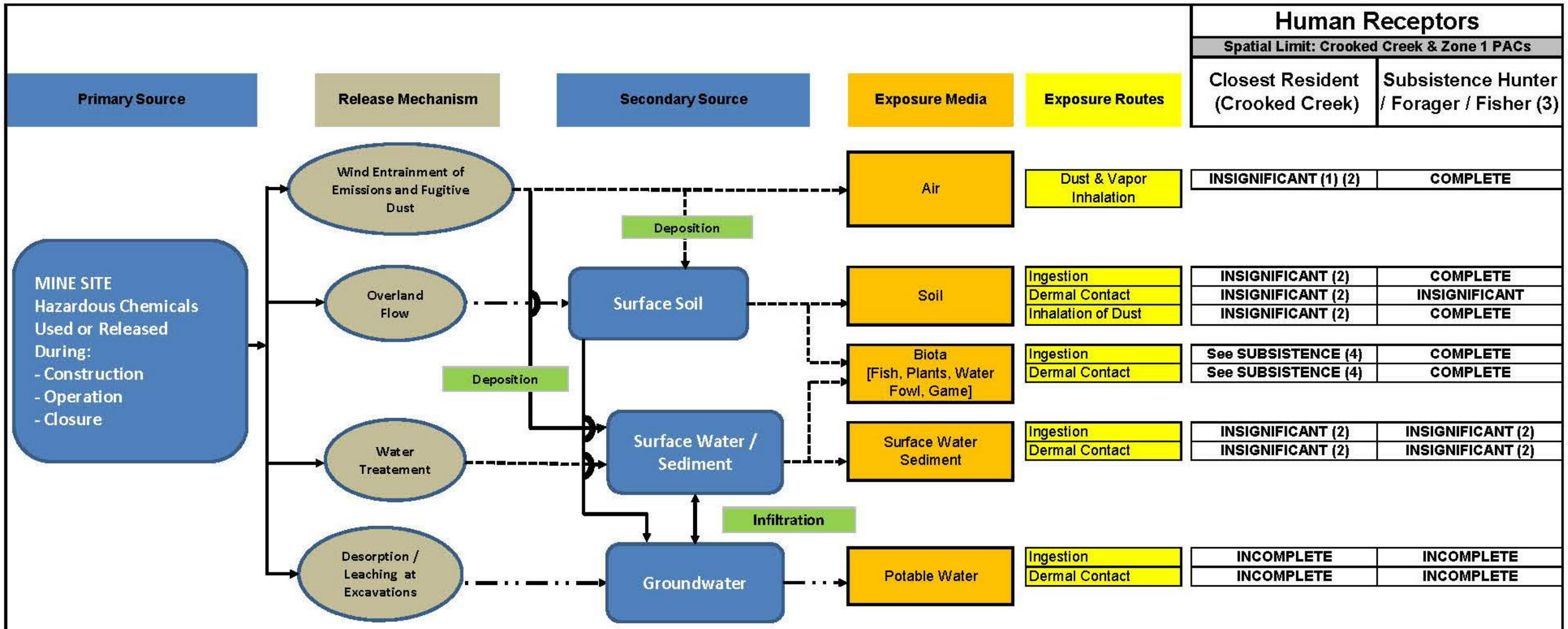
fugitive dust during pipeline ROW construction would be considered negligible because BMPs and design measures would be taken to minimize soil quality impacts, and public exposure is considered incomplete during construction. Fugitive dust emissions and deposition along the ROW would be expected to result in a redistribution of similar concentrations as baseline soils. Total dust deposition values along the Pipeline were conservatively estimated to be 0.2 and 0.01 percent accumulation at 3 feet and 330 feet from the pipeline footprint, respectively. Based on these conservative estimates, fugitive dust could result in up to a 1 percent increase in metal (e.g., arsenic) concentrations along the pipeline, but would be expected to remain similar to the range of concentrations in baseline soils. This indicates negligible potential project-related soil impacts along the ROW, which would not be expected to impact the health of the public (i.e., subsistence consumers that might utilize the area after completion of Construction).

As discussed in Section 3.2.3.2.4 (Soils), no pre-existing contaminated conditions of environmental concern have been identified along the Pipeline ROW. Although there are open contaminated sites at Beluga camp and storage yard and the Farewell airstrip, the construction activities at the Beluga camp and storage yard would not involve cuts or subsurface excavations. There is third-party responsibility for mitigation of potential soil impacts at Farewell if grading activities disturb existing petroleum-contaminated soils. Therefore, the potential soil exposure pathway for project-related activities to disturb and release pre-existing contamination is considered incomplete for all public human receptors, including non-project-related commercial / industrial workers (e.g., port workers not related to the project).

- Surface Water and Sediment – As discussed in Section 3.7, during construction discharges of the small amounts of pipeline hydrostatic test water would be required to meet the applicable Alaska Pollutant Discharge Elimination System (APDES) General Permit based on AWQC / AWQS. During Construction and Operations ESC measures and monitoring would be used to control erosion and overland flow; only temporary and localized impacts to turbidity and suspended solids (general chemistry parameters) would occur at water body crossings during construction. Conditions would return to pre-activity levels immediately afterward since the pipe would be buried below the scour potential (see Section 3.5, Surface Water Hydrology). At Closure, if the pipe were abandoned in place, then any new impacts caused by removal of the pipe would be avoided. Pipeline abandonment would follow a Pipeline Abandonment Plan, which would be developed based on standardized industry practices; including purging and cleaning (see Section 2.3.2.3.6). Based on the above discussions and that the Pipeline air pathway is insignificant, COPCs would not be expected to be released to surface water and sediment under anticipated pipeline activities.
- Groundwater - As discussed in Section 3.7.2.2.3 (Groundwater Quality), potential impacts to groundwater quality during Operations and Closure of the Pipeline would be expected to be minimal due to changes in groundwater flow and small groundwater general chemistry composition changes (SRK 2013b). For the areas along the pipeline route where groundwater depth may fall within the pipeline

burial depths, mitigation measures such as trench plugs would serve to isolate the pipeline from the groundwater and therefore prevent the potential for COPC contamination of groundwater (Section 3.6.2.2.3, Groundwater Hydrology, and Section 3.7.2.2.3, Groundwater Quality). During Closure under Alternative 2, the pipeline would be abandoned in place and no additional impacts to groundwater quality would be expected, except perhaps for the production and mobilization of minor corrosion products from the steel pipe sections. As noted, pipeline abandonment would follow a Pipeline Abandonment Plan that would be developed based on standardized industry practices, including purging and cleaning (see Section 2.3.2.3.6). Throughout all phases, groundwater quality impacts would be expected to remain below applicable regulatory criteria. Therefore, the groundwater exposure pathway is incomplete.

- Biota – With the Pipeline surface water and sediment pathways incomplete, they do not represent sources of COPCs to biota. Since the Pipeline air exposure pathway is insignificant and soil impacts from dust deposition negligible and within naturally occurring baseline ranges, biota would not be expected to uptake COPCs in measurable concentrations above baseline.



LEGEND

The CSM is based on the Proposed Alternative Two and does not evaluate exposure pathways based on accidents, spills, or failures of mitigation measures scenarios.
The proposed release, transport, and exposure to chemicals are based on potential project activities.
Resident Receptors are Crooked Creek residents approximately 10 miles from the mine site.
Project related workers, who are assumed to be covered under the project health & safety plans, and unanticipated project sources are not included in this CSM
Subsistence Receptors are likely Crooked Creek residents but may be from other villages further away.
Evaluation of Subsistence and Recreational Receptors during the active mine phases is protective of these recepters during post-closure (see Section AB.4.2.3).

Exposure Pathways: "Complete" refers to a potential exposure pathway resulting in receptor exposure of project related hazardous constituents in various media during any of the project phases. "Incomplete" refers to a potential exposure pathway with a break in the path that prevents receptors from exposure to project related hazardous constituents.

- ▬ · · ➡ Transport Pathway is incomplete due to proposed mitigation measures expected to ensure containment of groundwater and surface water run-off (Section 3.7.1.2.1) and because groundwater that could be impacted by the proposed Project is not currently or anticipated to be a future source of drinking water (Sections 3.6 and 3.7 of EIS).
- - - - - ➡ Transport pathway is complete, but insignificant based on modeled concentrations and treatment of effluent prior to discharge.
- ▬▬ ➡ Transport pathway is complete

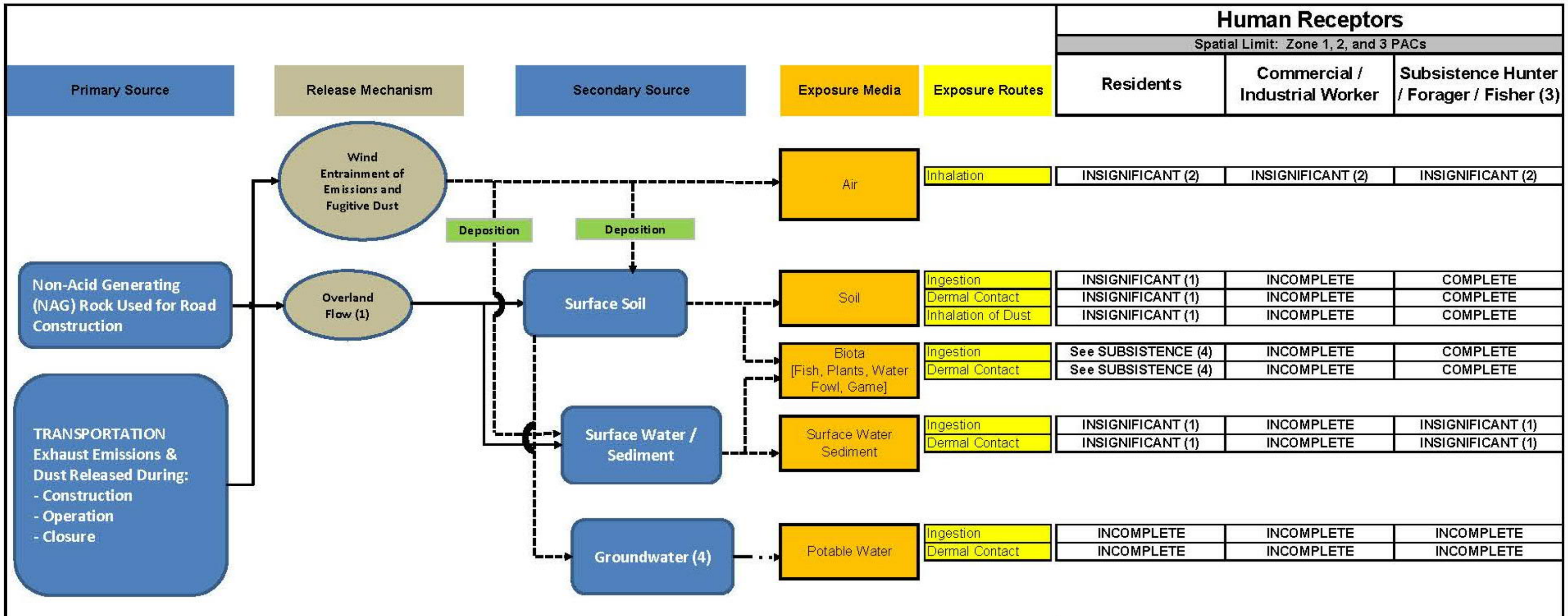
(1) Based on predicted air emmissions calculations (Air Sciences, 2014)
(2) Exposure is due to deposition transport to soil, sediment, and surface water with potential migration into biota and groundwater. Based on low modeled air concentrations of mercury (Section 3.8) [Arcadis, 2014].
(3) Exposure to subsistence receptors increases based on proximity to the Mine Site boundary. Exposure Pathway designation is for receptors close to the boundary, but dermal exposure is expected to be insignificant relative to exposure from dietary pathway.
(4) Residential exposure to harvested biota shared by subsistence users could be complete; however, this pathway is captured and evaluated under subsistence receptors
(5) Under anticipated operations, process reagents are not expected to be released to exposure media (see reagent discussions in Sections 3.2, 3.7, 3.8 and 3.24)

Conceptual Site Model

Mine Site

Figure AB.4-1

Figure AB.4-1: Conceptual Site Model, Mine Site, Human Receptors



LEGEND

The CSM is based on the Proposed Alternative Two and does not evaluate exposure pathways based on accidents, spills, or failures of mitigation measures scenarios. The proposed release, transport, and exposure to chemicals are based on potential project activities.

Resident Receptors are Crooked Creek residents approximately 10 miles from the mine site.
Commercial / Industrial Workers are located at the transportation route major ports and harbors (not Mine Site workers associated with the project).
Subsistence Receptors are likely Crooked Creek residents but may be from other villages further away.
Evaluation of Subsistence and Recreational Receptors during the active mine phases is protective of these recepters during post-closure (see Section AB.4.2.3).
Unanticipated project sources are not included in this CSM.

Exposure Pathways: "Complete" refers to a potential exposure pathway resulting in receptor exposure of project related hazardous constituents in various media during any of the phases (i.e., construction, operations, and closure). "Incomplete" refers to a potential exposure pathway with a break in the path that prevents receptors from exposure to project related hazardous constituents.

- — · · → Transport Pathway is incomplete, see footnote 4
- - - - - → Transport pathway is complete, but insignificant based on modeled concentrations (Environ, 2014)
- ——→ Transport pathway is complete

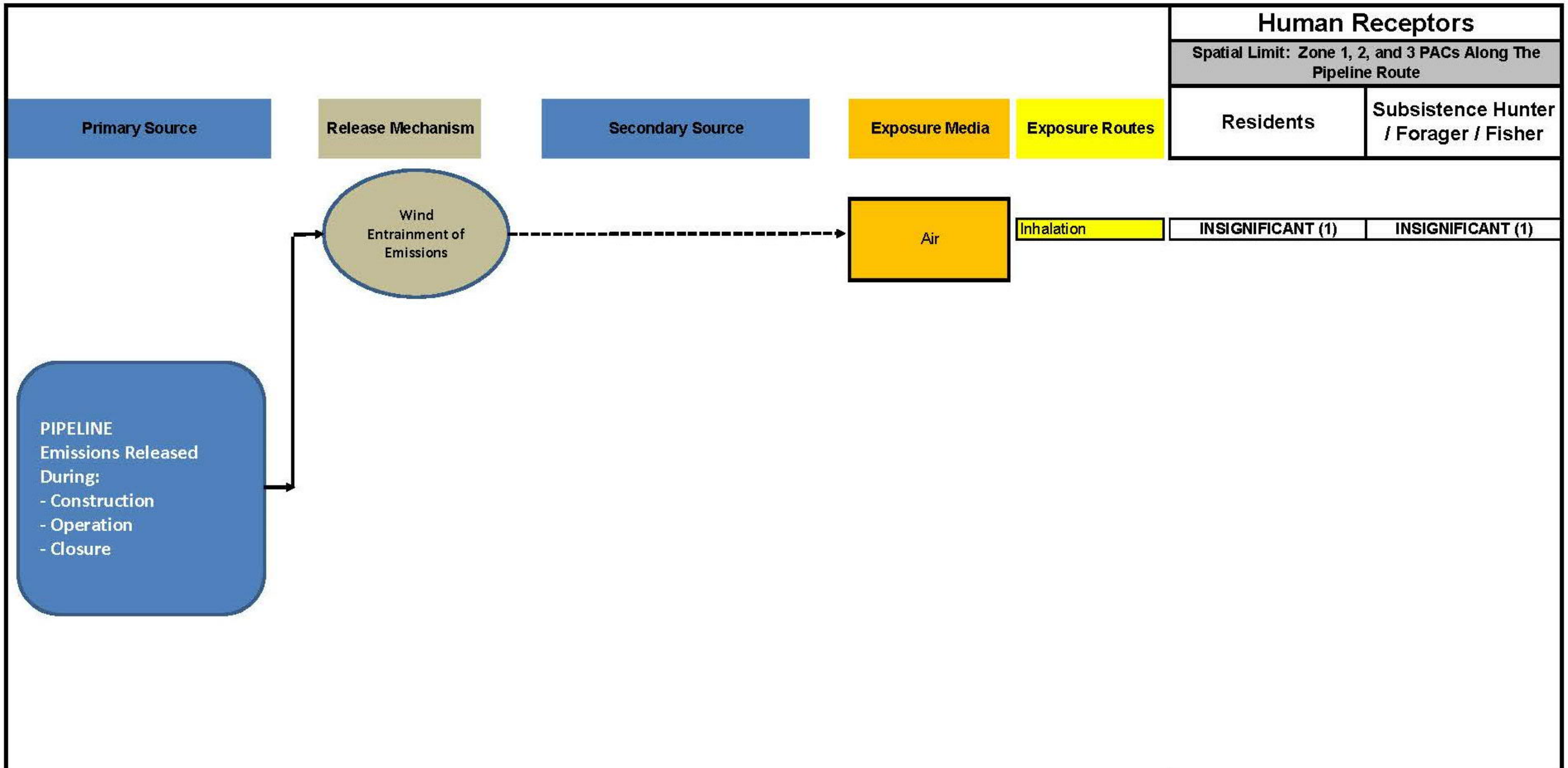
(1) This transport pathway is limited to the local Mine Site roads and only relevant to receptors nearby
(2) Impacts to air quality are expected to be below permit thresholds (Air Sciences, 2014)
(3) Exposure to subsistence receptors increases based on proximity to the Mine Site boundary. Exposure Pathway designation is for receptors close to the boundary.
(4) Residential exposure to harvested biota shared by subsistence users could be complete; however, this pathway is captured and evaluated under subsistence receptors
(5) The transport pathway for groundwater is localized near Mine Site (NAG based) roads only and therefore too distant from residents to be a potable water source.

Conceptual Site Model

Transportation Corridor

Figure AB.4-2

Figure AB.4-2: Conceptual Site Model, Transportation Corridor, Human Receptors



LEGEND

The CSM is based on the Proposed Alternative Two and does not evaluate exposure pathways based on accidents, spills, or failures of mitigation measures scenarios. The proposed release, transport, and exposure to chemicals are based on potential project activities.
Unanticipated project sources are not included in this CSM.

Exposure Pathways: "Complete" refers to a potential exposure pathway resulting in receptor exposure of project related hazardous constituents in various media during any of the phases (i.e., construction, operations, and closure). "Incomplete" refers to a potential exposure pathway with a break in the path that prevents receptors from exposure to project related hazardous constituents.

- - - - - - → Transport pathway is complete, but insignificant based on the large distances between the source to the potential receptors
———→ Transport pathway is complete

(1) Impacts to air quality are expected to be below permit thresholds (Air Sciences, 2014)
(2) Other potential exposure routes (i.e., soil, surface water, sediment, and groundwater) are incomplete or insignificant and are not illustrated on the CSM.

Conceptual Site Model

PIPELINE

Figure - AB.4-3

Figure AB.4-3: Conceptual Site Model, Pipeline, Human Receptors

AB.5 STEP 2 - SCREENING LEVEL PATHWAY EVALUATION

Step 2 of the FRA is the screening level evaluation for complete and potentially complete pathways, including those that are expected to be insignificant. This step evaluates and verifies whether the complete pathways identified in Section AB.4.2.4 and illustrated in the CSMs (Figures AB.4-1, AB.4-2, and AB.4-3) may pose a risk, relative to risk-based screening levels, and warrant further evaluation.

As noted in Sections AB.1.1 and AB.3, the approach used in the FRA generally follows the approach used to evaluate existing contaminated sites under ADEC and EPA guidance (ADEC 2015, 2016a; EPA 1989, 1991, 2002b, 2016), with modifications to be consistent with NEPA practice (i.e., disclosure of likely impacts, both negative and beneficial). The media-specific selected screening levels presented in Sections AB.5.1 through AB.5.3 are the promulgated human health-protective values from the sources noted in Section AB.3.2. As described in Section AB.3.2, the approach for selecting screening values (HQ = 1; ELCR = $1x10^{-5}$ and $1x10^{-6}$ for ADEC and EPA RSL values, respectively) maintains consistency with the EIS and NEPA practice. In addition, the cumulative and multi-media human health evaluation was conducted at the quantitative HHRA step. This modified approach avoids the worse-case, maximum approach used for screening-level risk assessments at contaminated sites under CERCLA, which may lead to an over-estimation of COPCs at the screening step from potential impacts from the proposed project.

The following sections present the media-specific screening evaluations for these exposure pathways.

AB.5.1 AIR SCREENING-LEVEL EVALUATION

Air emissions related to the project may originate from three types of sources: stationary (e.g., emissions from power plant stack, boiler, generators), mobile (e.g., exhaust from transport and construction equipment, vehicles and vessels) and fugitive (e.g., emissions from wind erosion, roads, drilling, blasting, crushing, material / ore handling, waste handling). The emissions may consist of chemicals that are in the vapor phase or particulate phase.

Air pollutants may be inhaled by members of affected communities resulting in consequences to human health. Emissions to air that may affect human health include those classified as criteria air pollutants and those classified as HAPs. There are six common criteria pollutants that the CAA requires EPA to set NAAQS for maximum allowable concentrations in outdoor air: carbon monoxide, lead, ground-level ozone, nitrogen dioxide, particulate matter, and sulfur dioxide. The standards are set at a level that protects public health with an adequate margin of safety. Hazardous air pollutants are those known to cause cancer and other serious health impacts. The CAA requires the EPA to regulate toxic air pollutants, also known as air toxics, from categories of industrial facilities. A “technology-based” approach is utilized where EPA develops standards for controlling the emissions of air toxics from sources in an industry group (or “source category”) and then periodically reviews the effectiveness of those standards to determine whether the maximum achievable control technology (MACT) standards protect public health with an ample margin of safety, and protect against adverse environmental effects. These MACT standards are based on emissions levels that are already being achieved by the controlled and low-emitting sources in an industry.

Mine Site and Transportation Corridor – Construction, Operation and Closure Phases

Air quality modeling, assuming worst-case conditions (i.e., using fuel type that yields the highest emissions allowed by the permit), was performed and is detailed in Section 3.8, Air Quality. Total annual emissions were estimated for the following criteria pollutants: ozone (precursors: oxides of nitrogen [NOx] and volatile organic compounds [VOCs]), NO_2, carbon monoxide (CO), sulfur dioxide (SO_2), lead, and PM (including PM_{10} and $PM_{2.5}$). Total annual emissions were also estimated for carbon dioxide (CO_2) and HAPs (total HAPs, as well as the individual constituents, antimony, arsenic, mercury, and hydrogen cyanide [HCN]). The total annual emissions were estimated for the following project components and phases (tables cited below are located in the EIS in Section 3.8, Air Quality):

- Mine Site Construction, Operations, and Closure from stationary, fugitive, and/or mobile sources (Table 3.8-17, 3.8-18 and 3.8-26).
- Land and Air Transportation Construction and Operations from stationary, fugitive, and/or mobile sources (Table 3.8-27 and 3.8-28); River Traffic Construction and Operations from mobile sources (Tables 3.8-29 and 3.8-31); and Ocean Traffic Construction and Operations from mobile sources (Tables 3.8-30 and 3.8-32).

In Section 3.8.3.3.1 (Air Quality), Mine Site Operations sources were evaluated with respect to air quality permitting requirements (see Table 3.8-16) including comparing potential-to-emit emissions from applicable source types to permitting thresholds. This evaluation indicates that the Mine Site Operations would be considered a Prevention of Significant Deterioration (PSD) Major Source of ozone precursors (VOCs and NOx), PMs (both PM_{10} and $PM_{2.5}$), and nitrogen dioxide (NO_2) for the area. Mine Site Operations would be considered a Title V Area source of HAPs when assessing what regulatory standards apply because the estimated total HAPs from stationary sources of 18.6 tons per year (tpy) is less than the Title V Major Source Threshold of 25 tpy for total HAPs, and individual HAPs (antimony, arsenic, lead, and mercury, and HCN) have individual estimated emissions (ranging from 0.0017 tpy to 1.9 tpy) much lower than the Title V Major Source threshold of 10 tpy for individual HAPs. Table AB.5-1 summarizes the estimated annual emissions from Mine Site Operations from stationary sources compared to permit thresholds.

Table AB.5-1: Mine Site Operations - Permit Threshold Evaluation Summary

Air Pollutant	Estimated Emissions from Stationary Sources (tpy)[1]	Permit Thresholds (tpy)[2]			Exceed Permit Threshold(s)?
		PSD Major Source	PSD Significant Rate	Title V Major Source	
CO	1,256	250	100	100	**Yes**
NOx (as O_3 precursor)	1,230	250	40	100	**Yes**
VOCs (as O_3 precursor)	1168	250	40	100	**Yes**
SO_2	23	250	40	100	No
Total PM	693	250	25	100	**Yes**
$PM_{2.5}$	367	250	10	100	**Yes**
PM_{10}	660	250	15	100	**Yes**
Total HAPs	23	--	--	25	No
Antimony	0.002	--	--	10	No
Arsenic	0.14	--	--	10	No
Lead	0.007	--	--	10	No
Mercury	0.3	--	--	10	No
HCN	2	--	--	10	No

Notes:

1 Air pollutant estimated emissions from stationary sources are from Section 3.8, Air Quality, Table 3.8-19.

2 Permit thresholds are from Section 3.8, Air Quality, Table 3.8-20.

-- = Not available PSD = Prevention of Significant Deterioration tpy = tons per year

The purpose of these permits (and thresholds) is to ensure that the project complies with the CAA for the protection of public health / welfare and the environment by controlling common air pollutants (see Section 3.8.1, Air Quality). As discussed in Section 3.8.3.3.1, Air Quality, Donlin Gold is required to obtain PSD major source and Title V air quality control permits from the ADEC for Mine Site operations since it is considered a major source for several criteria pollutants (O_3, CO, NO_2, and PMs). Title V permit requirements include monitoring, recordkeeping, and reporting to track compliance with applicable regulatory requirements. The PSD permit process would require Donlin Gold to perform an air quality impact analysis to ensure compliance with air quality standards and increments, and would require best available control technology on emission units to minimize air pollution. Human health impacts are expected to be protected through applicable MACT standards. The controls, monitoring, and reporting requirements of the PSD and Title V permits are expected to keep the facility from causing or contributing to a violation of the NAAQS, where are set at levels determined to be protective of human health.

In order to show compliance with air quality standards and increments (i.e., predicted project-related increases relative to baseline or permitting thresholds) for PSD permitting and to support the EIS (i.e., verify that human health impacts are insignificant), future ambient air concentrations during Mine Site Operations (maximum impact from stationary stack + fugitive sources + background; i.e., RME concentrations) were estimated for CO, NO_2, $PM_{2.5}$, PM_{10}, and mercury (Tables 3.8-23 and 3.8-24). Table AB.5-2 summarizes the modeled ambient air concentrations from maximum estimated impacts from Mine Site Operations for representative air pollutants and compares them to air quality standards, guidelines, and risk-based screening levels. As discussed in Section 3.8.3.3.1 (Air Quality) and shown in Table AB.5-2, estimated future ambient air concentrations during Mine Site Operations for CO, NO_2, and PMs are well below National and Alaska air quality standards, while mercury is below available EPA and WHO air quality guidelines (EPA 2014b; WHO 2003). For the purposes of the focused risk analysis, EPA's risk-based Regional Screening Levels (RSLs) for ambient air were also used as comparison levels to evaluate the potential for risks related to the inhalation pathway. Since the air quality guidelines for mercury (0.3 µg/m^3 and 0.2 µg/m^3) are equal to or less than the current risk-based EPA RSLs (0.31 µg/m^3, at HQ =1) for residential air (EPA 2016), the mercury air quality evaluation is protective of human health. Ambient mercury modeling (Table 3.8-24) shows that expected annual exposure from the Mine Site (0.00167 µg/m^3) is less than 1 percent of the most stringent air quality guideline (WHO guideline of 0.2 µg/m^3, based on no observed adverse effect); therefore, human health impacts are expected to be insignificant.

Table AB.5-2: Mine Site Operations - Ambient Air Modeling Evaluation Summary

Air Pollutant	Averaging Period	Baseline Conc. (µg/m^3)[1,2]	Total Estimated Conc. (µg/m^3)[1,2]	NAAQS/ AAAQS (µg/m^3)[1]	EPA IRIS RfC, WHO, and EPA Acute (µg/m^3)[3]	EPA Resident RSL (µg/m^3)[4]	Exceed Standard or Guideline?
CO	8-hour	457.9	3,609.4	10,000	--	--	No
	1-hour	686.9	13,412.4	40,000	--	--	No
NO_2	Annual	(included)	12.4	100	--	--	No
	1-hour	(included)	116.4	188	--	--	No
$PM_{2.5}$	Annual	2.3	3.1	12	--	--	No
	24-hour	6.8	9.9	35	--	--	No
PM_{10}	24-hour	14.1	39.8	150	--	--	No
Mercury	Annual	0.0014	0.00167	--	0.3/0.2	0.31	No
	1-hour Max	0.002	0.077	--	1700		No

Notes:

1 Criteria pollutants (CO, NO_2, PMs) total concentration = modeled maximum impact (from stationary and mobile sources) + background; see Section 3.8, Air Quality, Table 3.8-23. Criteria pollutant NAAQS/AAAQS values also from Table 3.8-23.

2 Mercury total concentration = modeled maximum (from stack and fugitive sources) + baseline at camp; see Section 3.8, Air Quality, Table. 3.8-24.

3 Annual guidelines are the EPA IRIS RfC (2014b) and WHO (2003) values (0.3 and 0.2, respectively), while the acute guideline (compared to the 1-hour Max) is the EPA acute exposure value for mercury vapor (EPA 2010b). These guideline values are also from Table. 3.8-24.

4 EPA Risk-based screening level (RSL), at HQ = 1 (EPA 2016)

-- = Not available

EPA = U.S. Environmental Protection Agency

IRIS = Integrated Risk Information System (EPA 2014b)

NAAQS/AAAQS = National/Alaska Ambient Air Quality Standards

µg/m^3 = micrograms per cubic meter

WHO = World Health Organization

As discussed in Section 3.8.3.3.2, Air Quality, during the Transportation operations phase, air emissions are primarily from non-road diesel engines and/or aircraft. Total estimated annual emissions from Transportation Operations are less than total estimated annual emissions from Mine Site Operations (see Table AB.5-3), which were shown to have modeled impacts below required thresholds. Thus, impacts are expected to meet regulatory standards.

As discussed in Section 3.8.3.3.1 and 3.8.3.3.2, Air Quality, during the Mine Site and Transportation construction and closure phases, air quality would be reduced infrequently and would be expected to return to pre-activity levels at the completion of the activity (i.e., temporary impacts). Since there are no stationary sources during Construction, and minimal emissions during Closure (Table 3.8-24 and Section 3.8 Air Quality), air permitting is not required for these phases. Best management practices will be utilized to limit air quality impacts. As shown in Section 3.8 Air Quality Table 3.8-1, the $PM_{2.5}$ (282 tons), PM_{10} (2,169 tons) and total HAP (12.3 tons) worst-case emissions from Mine Site and Land/Air Transportation Construction for the entire construction phase (3 to 4 years) is less than the annual emissions (tpy) from Mine Site and Air/Land Transportation Operations. Air emissions (tpy) from closure activities are also less than the annual emissions from operations. Table AB.5-3 summarizes emissions from Mine Site Operations emissions to emissions from other project components and phases.

Table AB.5-3. Project Emissions Comparison Summary[1]

Component	Phase	$PM_{2.5}$ (tpy)	PM_{10} (tpy)	Total HAPs (tpy)	Mercury (tpy)
Mine Site	***Operations***	***836***	***2,024***	***31***	***0.4***
	Construction	121	765	5	0.002
	Closure	49	273	2.4	0.0003
Land/Air Transportation	Construction	161	1,404	7.7	0.0031
	Operations	5	40	1	nc
River Transportation	Construction	9	9	nc	nc
	Operations	12	12	nc	nc
Pipeline	Construction	71	518	11.3	0.0013
	Operations	0.6	0.6	0.01	nc

Notes:

1 See Section 3.8, Air Quality, Tables 3.8-17, 3.8-19, 3.8-26 to 3.8-27, 3.8-28, 3.8-29, 3.8-31, and 3.8-33

nc = not calculated (negligible)   tpy = tons per year

Mine Site and Transportation Corridor emissions during the Construction and Closure phases are less than the estimated annual emissions from Mine Site Operations, on a tons per year basis. Since the Mine Site Operations emissions, based on higher tons per year emissions, have modeled impacts below required thresholds (i.e., estimated ambient air concentrations below ambient criteria), Construction and Closure impacts would be expected to meet regulatory air quality standards, which are designed to be protective of human health. Thus, air quality-related human health impacts are expected to be insignificant during these phases.

Pipeline – Construction, Operation and Closure Phases

Air quality modeling, assuming worst-case conditions, was also performed for the Pipeline and is detailed in Section 3.8.3.3.3, Air Quality. Total annual emissions were estimated for the same criteria pollutants (ozone [precursors NOx and VOCs], CO, SO_2, lead, and PMs), CO_2 and HAPs (total HAPs, as well as the individual HAPs antimony, arsenic, mercury, and HCN) as was done for the Mine Site and Transportation Corridor. The total annual emissions (tpy) were estimated for Pipeline Construction and Operations Phases from stationary, fugitive, and mobile sources (Tables 3.8-33 and 3.8-34). As discussed in Section 3.8.3.3.3, Air Quality, impacts to air quality during Pipeline Closure would be expected to be negligible and were not calculated.

The air emissions from permittable sources during Construction of the pipeline would not exceed permit thresholds (see Section 3.8.3.3.3, Air Quality). Increases in emissions due to the natural gas-fired compressor station would be subject to ADEC permitting and review process, unless they are already accounted for in the existing permit. ADEC would not permit changes in emissions that would cause or contribute to a violation of the NAAQS or AAAQS. Although some open burning may occur in remote areas, air pollutant emissions from such open burning would be minimal and would be conducted in accordance with an open burn approval as required by the ADEC (SRK 2013b; Rieser 2014c).

As shown in Table AB.5-3, the total annual estimated PM (0.6 tpy) and total HAPs (0.0004 tpy) from Pipeline emissions are far less than the annual emissions (tpy) from Mine Site and Air/Land Transportation Operations. Mine Site emissions were shown to have modeled ambient air impacts for representative pollutants below air quality standards/guidelines (Table AB.5-2). Therefore, air quality impacts from the Pipeline are also expected to meet regulatory standards/guidelines, and human health impacts would be protected.

Air Quality Summary

Inhalation of air emissions for arsenic, antimony, cyanide, lead, mercury, diesel, particulates, and other air pollutants are not expected to pose a health concern any of the potentially exposed human receptors. Based on the discussions above, residential and recreational exposure to air emissions/dust from the Mine Site are insignificant, while subsistence consumer exposure may be complete but exposure would be below air quality standards/guidelines protective of human health. Transportation Corridor air emissions/dust inhalation exposure for all potential human receptors is insignificant. Residential, recreational, and subsistence consumer inhalation exposure is likewise insignificant for the Pipeline-related air discharges. Since Step 2 represents a single-media, individual-chemical evaluation, representative chemicals (i.e., mercury, arsenic, antimony), which are anticipated to contribute the most to future media increases, were retained for further evaluation in Step 3 in order to assess potential human health impacts from multi-media and multi-chemical exposure.

AB.5.2 SOIL SCREENING-LEVEL EVALUATION

Although metals are naturally occurring minerals, anthropogenic activities (i.e., mining activities) may result in metal concentrations in soil that are elevated above naturally occurring levels and/or above levels that may be of human health concern. As discussed in Section 3.2.2.1.4 (Soils), high arsenic levels in soils from natural mineralized and volcanic sources are common in Alaska (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). Baseline concentrations of metals in soil within the Mine Site and vicinity are shown in Table AB.5-4 and are compared to ADEC Soil Cleanup Levels (at HQ=1 and ELCR=1x10^{-05})and EPA Soil Residential RSLs (at HQ=1 and ELCR=1x10^{-06}). While neither of these criteria are currently applicable to the Mine Site, consistent with the EIS approach in Section 3.2 (i.e., comparison to ADEC levels), they are listed in Table AB.5-4 for comparison purposes to provide a framework for understanding existing soil conditions and to identify any metals that are currently elevated at or near the Mine Site prior to Donlin Gold Mine activities from either naturally occurring sources or potentially other anthropogenic sources (e.g., former mines in the area).

Table AB.5-4: Concentrations of Inorganics in Baseline Soils, Mine Site and Vicinity

Analyte	Arithmetic Mean[1] (mg/kg)	95% UCL[1] (mg/kg)	Geometric Mean[1] (mg/kg)	ADEC Soil Cleanup Level[2] (mg/kg)	EPA Soil RSL[3] (mg/kg)	Baseline Conc. Exceed Criteria?
Antimony	5.35	11.1	2.08	41	31 NC	No
Arsenic	78.8	169	23.9	8.8	0.68 CR	**Yes**
Barium	480	640	380	20,000	15,000 NC	No
Beryllium	0.963	1.07	0.66	200	160 NC	No
Cadmium	0.245	0.289	0.23	92	71 NC	No
Cobalt	13.5	14.5	12.7	-	23 NC	No
Chromium, total	58.1	63.9	52.7	100,000[4]	120,000 NC, 4	No
Copper	33.9	54.1	26.3	4,100	3,100 NC	No
Lead	12.9	14.0	12.0	400	400 NC	No
Manganese	525	567	491	-	1,800 NC	No
Mercury	0.212	0.415	0.123	30/10[5]	23/7.8 NC, 5	No
Nickel	33.9	37.7	31.1	2,000	1,500 NC	No
Selenium	2.07	2.27	1.94	510	390 NC	No
Silver	0.369	0.909	0.17	510	390 NC	No
Thallium	0.535	0.592	1.36	1	0.78 NC	**Yes** - Geometric Mean Only
Uranium	2.41	2.59	3.23	-	230 NC	No
Vanadium	80.7	88.3	72.5	510	390 NC	No
Zinc	91.7	97.4	88.7	30,000	23,000 NC	No

Notes:

1 From Table 3.2-1 in Section 3.2 (Soil Quality).

2 18 AAC 75: Table B1. Method Two, Under 40-inch Zone, Human Health (ADEC 2017a) at HQ=1 and ELCR=1x10^{-05}.

3 EPA Residential Soil Regional Screening Levels (RSL; EPA 2016, May) at HQ=1 and ELCR=1x10^{-06}.

4 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).

5 Mercury guidelines are shown as mercuric chloride/methylmercury.

95% UCL = 95 percent upper confidence level NC=non-cancer

Soil quality could be impacted by Mine Site air emission deposition on surrounding soil and project-related fugitive dust settling on soil. As shown in the Mine Site and Transportation Corridor CSMs (Figures AB.4-1 and AB.4-2), members of affected communities outside the Mine Site fence may be exposed to soil impacted by the project, either directly (dermal and ingestion) or indirectly (through ingestion of subsistence foods), with the potential to result in consequences to human health. The direct soil exposure pathways are evaluated in this section of the FRA, while indirect subsistence exposure is evaluated separately for bioaccumulative chemicals in fish tissue, waterfowl, and wildlife.

The soil screening level used for thallium is subject to a high level of uncertainty, and is drawn from EPA's Provisional Peer-Reviewed Toxicity Values (PPRTV). The PPRTV reference dose for thallium is 1 x 10^{-5} mg/kg-day (EPA 2015a). In the absence of reliable human toxicity data, the provisional screening value is based on a 1988 rat study with hair follicle atrophy as the critical effect. An uncertainty factor of 3,000 was applied. Neither PPRTVs nor appendix toxicity screening values typically receive the multi-program review provided for IRIS values. Therefore, due to various critical limitations in the study, EPA presents this reference dose as a provisional screening value in Appendix A of the PPRTV document, with even more uncertainty than a PPRTV (EPA 2012c) and does not endorse this value as part of the recommended hierarchy of toxicity values. Therefore, EPA (2017b) notes that this screening level value should be used and interpreted with great caution and with recognition of the associated uncertainty. Given this high level of uncertainty in the screening value for thallium, the very minor exceedance of the geometric mean (by less than a factor of 2), is considered to be minor and health concerns related to thallium would be negligible and no further evaluation of thallium is warranted.

Mine Site During all Phases – Air Emission and Fugitive Dust Deposition to Soil

During Mine Site Operations, air emissions and fugitive dust may result in deposition of pollutants onto surrounding soil, with mercury deposition being of particular concern. Any inorganic impacts to soil would persist after closure of the mine. As discussed in Section 3.2.3.2.4 (Soils), in order to support the EIS, mercury concentrations in soil was modeled using three different statistical approaches. Since dust is expected to be generated during construction and reclamation activities, as well as during Operations, the estimates were calculated at Year 35, which includes 3 years of Construction, 28 years of Operations, and 4 years of Closure. At year 35, mercury concentrations in hallow soil at the Mine Site and vicinity were estimated (see Table AB.5-5) and potential increases range from 0.5 percent to up to 22 percent above baseline, as summarized below:

- As shown on Figure 3.2-12 in Section 3.2 (Soils), CALPUFF model estimated average mercury soil concentrations by simulating the atmospheric dispersion and deposition of the Mine Site stack emissions and fugitive dust, and indicates an increase of mercury ranging from 0.5 percent to 6 percent (ARCADIS 2014; Environ 2015; SRK 2014a).
- To explore the upper bounds of potential average exposure concentrations, the RME model estimated mercury concentrations in soil due to fugitive dust using the watershed with the highest fraction of total dust (0.55 percent at Eta-Crooked Creek Watershed) combined with conservative statistical concentrations for baseline (95 percent upper confidence limit [UCL]) and dust (arithmetic mean) concentrations. This model resulted in an estimated increase of mercury in soil of 22 percent.
- The CAM model estimated mercury concentrations due to fugitive dust using the arithmetic means for both baseline and dust, in order to identify the potential average exposure concentrations using comparable statistics. This model resulted in estimated increase of mercury in soil of 11 percent.

As discussed in Section 3.2.3.2.4, the geochemistry of baseline soils and potential dust sources, combined with comparison of baseline dust concentrations to ADEC soil cleanup levels (see

Table 3.2-4), suggests that antimony and arsenic are also metals of potential concern for soil quality. Therefore, the RME and CAM models were also used to estimate soil concentrations of antimony and arsenic at year 35. Over the life of the mine, these models result in estimated increases of up to 1.6 percent for antimony and up to 3.3 percent for arsenic (see Table AB.5-5).

Although cyanide will be emitted from the process plant and lacks baseline soil data, it is anticipated to be primarily an air quality impact and is expected to have little effect on soil quality, as discussed in Section 3.2.3.2.4 (Soils). The atmosphere is considered the ultimate sink for almost all cyanide. Although small amounts may be present in PM emissions, cyanide is not expected to persist in soil due to volatilization and biodegradation (ATSDR 2006).

Table AB.5-5: Estimated Metals Concentrations in Mine Site Vicinity Soil

Analyte/ Model Methodology[1]	Baseline Soil Concentration[2,3] (mg/kg)	Soil, Year 35		ADEC Soil Cleanup Level[4] (mg/kg)	EPA Soil RSL[5] (mg/kg)	Predicted Future Soil Conc. Exceed Criteria?
		Estimated Conc.[2,3] (mg/kg)	% Increase above Baseline			
Mercury (total)						
CALPUFF	0.0712 – 0.917	0.0716 – 0.919	0.1 - 6	30/10[6]	23/7.8[NC,6]	No
RME	0.415 (95% UCL)	0.460	11			
CAM	0.212 (mean)	0.258	22			
Antimony						
RME	11.1 (95% UCL)	11.2	0.5	41	31[NC]	No
CAM	5.35 (mean)	5.44	1.6			
Arsenic						
RME	169 (95% UCL)	171	1.2	8.8	0.68[CR]	**Yes**; as does Baseline
CAM	78.8 (mean)	81.4	3.3			

Notes:

1 CALPUFF model based on stack emissions and fugitive dust; RME and CAM models based on fugitive dust.

2 CALPUFF baseline and estimated concentrations from Figure 3.2-12 in Section 3.2 (Soils), low and high ranges of mean concentrations in soil for individual watersheds.

3 RME and CAM baseline and estimated concentrations from Table 3.2-5 in Section 3.2 (Soil Quality).

4 18 AAC 75: Table B1. Method Two, Under 40-inch Zone, Human Health (ADEC 2017a) at HQ=1 and ELCR=$1x10^{-05}$.

5 EPA Residential Soil Regional Screening Levels (RSL) (EPA 2016, May) at HQ=1 and ELCR=$1x10^{-06}$.

6 Mercury guidelines are shown as mercuric chloride/methylmercury.

95% UCL = 95 percent upper confidence level

CAM = comparable arithmetic mean   RME = reasonable maximum exposure   NC=non-cancer   CR= carcinogenic target risk

ADEC = Alaska Department of Environmental Conservation

These models incorporate conservative assumptions 1) that dust suppression for emission reduction would not occur, except in the case of unpaved roads that are assumed to be controlled at 90 percent efficiency, and 2) 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. However, the project design includes a number of BMPs that would minimize wind erosion and fugitive dust, and limit traffic and soil disturbance during construction and operations. These measures would be detailed in a Fugitive Dust Control Plan prior to construction (Rieser 2015b; BGC 2015f).

As shown in Table AB.5-5, mercury and antimony modeled future concentrations are below soil guidelines protective of human health, and these metals are not expected to pose a health concern to affected communities. Additionally, as shown in Table AB.5-5, arsenic concentrations could increase by about 2 to 5 percent in soils immediately adjacent to the Mine Site footprint. However, the lateral extent of dust deposition and arsenic contributions from mine dust based on modeling are expected to reach negligible levels within 5 to 10 miles of the Mine Site footprint (Section 3.2.3.2.4, Soils). The closest residential community to the Mine Site is Crooked Creek, located 10 miles away to the southeast. Therefore, risk to recreational and residential receptors from exposure to arsenic in soil is expected to be insignificant.

Although the modeled future concentration of arsenic exceeds the soil guidelines, arsenic concentrations commonly exceed the ADEC soil cleanup level in Alaska as concentrations are naturally elevated throughout western Alaska (illustrated by the baseline concentrations above guideline shown in the table above). Arsenic concentrations within the U.S. commonly exceed the EPA residential RSL because naturally occurring concentrations throughout the U.S. are typically above this EPA guideline. The predicted future arsenic concentrations are not substantively greater than baseline, falling within the range of natural variation in the project vicinity. However, since baseline concentrations of arsenic are above the soil screening criteria and project activities are expected to result in increases of up to 5 percent within the vicinity of the Mine Site, the incremental risk between baseline concentrations and those associated with the maximum predicted increase due to project-level inputs of arsenic warrants further evaluation in Step 3 for subsistence consumers.

Transportation Corridor During all Phases - Fugitive Dust Deposition to Soil

Dust generated during road construction and from road use during all phases 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.

As discussed in Section 3.2.3.2.4, modeling indicates that maximum dust deposition along the road will occur within the Eagle Creek watershed. Since arsenic levels are naturally elevated and in order to evaluate maximum potential project-related impacts, concentrations of arsenic in soil due to road dust deposition at the end of mine life (Year 35, inclusive of Construction, Operations, and Closure) were estimated based on baseline soil data from the Eagle Creek watershed. Since the fraction of dust expected to accumulate immediately adjacent to the road (1.9 percent) drops by an order of magnitude (0.19 percent) about 160 feet from the road, the arsenic concentrations were estimated for the two distances (see Table AB.5-6), using the RME and CAM approaches previously discussed for Mine Site, and are compared to soil guidelines.

Table AB.5-6: Estimated Arsenic Concentrations in Soil along Mine Access Road due to Fugitive Dust

Analyte/ Model Methodology[1]	Baseline Soil Concentration[2] (mg/kg)	Outcrop/ Rock Rubble[2] (mg/kg)	Soil, Year 35		ADEC Soil Cleanup Level[3] (mg/kg)	EPA Soil RSL[4] (mg/kg)	Predicted Future Soil Conc. Exceed Criteria?
			Estimated Conc.[2] (mg/kg)	% Increase above Baseline			
Arsenic – 3 feet from road							
RME	11.8 (95% UCL)	-	12.7	7.6	8.8	0.68[CR]	**Yes**; as does Baseline
CAM	9.44 (mean)	59 (mean)	10.4	10			
Arsenic – 160 feet from road							
RME	11.8 (95% UCL)	-	11.9	0.8	8.8	0.68[CR]	**Yes**; as does Baseline
CAM	9.44 (mean)	59 (mean)	9.5	1.0			

Notes:

1 RME and CAM models based on fugitive dust.

2 RME and CAM baseline, rubble, and estimated concentrations from Table 3.2-6 in Section 3.2 (Soils). The rubble samples collected along the mine access road are assumed similar to potential borrow pit material to be used as road base.

3 ADEC 18 AAC 75: Table B1. Method Two, Under 40-inch Zone, Human Health (ADEC 2017a) at HQ=1 and ELCR=1x10^{-05}.

4 EPA Residential Soil Regional Screening Levels (RSL) (EPA 2016, May) at HQ=1 and ELCR=1x10^{-06}.

95% UCL = 95 percent upper confidence level

CAM = comparable arithmetic mean RME = reasonable maximum exposure CR= carcinogenic target risk

As discussed in Section 3.2.3.2.4 (Soils) and shown in Table AB.5-6, the results indicate that arsenic concentrations could increase by about 8 to 10 percent in soils immediately adjacent to the road, but drop to a 1 percent increase 160 feet from the road (i.e., negligible). These predicted future arsenic concentrations are not substantively greater than baseline, falling within the range of natural variation in the project vicinity. Since baseline concentrations of arsenic are above the soil screening criteria and project activities are expected to result in increases of up to 10 percent within 3 feet of the roadway, the incremental risk between baseline concentrations and those associated with the maximum predicted increase due to project-level inputs of arsenic warrants further evaluation in Step 3 for subsistence consumers.

As presented in Section 3.2.3.2.4 (Soils), mercury results for the road location are estimated to be the same as those described above under Mine Site because the Eagle Creek watershed (with the highest predicted Mine Site dust impacts) is located within the boundaries of the Mine Site evaluation. Therefore, health concerns from mercury dust deposition along the mine access road are not expected because mercury concentrations are expected to be well below soil guidelines (see Table AB.5-5). Antimony in baseline soil is not elevated with respect to ADEC levels for potential road dust sources; therefore, it was not included for mine access road dust deposition analysis and health concerns are not expected.

The dust deposition models are conservative and do not take into account measures that will be used to minimize the level and extent of fugitive dust effects, which will include evaluation of metal leaching potential of roadway material prior to construction and planned mitigation BMP measures for dust control (e.g., water trucks). Leaching testing methods that will be utilized to evaluate metal leaching potential of roadway material includes bulk geochemistry, meteoric water mobility procedure (MWMP), and acid-base accounting (ABA). For further details on waste rock evaluations, see Section 3.7.2.4.1 (Water Quality).

Summary

Soil Quality impacts in the vicinity of the Mine Site and along the Transportation Corridor are not expected to pose a health concern to nearby residents, recreationalists or subsistence consumers from antimony or mercury. Based on the discussions above, residential and recreational exposure to potentially impacted soil from the Mine Site are insignificant. While subsistence consumer soil exposure from Mine Site activities may be complete, project related impacts are generally within the natural variation of background and predicted soil concentrations of mercury and antimony would be below soil quality guidelines. Transportation Corridor soil exposure for residential and recreational exposure is insignificant, and subsistence consumer exposure is complete but likewise negligible compared to baseline concentrations for antimony and mercury. Although future predicted arsenic concentrations in soil in the vicinity of the Mine Site and Transportation Corridor are not substantively greater than background, further evaluation arsenic is warranted in Step 3 (i.e., quantitative incremental risk evaluation) for subsistence consumer exposure. In addition, since Step 2 represents a single-media, individual-chemical evaluation, representative chemicals (i.e., mercury, arsenic, antimony), which are anticipated to contribute the most to future media increases, were retained for further evaluation in Step 3 in order to assess potential human health impacts from multi-media and multi-chemical exposure.

AB.5.3 WATER SCREENING-LEVEL EVALUATION

"The State of Alaska has some of the highest levels (up to 10,000 µg/liter) of naturally occurring arsenic in drinking water in the U.S." (Harrington et al. 1978, as cited in Newfields 2015). Due to naturally occurring elevated concentrations of some metals (e.g., arsenic), historic mining at Red Devil mine, and other anthropogenic sources (e.g., former mines), lengths of the middle Kuskokwim River exceed screening levels for mercury, arsenic, and antimony which affect water quality and forces fish advisories (ADHSS 2010, as cited in Newfields 2015). While no water bodies in the EIS Analysis Area are listed as impaired under Section 303(d) of the federal Clean Water Act, the Kuskokwim River is listed as a Category 5 impaired water body under state water quality standards at the outflow of Red Devil Creek. The designation extends 100 feet upriver to 900 feet downriver from the confluence of Red Devil Creek and the Kuskokwim River. This designation requires a Total Maximum Daily Load technical analysis to calculate pollution reductions. See Section 3.7, Water Quality, for additional information on this topic.

As shown in the Mine Site, Transportation Corridor, and Pipeline CSMs (Figures AB.4-1 through AB.4-3), members of affected communities may be exposed to surface water bodies impacted by the project, either directly (ingestion and incidental dermal) or indirectly (through ingestion of plants, fish, invertebrates, and wildlife), with the potential to result in consequences to human health. The direct water and sediment exposure pathways are evaluated in this section of the FRA, while indirect subsistence exposure is evaluated separately for bioaccumulative chemicals in fish tissue, waterfowl, and wildlife. As mentioned in Section AB.2.2, none of the surface water bodies in the vicinity of the Mine Site are known to be used for potable water supply purposes, although periodic use by subsistence consumers could occur. Crooked Creek will be monitored during all project phases (Construction, Operations, and Closure) and Post-Closure as a mitigation measure to reduce potential human health impacts (as described in Section 3.22.4.2.10), with associated contingency measures (see Section 3.22.4.2.11 and Chapter 5). The closest known use of surface water for potable purposes is at the

Kuskokwim River downstream from its confluence with Crooked Creek (see Section 3.7.2.1, Water Quality, and Section 3.5, Surface Water Hydrology).

Mine Site Operations

During Mine Site Operations, the primary industrial uses of site water would be from groundwater related to dewatering, and well water and surface water from Snow Gulch for contact and processing. Pit dewatering water, contact, and process waters would be collected and reused for processing. As designed, Donlin Gold would not discharge excess mine-contacted waters without treatment to AWQC. Surface water from the creeks in the vicinity of the Mine Site is not used for water supply purposes; the nearest residences are in Crooked Creek which is 10 miles away, and the nearest use of surface water for potable purposes is the Kuskokwim River. Water from the Kuskokwim River is considered fit for all purposes, including drinking and several villages between Crooked Creek and Bethel draw drinking water directly from the river (Section 3.7.2.1.2, Water Quality). See Sections 3.7.1.1, 3.7.2.1, and 3.7.2.2 (Water Quality), for further details on water quality regulations and programs. As described in Section 3.7.3 (Water Quality), other changes that may occur during Operations, such as reduced flows to Crooked Creek and geochemical changes to wetlands along the creeks, are not expected to result in changes to surface water quality that would be different from baseline conditions or affect human health.

Surface Water and Sediment – This subsection presents the Mine Site Operations impacts on surface water and sediment from Mine Site effluent and air emissions. Table AB.5-7 presents the maximum concentrations (i.e., RMEs) predicted in the treated effluent from the Mine Site WTP that will be discharged to American Creek and subsequently Crooked Creek during the Operations phase. Active management (treatment) of the effluent for metals and total dissolved solids (TDS) would be required to produce treated effluent that would conform to the AWQC limitations for protection of both ecological and human health under the APDES permit.

WTP effluent would then be diluted as it mixes with the American and Crooked Creek waters, and further diluted when it connects with the Kuskokwim River. As discussed in Section 3.5.2 (Surface Water Hydrology), the WTP effluent would be discharged during the summer operational period (approximately six-months from June to October). The relative flow rates of the effluent compared to these water bodies are worth presenting, as they demonstrate the relative flows, impacts, and effluent dilution. During the summer months (June to October), the effluent predicted annual discharge during Mine Site Operations is 2.88 cubic feet per second (cfs, converted from 1,293 gallons per minute presented in Section 3.7.3, Water Quality,) compared to American Creek, with average monthly ranges of 2.8 to 20.6 cfs, Crooked Creek, with average monthly ranges of 54 to 334 cfs, and Kuskokwim River, with an average flow of 73,900 cfs at the confluence with Crooked Creek (see Section 3.5.2, Surface Water Hydrology).

Table AB.5-7: Mine Site Operations Water Treatment Plant Effluent Evaluation

Parameter	Units	Predicted Maximum Conc. in Treated Effluent[1]	Average Baseline Surface Water[1]	Alaska Water+ Organism Criteria[2]	Alaska Water Criteria[3,4]	EPA Resident Tapwater[5]	Treated Water Exceeds Criteria?
General Chemistry Parameters							
pH	units	6.5-8.5	7.23	--	6.5-8.5	--	No
Ammonia	mg/L	0.5	0.062	--	--	--	--
Chloride	mg/L	1	1.66	--	250	--	No
Sulfate	mg/L	60	21.5	--	250	--	No
TDS	mg/L	240	142	--	500	--	No
TSS	mg/L	1	15.9	--	20	--	No
Pollutant Parameters							
Aluminum	µg/L	50	288	--	5,000 IW	20,000 NC	No
Antimony	µg/L	5	0.57	14	6 DW	6 MCL	No
Arsenic	µg/L	6	7.21	--	10 DW	0.052 CR	No for AWQC, Yes for EPA Tapwater,
Barium	µg/L	400	60.9	--	2,000 DW	2,000 MCL	No
Beryllium	µg/L	0.59	0.2	--	4 DW	4 MCL	No
Boron	µg/L	50	18.4	--	750 IW	4,000 NC	No
Cadmium	µg/L	0.11	0.28	--	5 DW	5 MCL	No
Chromium, total	µg/L	2	1.13	--	100 DW	100 MCL	No
Cobalt	µg/L	1	2.01	--	50 IW	6 NC	No
Copper	µg/L	1	0.59	1,300	200 IW	800 NC	No
Iron	µg/L	50	662	--	5,000 IW	14,000 NC	No
Lead	µg/L	1	0.28	--	50 SW	15 NC/MCL	No
Lithium	µg/L	170	5.41	--	2,500 IW	40 NC	No for AWQC, Yes for EPA Tapwater
Manganese	µg/L	50	107	50	200 IW	430 NC	No
Mercury	ng/L	12	5.77	50	2,000 DW	2,000 NC/MCL	No
Molybdenum	µg/L	5	4.76	--	10 IW	100 NC	No
Nickel	µg/L	5	1.13	610	200 IW	390 NC	No
Nitrate	mg/L	5	0.52	--	10 DW	10 MCL	No
Selenium	µg/L	5	2.48	170	10 SW	50 MCL	No
Thallium	µg/L	0.58	0.5	1.7	2 DW	0.2 NC	No for AWQC, Yes for EPA Tapwater
Vanadium	µg/L	8.4	9.88	--	100 IW	86 NC	No
WAD Cyanide	µg/L	5	2.45	700	200 DW	1.5 NC	No for AWQC, Yes for EPA Tapwater
Zinc	µg/L	20	4.29	9,100	2,000 IW	6,000 NC	No

Notes:

1 Predicted Water Treatment Plant Effluent and Average Baseline Surface Water for Category 2 from Table 3.7-39. Source: Hatch 2017, Table 4-5; SRK 2017b

2 Alaska Water Quality Criteria (AWQC), Human Health for Consumption of Water + Organism (ADEC 2008).

3 Alaska Water Quality Standards (ADEC 2017b) for general chemistry parameters (pH, ammonia, chloride, sulfate, TDS, TSS).

4 AWQC (ADEC 2008) for pollutants (aluminum through zinc); the lowest of drinking water (DW), stock water (SW), and Irrigation Water (IW) is shown and noted, above, as promulgated.

5 EPA Resident Tapwater Regional Screening Levels (EPA 2016); the lowest of the maximum contaminant level (MCL), carcinogenic target risk for 1E-06 (CR), and non-cancer child target HQ of 1 (NC) is shown and noted, above.

WAD = Weak Acid Dissociable

It is worth emphasizing that the human health-based AWQC values are intended to be protective of long-term water consumption and even if a short-term exceedance were to occur, this would not necessarily result in adverse health effects. Of the predicted Operational WTP effluent parameters, none exceed the AWQC for protection of human health. When compared to the EPA Tapwater RSL (at HQ=1 and ELCR=$1x10^{-06}$), arsenic, lithium, thallium, and WAD cyanide exceed the residential Tapwater RSL. The arsenic maximum predicted WTP effluent concentration is below the average baseline surface water concentration, while thallium and WAD cyanide maximum predicted WTP effluent concentrations are slightly above the average baseline surface water concentrations. Lithium maximum predicted WTP effluent concentration is above both the EPA Tapwater RSL and the average baseline surface water concentrations, but over an order of magnitude less than the AWQC. Further, it should be noted that the EPA Tapwater RSL for lithium is based on a provisional oral toxicity value in which EPA has only low to medium confidence (EPA 2008). Therefore, there is a high degree of uncertainty and conservatism that has been incorporated into evaluating of toxicity at low concentrations. Comparison to EPA Tapwater RSL is highly conservative since the WTP effluent will not be directly used as drinking water. As noted earlier, Crooked Creek is not a potable water source for affected communities and dilution of the effluent within American Creek, Crooked Creek, and subsequently within the Kuskokwim is expected to result in concentrations for all chemicals (including arsenic, lithium, thallium, and WAD cyanide) at concentrations similar to background, less than AWQC, or less than EPA RSLs. Therefore, human health impacts from Mine Site Operations WTP effluent are expected to be insignificant and/or indistinguishable from background.

As detailed in the Section AB.5.1, air quality impacts from mercury and other pollutants would be expected to meet regulatory standards and human health impacts would be expected to be insignificant. To support the EIS and verify that human health impacts would be insignificant, conservative future estimates of the potential changes in mercury concentrations in surface water and sediment due to atmospheric deposition resulting from activities proposed under Alternative 2 were developed (ARCADIS 2014), as described in Sections 3.7.2.2 and 3.7.2.4 (Water Quality). The study area for the model included the Hydrologic Unit Code (HUC) 12 watershed in which the Mine Site would be located, as well as the surrounding watersheds in the area where potential for deposition would occur. Baseline and modeled surface water and sediment concentrations from project operations are detailed in Section 3.7.2.1 and summarized in Tables AB.5-8 and AB.5-9. Tables AB.5-8 and AB.5-9 also present the selected promulgated Alaska and EPA criteria for mercury (at HQ=1).

Table AB.5-8. Evaluation of Mercury in Surface Water for the Mine Site Study Area Watersheds

Exposure Point Concentration	Baseline Conc. (ng/L)		Estimated Future Watershed[5] Conc. (ng/L)		Alaska Water+ Organism Criteria[3] (ng/L)	Alaska & EPA Tapwater Criteria[4] (ng/L)	Exceeds Criteria?
	Total Mercury[1]	Methyl-mercury[2]	Total Mercury[1]	Methyl-mercury[2]			
Average	7.81	0.280	11.4	0.398	50	2,000	No
95% UCL	23.5	--	33.4	--			No

Notes:

1 Total mercury surface water average and 95%UCL concentrations (baseline and estimated from Mine Site Operations) are from Table 3.7-41 in Section 3.7, Water Quality.

2 Average methylmercury concentrations were estimated as detailed in Section 3.7.2.2.2, Surface Water Quality.

3 Alaska Criteria = Alaska Water Quality Criteria for Human Health Consumption of Water + Aquatic Organisms for inorganic mercury (ADEC 2008).

4 EPA Criteria = EPA Residential Tapwater Regional Screening Level (RSL) for total mercury (salts) and methylmercury (EPA 2016) at HQ=1, and Alaska Water Quality Criteria for Drinking Water for total mercury (ADEC 2008) at HQ=1.

5 Mine Site Study Area HUC 12 Watersheds: Crooked Creek, Donlin Creek, Flat Creek, Grouse Creek, West Juningguira Mountain, Getmuna Creek, and Bell Creek.

Table AB.5-9. Evaluation of Total Mercury in Sediment for the Mine Site Study Area Watersheds

HUC 12 Watershed	Average Baseline Total Mercury Conc. (µg/kg)	Estimated Future Average Total Mercury Conc. at 27 years (µg/kg)	% Increase at 27 years	WA Sediment Methyl-mercury Criteria[2] (µg/kg)	EPA Soil Mercury Criteria[3] (ug/kg)	Exceeds Criteria?
Crooked Creek	N/A	N/A	N/A	64,000	23,000[4] (salts) 7,800 (methyl)	No
Donlin Creek	173	175	1.2%			No
Grouse Creek	236	238	0.6%			No
Flat Creek	238	238	0.4%			No
Bell Creek	205	206	0.2%			No
Village Creek	43	43	0.8%			No

Notes:

1 Total mercury sediment baseline and modeled future average concentrations are from Table 3.7-44 in Section 3.7, Water Quality.

2 Washington Sediment Cleanup User's Manual II, Table 9-2, Human Health risk-based mercury sediment concentrations for ingestion of and direct contact with sediment (Ecology 2017) at HQ = 1. The lowest methylmercury risk-based sediment concentration was selected and is based on child beach play (more conservative than adult subsistence clam digging and adult subsistence net fishing).

3 EPA Criteria = EPA Residential Soil RSL for mercury (elemental) and methylmercury (EPA 2016) at HQ = 1.

These estimates represent the upper limit of potential changes in mercury concentrations in surface water and sediment resulting from the activities proposed under Alternative 2. Future estimated surface water concentrations are expected to be below the AWQC protective of human health for consumption of water and organism for inorganic mercury and below the drinking water standard for both methyl- and inorganic mercury (Table AB.5-8). Other air pollutants from Mine Site emissions are expected to meet air quality regulatory standards, as was presented in the Air Quality FRA, and adverse effects to human health are likewise expected to be insignificant from direct contact with and ingestion of surface water and sediment.

However, since the consumption-based AWQC is based on inorganic mercury and not methylmercury (see Table AB.5-8), and other pollutants have the potential to bioaccumulate in fish and other wildlife which may affect human health by consumption of contaminated subsistence foods, this exposure pathway (via subsistence foods) is addressed further in a separate FRA for bioaccumulative chemicals in fish tissue, waterfowl, and wildlife.

Mine Site Closure

As described in Sections 3.7.3.2.2 and 3.7.3.2.4 (Water Quality), concurrent and final reclamation of WRF, TSF, remaining overburden stockpiles, and associated disturbed areas would be designed to manage stormwater runoff and reduce infiltration. At mine closure, contact water would be managed and low permeability covers installed so that release of leachate from the waste rock and tailing facilities is controlled, although some infiltration and seepage through the unlined WRF and then to the pit lake is expected to continue in post-closure.

Surface Water and Sediment - After closure of the mine, all Mine Site contact water (runoff, TSF, WRF, and seepage recovery system water), including onsite impacted groundwater seepage from the WRF, would be retained and collected on site in the pit lakes. The pit lakes would slowly fill, and discharge to surface water bodies would not be allowed until the collected water within the pit lakes met AWQC. Water treatment would begin 2 to 3 years prior to the pit lake filling (approximately 52 years following closure). As discussed in Section 3.7.3.2.1 (Water Quality), assumptions regarding the weathering of pit lake highwall rock produce substantial differences in metals concentrations from those during Mine Site Operations; therefore, pit lake surface water and post-closure WTP effluent was predicted during the modeled post-closure treatment period (approximately 52 years following closure when treatment is expected to begin until 99 years after closure). Table AB.5-10 presents the predicted Pit Lake WTP effluent concentrations after closure of the Mine that would discharge directly to Crooked Creek at a predicted post-closure annual discharge of 6.5 cfs (converted from 2,916 gallons per minute presented in Section 3.7.3, Water Quality).

Table AB.5-10. Mine Site Post-Closure Pit Lake Treated Water Effluent Evaluation

Parameter	Units	Predicted Treated Water[1]	Average Baseline Surface Water[2]	Alaska Water+ Organism Criteria[3]	Alaska Water Criteria[4,5]	EPA Resident Tapwater[6]	Treated Water Exceeds Criteria?
General Chemistry Parameters							
pH	units	6.5-8.5	7.23	--	6.5-8.5	--	No
Sulfate	mg/L	31	21.5	--	250	--	No
TDS	mg/L	139	142	--	500	--	No
Pollutant Parameters (dissolved)							
Aluminum	µg/L	1.3	288	--	5,000 [IW]	20,000 [NC]	No
Antimony	µg/L	0.040	0.57	14	6 [DW]	6 [MCL]	No
Arsenic	µg/L	0.18	7.21	--	10 [DW]	0.052 [CR]	Yes (EPA), but < AWQC & Baseline
Barium	µg/L	13	60.9	--	2,000 [DW]	2,000 [MCL]	No

Table AB.5-10. Mine Site Post-Closure Pit Lake Treated Water Effluent Evaluation

Parameter	Units	Predicted Treated Water[1]	Average Baseline Surface Water[2]	Alaska Water+ Organism Criteria[3]	Alaska Water Criteria[4,5]	EPA Resident Tapwater[6]	Treated Water Exceeds Criteria?
Boron	µg/L	194	18.4	--	750 IW	4,000 NC	No
Cadmium	µg/L	0.030	0.28	--	5 DW	5 MCL	No
Chromium, total	µg/L	4.2	1.13	--	100 SW	100 MCL	No
Cobalt	µg/L	<3	2.01	--	50 IW	6 NC	No
Copper	µg/L	0.0235	0.59	1,300	200 IW	800 NC	No
Iron	µg/L	<1,000	662	--	5,000 IW	14,000 NC	No
Lead	µg/L	2.0	0.28	--	50 SW	15 NC/MCL	No
Manganese	µg/L	0.397	107	50	200 IW	430 NC	No
Mercury	ng/L	11	5.77	50	2,000 DW	2,000 NC/MCL	No
Molybdenum	µg/L	<0.473	4.76	--	10 IW	100 NC	No
Nickel	µg/L	0.40	1.13	610	200 IW	390 NC	No
Selenium	µg/L	1.41	2.48	170	10 SW	50 MCL	No
WAD Cyanide	µg/L	<0.1	2.45	700	200 DW	1.5 NC	No
Zinc	µg/L	7	4.29	9,100	2,000 IW	6,000 NC	No

Notes:

1 Post-Closure Modeled Pit Lake Water Treatment Plant Effluent from Table 3.7-42 (Water Quality) and Table 4.2-5 in the 2013 Environmental Evaluation Designation (ARCADIS 2013a).

2 Average Baseline Surface Water for Category 2 from Table 3.7-39 and Table 3.7-3 (dissolved).

3 Alaska Water Quality Criteria (AWQC), Human Health for Consumption of Water + Organism (ADEC 2008), as promulgated.

4 Alaska Water Quality Standards (ADEC 2017b) for general parameters (pH, ammonia, chloride, sulfate, TDS), as promulgated.

5 AWQC (ADEC 2008) for chemicals (aluminum through zinc); the lowest of drinking water (DW), stock water (SW), and Irrigation Water (IW), as promulgated, is shown and noted, above.

6 EPA Resident Tapwater Regional Screening Levels (RSL; EPA 2016); the lowest of the maximum contaminant level (MCL), carcinogenic target risk for 1E-06 (CR), and non-cancer child target HQ of 1 (NC) is shown and noted, above.

Of the predicted Closure WTP effluent parameters, none exceed the AWQC for protection of human health. It is worth emphasizing that the human health-based AWQC values are intended to be protective of long-term surface water consumption, not in the Mine Site or associated creeks, but only after confluence with the Kuskokwim River. Therefore, even if a short-term exceedance were to occur in the local surface water, this would not necessarily result in adverse health effects. Only arsenic is expected to exceed the EPA resident Tapwater RSL, but arsenic is well below baseline concentrations. Since Closure WTP effluent discharges would be below AWQC protective of human health, arsenic would be below baseline, and the effluent would be further diluted once discharged to Crooked Creek (see discussion under Mine Site Operations effluent discharges), human health impacts from WTP effluent into Crooked Creek would be expected to be insignificant and indistinguishable from background.

Transportation Corridor Construction

Under Alternative 2, construction activities would take place over a 3-year period and potential impacts to surface water would come from runoff from construction materials, and erosion and sedimentation. As discussed in Section 3.7.2.2, Surface Water Quality, and Section 3.7.2.4, Sediment Quality, in order to address these potential impacts to surface water quality, BMPs and ESC measures will include:

- Materials that could act as sources of contamination along the Transportation Corridor would be tested prior to stockpiling and use for construction. If materials could act as sources of contamination, they would not be stockpiled or used as road construction material (i.e., only NAG waste rock that does not indicate leaching potential would be used for road construction). For further discussions on waste rock characteristics and testing, see Sections 3.7.1.4.1 (Water Quality) and 3.2.3.2.4 (Soils).
- BMPs and ESC measures would be used to minimize potential erosion and sedimentation effects, ensure receiving bodies comply with AWQC, and prevent degradation of wetlands and water bodies during Construction. Although ESC would be used, localized impacts (turbidity and suspended solids) to surface water bodies would occur from construction at water body crossings. However, turbidity and suspended solids would be expected to return to pre-activity levels immediately following the cessation of the construction activities at the crossings.

With these BMPs and ESC measures, surface water and sediment quality impacts from Transportation Corridor would be expected to be minimized and generally meet regulatory standards, with exception of temporary and localized impacts of turbidity and suspended solids during Construction at water crossings. Based on this analysis, human health impacts would be expected to be insignificant during the Construction Phase.

Transportation Corridor – Operations and Closure Phases

Surface Water and Sediment - As discussed above in the Construction sub-section and detailed in Section 3.7.3 (Water Quality), NAG waste rock used for Transportation Corridor roadway construction would be tested for metal leaching potential prior to stockpiling/use and material that could act as a source of contamination would not be used for road construction. Therefore, the use of NAG waste rock would not be expected to be a significant source of metals to surface water bodies adjacent to roadways that might receive runoff, and impacts to human health (e.g., subsistence users) would not be expected to be of concern.

Water Quality Summary

Water quality impacts would not be expected to pose a health concern to residents, subsistence consumers, and non-project-related commercial/industrial workers. Based on the discussions presented above, residential, recreational, and subsistence consumers exposure to surface and sediment potentially impacted from the Mine Site would be complete but insignificant. Transportation Corridor surface water and sediment exposure for residential, recreational, and subsistence consumer exposure would be complete but insignificant. Since Step 2 represents a single-media, individual-chemical evaluation, representative chemicals (i.e., mercury, arsenic, antimony), which would be anticipated to contribute the most to future media increases, were retained for further evaluation in Step 3 in order to assess potential human health impacts from multi-media and multi-chemical exposure.

AB.5.4 TISSUE SCREENING-LEVEL EVALUATION

Consumption of local subsistence foods (fish, waterfowl, small and large mammalian wildlife, and fruits and berries) is an important part of the diet of the local communities. Deposition on, and uptake/bioaccumulation of project-related contaminants by these natural resources may potentially occur due to project impacts to the aquatic and terrestrial environments. Stakeholder concerns have been expressed regarding this potential threat to human health, particularly based on the potential bioaccumulation of project-related contaminants such as mercury by subsistence consumers and recreational harvesters.

Deposition onto fruits and berries could potentially occur through emissions and fugitive dust. Fish may be directly exposed to potentially impacted surface water and sediment, as well as through their diet (ingestion of aquatic prey that has taken up project-related contamination). Waterfowl and wildlife may uptake and bioaccumulate project-related chemicals through inhalation of potentially impacted air, and direct contact with and/or ingestion of potentially impacted media (soil, water, sediment) or through diet (vegetation and/or prey that has taken up project-related contamination).

Of the primary air pollutants from Mine Site Operations emissions (see Table AB.5-1), arsenic, lead, and mercury are considered bioaccumulative by ADEC (2017c). However, since estimated emissions of lead from stationary sources are more than three orders of magnitude less than the permit threshold levels, and baseline lead levels in soil are more than an order of magnitude less than both the ADEC cleanup level and EPA residential RSL, lead is not expected to accumulate in media or biota at levels that would pose unacceptable risk to subsistence consumers.

Arsenic and mercury (in addition to antimony, which is not considered bioaccumulative) would be expected to increase concentrations in soil within the vicinity of the Mine Site and the Transportation Corridor from emissions and fugitive dust (see Section AB.5 and Tables AB.5-5 and AB-6). However, the large terrestrial mammalian wildlife species that are of interest to subsistence hunters in the EIS Analysis Area (e.g., moose, caribou, black bear; see Table 3.21-3 in Section 3.21.5.2, Subsistence) are generally not a concern for bioaccumulation of chemicals from soils and vegetation. As described in Section 3.12.2.2.1 (Wildlife), the moose and caribou are herbivorous and the black bear has a diet comprised primarily of new plant growth in spring, berries during summer, and spawning salmon during summer and fall (Johnson 2008). These large mammals typically have sizable foraging areas where feeding on vegetation from the vicinity of the Mine Site would be only a minor portion of their range and diet. Therefore, quantifying incremental risks to receptors with large home ranges would be subject to a high level of uncertainty. As anadromous species, salmon spend most of their lives and acquire most of their body mass in the ocean, outside of the Study Area. Salmon occur in the project area only as juveniles, when they are consuming prey from lower trophic levels, and as spawning adults that are not in a feeding stage and therefore not accumulating contaminants from prey. Thus, salmon are poor barometers of project-related contamination. Based on all of the above, there is low likelihood that consumption of large subsistence game (e.g., moose, caribou, black bear) would result in human health impacts from the project distinguishable from baseline. Unlike large terrestrial mammals, small mammals, such as the beaver, have foraging ranges less than the Mine Site area and may be harvested and consumed; therefore, they could potentially be exposed to bioaccumulative project-related contaminants (i.e., arsenic, mercury) at levels that could warrant risk evaluation for subsistence consumers.

Fugitive dust could be deposited directly on berries, and roots could take up metals from soils impacted by emissions and fugitive dust in the vicinity of the Mine Site and Transportation Corridor. Although most berry picking by residents of Crooked Creek likely takes place in areas away from the Mine Site and Transportation Corridor where deposition modeling shows that dust levels are expected to be negligible (see Sections 3.2, Soils; 3.10, Vegetation; and 3.21, Subsistence), this exposure pathway was retained for further quantitative evaluation in Step 3.

As noted in Section 3.12.3 (Wildlife), standing water bodies would have varying levels of inorganic constituents, with the TSF likely to have higher concentrations of antimony, arsenic, and selenium than the pit lake. The TSF would be characterized by on-going mining activity during the Operations Phase, and would be unlikely to support growth of vegetation or invertebrates that might serve as food sources for waterfowl. Without food sources and with the expected short durations of visits to the pit lakes, waterfowl are unlikely to stay long in the TSF. Migratory waterfowl are not expected to be at risk from ingestion of toxic water, food or sediment at the Mine Site water storage features. However, emissions and fugitive dust could be deposited and/or transported into other surface water bodies within the vicinity of the Mine Site and Transportation Corridor, and subsequently taken up by aquatic biota. As discussed above, the bioaccumulative chemicals from emissions and dust are arsenic and mercury; these metals have the potential to accumulate in fish and waterfowl and subsequently consumed by subsistence populations.

Diesel exhaust, which would be generated from all project components, is not listed as a bioaccumulative chemical due to the fact that diesel exhaust is comprised of various chemicals, the majority of which are VOCs and polycyclic aromatic hydrocarbons (PAHs). Most VOCs are not considered bioaccumulative, with the exception of three chlorinated VOCs (1,2,4-trichloroethane, hexachloroethane, and hexachlorobenzene) that are not typically associated with diesel exhaust and would not be expected to bioaccumulate in biota from project-related activities. Although PAHs are considered bioaccumulative (ADEC 2017c), they have a low potential in the terrestrial environment and more readily bioaccumulate in aquatic environments (ADEC 2014), they are generally metabolized in fish tissue and generally do not persist long enough to accumulate to significant levels in fish tissue (NOAA undated), and have a low potential for bioaccumulation in terrestrial vegetation and upland wildlife.

Of the WTP treated effluent pollutants listed in Tables AB.5-7 and AB.5-10, arsenic, cadmium, copper, lead, mercury, nickel, selenium, and zinc are considered bioaccumulative in both terrestrial and aquatic environments (ADEC 2017c), as well as chromium (if present in its hexavalent form). As shown in the tables, none of the chemicals with Alaska criteria protective of both ingestions of water and organisms (including copper, mercury, nickel, selenium, and zinc; as well as antimony, cyanide, and manganese) have predicted maximum concentrations in treated effluent above their chemical-specific criteria. Arsenic, cadmium, chromium, and lead lack criteria protective of ingestion of water and organism. However, since treated effluent maximum concentrations of arsenic and cadmium would be below average baseline surface water concentrations, potential bioaccumulation of these metals into biota would be indistinguishable from baseline potential. Although total chromium and lead maximum effluent concentrations would be predicted to be slightly above average baseline surface water concentrations (see Tables AB.5-7 and AB.5-10), treated maximum concentrations would meet aquatic life AWQC (see Table 3.7-43 in Section 3.7, Water Quality), the maximum effluent concentrations fall within natural variations of baseline surface water concentrations (see Tables 3.7-2 through 3.7-4 in Section 3.7, Water Quality), and average treated effluent concentrations would typically be lower. In addition, the point of discharge to Crooked Creek would be within the Mine Site footprint and dilution of the effluent within Crooked Creek and subsequently within the Kuskokwim would be expected to result in concentrations of these chemicals at concentrations similar to baseline. Based on all of the above, none of the effluent pollutants would be discharged at concentrations above Alaska criteria protective of both ingestions of water and organisms, or at concentrations that would bioaccumulate in biota above baseline levels. Therefore, further evaluation of WTP treated effluent is not warranted for this exposure pathway.

Dietary Exposure Pathway Summary

Impacts in the vicinity of the Mine Site and along the Transportation Corridor would not be expected to pose a health concern to nearby residents or subsistence consumers through ingestion of fish, wildlife, or vegetation for the majority of project-related chemicals. Arsenic and mercury are recommended for further evaluation in Step 3 for potential bioaccumulation in berries, small mammals, fish, and waterfowl that may be consumed by residents and subsistence populations.

AB.5.5 UNCERTAINTY ANALYSIS

Uncertainties are inherent in the risk assessment process because assumptions, estimations, and choices that are made during the risk assessment process can impact the results and introduce bias. The nature and magnitude of uncertainties typically depend on the amount and quality of the data available, the exposure assumptions, and the degree of confidence in the toxicity criteria. The following summarizes the primary project-specific uncertainties associated with the screening-level evaluation:

- Baseline data collected within the HHRA Study Area; sample size and laboratory reporting were considered adequate to represent baseline conditions.
- To evaluate the potential impacts from the Donlin Gold Project, the human health evaluation is based on future predicted concentrations modeled from baseline concentrations. In addition to the uncertainties that are present regarding the representativeness of collected data (i.e., the baseline data), the use of EPCs based on modeling has a greater level of uncertainty than EPCs estimated with measured concentrations (ADEC 2015). However, due to the nature of this human health evaluation, measured concentrations could not be used to estimate the EPC for risk evaluation. Conservative assumptions, including assuming worst-case conditions (i.e., using fuel type that yields the highest emissions allowed by the permit) for air modeling, were used to avoid underestimation of future concentrations. These conservative assumptions are more likely to have led to Type I errors (over-estimation or false-positive conclusions) rather than Type II errors (under-estimation or false-negative conclusions).
- Alaska does not require modeling media concentrations from air emissions as part of the EIS/NEPA process. However, to support the project permitting process and verify that future human health impacts would be insignificant, future media concentrations were estimated for select chemicals. Multiple lines of evaluation were used to select the chemicals for future media modeling (i.e., comparison of baseline concentrations to protective criteria, evaluation of data relative to permit thresholds, comparison of emissions between project components, and geochemical evaluations) and this helped to minimize the potential for under-estimation of risk.
- The screening-level toxicity criteria selected for use in Step 2 are inherently conservative in nature. They have been developed by ADEC and EPA from available toxicological data, which frequently involve high-to-low-dose extrapolations and are often derived from animal rather than human data for ethical reasons. As the unknowns increase, the

uncertainty of the value increases; however, this is addressed by applying relative uncertainty factors in order to provide an adequate margin of safety. The result is a tendency for Type I errors rather than Type II errors.

AB.6 STEP 3 – QUANTITATIVE HHRA SUMMARY

This section summarizes the quantitative HHRA that was conducted by ERM (2017). The HHRA evaluated risk to human receptors from the potential addition of metal constituents to the environment in areas where subsistence populations live and harvest wild foods near the Core Operating Area of the Donlin Gold Project. The approach of the HHRA was to evaluate incremental risk; that is, what is the added human health exposure and associated incremental risk due to predicted future concentrations of certain metals in soil, sediment, surface water, wildlife and fish that may be harvested and consumed near the project as well as from inhalation associated with air emissions. Incremental risk from antimony, arsenic, and mercury (constituents of potential concern, or COPCs) were quantified in the HHRA. A health-protective approach was taken to quantify incremental exposure to these constituents, in that conservative exposure assumptions were used to calculate potential incremental risk to subsistence populations that may be hunting, gathering, or living in the area around the proposed Core Operating Area.

A deterministic computation (i.e., point estimates of risks based on a single defined set of assumptions) of non-cancer and cancer risks was completed following ADEC and EPA guidelines for HHRAs. The HHRA integrated the results of the environmental media baseline studies, human receptor characteristics, subsistence information, and agency-recommended toxicity values to estimate non-cancer and cancer risks.

HHRA COPCs - Potential exposure to mercury (associated with mining activities) is a health concern expressed by stakeholders. Natural and anthropogenic sources of mercury currently exist in the environment in and around the proposed Core Operating Area. Proposed mining and processing activities could increase mercury levels in upland and aquatic habitats surrounding the Core Operating Area through point source (e.g., stack) and fugitive dust emissions. Geochemistry of baseline soils and potential dust sources was evaluated in the EIS (see Section 3.2.3.2.4). The analysis estimated potential dust deposition from the mine site on to soil and predicted future concentrations in soil. This analysis suggested that other metals of potential concern for soil quality include antimony and arsenic. Therefore, the COPCs selected for HHRA evaluation were mercury, antimony, and arsenic.

HHRA CSM –A CSM was developed to describe the relationship between the sources, transport mechanisms, exposure pathways, and media that may result in human exposure to COPCs. The following summarizes the temporal and spatial boundaries, primary sources and transport pathways, and exposure pathways, media, and populations evaluated in the HHRA.

- The temporal boundary selected for the HHRA was determined by the periods during which planned project activities would occur and have potential to affect the health of human receptors. The HHRA calculated risks at the end of mine life (year 27), because the increase in constituent concentrations in the environment due to emissions from the project would be expected to be highest at that time. After operations cease, project emissions will diminish, and accordingly, evaluating potential exposure as of the end of operations represents a reasonable temporal boundary for maximum potential risk related to releases from the project.

- The HHRA considered exposures within a 20-mile radius outside the Core Operating Area (also called the HHRA study area), which represents the spatial extent of the mercury air deposition model (Environ 2015).
- Primary sources of COPCs include fugitive and point source emissions generated by the project, and for mercury, existing deposition from global background sources. Atmospheric emissions from the project have the potential to enter the atmosphere, travel some distance, and be inhaled by receptors or settle as dustfall where they can reside in different media such as soil, vegetation, and subsistence foods. Surface water that comes in contact with mining infrastructure ("contact water") will be treated prior to discharge to levels at or below ADEC surface water quality criteria, which are protective of human health. Groundwater around the Core Operating Area is not a source of drinking water.
- The exposure pathways evaluated in the HHRA included inhalation of airborne constituents, incidental ingestion of constituents bound to soil, and ingestion of constituents associated with biota (fish, plants, and wildlife) that may be harvested in the study area. Because consideration of all individual species or wildlife trophic components of an ecological system is not practical or necessary in order to quantify incremental risk, representative species were evaluated in the HHRA. Based on a review of the subsistence food items reported to be harvested by eight Kuskokwim River communities, and considering physiological factors of different species, the HHRA evaluated the incremental risk from consumption of northern pike (representing resident fish consumption), beaver (representing small mammal consumption), mallard ducks (representing wild bird consumption), and blueberries and cranberries (representing wild berry consumption).
- The HHRA evaluated receptor populations that would have the highest exposure potential in the study area, which would be people who live in or near the project and engage in subsistence activities such as harvesting, hunting, and fishing in the study area. Crooked Creek, located south-southeast of the project, and Georgetown, located east-southeast of the project, are the only villages in the study area. Based on Brown et al. (2012) and other studies cited in the EIS, the information on subsistence harvest patterns establishes that people living closest to the project do not limit or concentrate their subsistence activities to the study area. Regional subsistence harvesting patterns shown in Brown et al. (2012) indicate that harvesting occurs predominantly outside of the study area. In order to be health-protective, a generalized subsistence population was conceptualized to evaluate exposures in the HHRA. This generalized population was assumed to live in the village of Crooked Creek (thus exposed to air and soil concentrations year around) and to hunt, fish, and gather only within the study area for beaver, mallard ducks, berries, and northern pike. Quantities harvested and consumed were based on data presented for eight Kuskokwim River communities (Brown et al. 2012), as this group lives nearest and most frequently harvests nearest to the project. The HHRA evaluated children and adults in the subsistence population: children between 0 and 6 years old, and adults greater than 21 years of age.

HHRA Data Evaluation – Selection of data for the HHRA followed, as closely as possible, the ADEC guidelines for data usability. Though ADEC guidance was developed for data collection at contaminated sites, the principles are applicable to this study. Project-specific studies, collected for the purposes of baseline environmental characterization, and other regional datasets, were used to develop baseline EPCs for various media, as well as used to develop bioaccumulation factors (BAFs) and predict future methylation rates. Much of the baseline soil and plant data collected in the study area was within the planned facilities footprint. The sampling program sought to collect representative samples from different vegetation communities throughout the area. Baseline aquatic data (sediment, surface water, fish, and macroinvertebrate) have been collected from monitoring stations established in the study area, representing locations upstream, within, and downstream of the planned facility footprint. In addition to project-specific sources, data collected regionally, near to the study area, were considered (i.e., Bureau of Land Management [BLM] and United States Geological Survey [USGS] regional datasets, and the ADHSS mercury hair sampling dataset).

HHRA Exposure Assessment – The exposure assessment is the process of determining magnitude, frequency, duration, and route of exposure to COPCs. The calculation of chemical intake, or dose, requires estimation of EPCs and estimation of intake rates. Future (and some baseline) EPCs were estimated based on models rather than empirical data. To estimate future EPCs, the potential for future mercury methylation was evaluated, and bioaccumulation factors (BAFs) developed to understand potential future mercury bioavailability and constituent uptake into biota.

- Methylation Rates. Atmospheric emissions from the project have the potential to increase mercury loadings to the environment. Transformation of deposited mercury into methylmercury is of particular concern because: (a) it is the most toxic form of mercury and (b) it bioaccumulates in food chains to a greater extent than other, inorganic forms of mercury. The rate of conversion of total mercury to methylmercury is the methylation rate. The methylation rate is dependent on complex environmental factors.

  Numerous studies (e.g., EPA 1997, Environment and Climate Change Canada 2016, Frohne et al. 2012, Houben et al. 2016, Scudder et al. 2009, Ullrich et al. 2001) have attempted to quantify these factors, sometimes with conflicting results and rarely with quantifiable relationships. The primary and secondary mechanisms that affect methylation rates are identified as the availability of mercury, followed by oxygen, sulfate, organic carbon, pH and temperature. Other tertiary mechanisms such as photomethylation reactions may occur on a localized basis. Of the factors that have been identified as potentially affecting methylation rates, the project is expected to change the total mercury and sulfate content through aerial deposition. These factors were incorporated into future estimates of methylmercury in soil and the aquatic environment.

  Future methylation rate was estimated using simple models based on empirical data. The project is estimated to increase mercury deposition over baseline in the nearest watersheds, decreasing with distance from the project. Atmospheric mercury that would be deposited would consist of gaseous mercury (Hg(0)), oxidized mercury (Hg2+), and particulate mercury (Hg(p)), with the majority in the particulate form. A minor component (approximately 1 to 2 percent) would be deposited as oxidized mercury, a form that is more likely to be methylated. Environ (2015) estimates that the deposition rate of Hg2+ from the project sources will be approximately 2 percent of total project deposition. Though Hg2+ can easily be methylated, the rate of methylation for the newly deposited Hg2+ is not known for the study area. As different forms of mercury may have different methylation rates, and "new" deposited mercury may be methylated more rapidly, instantaneous methylation of the newly deposited Hg2+ was assumed for purposes of the HHRA. Of the deposited mercury, 2 percent was assumed to be Hg2+, and 98 percent was assumed to be Hg(p). The EPA (2005a) equation to calculate soil concentration based on deposition rate was used to calculate the future soil Hg2+ and non-Hg2+ concentrations from project-related atmospheric deposition. All deposited Hg2+ was assumed to be converted to methylmercury, and deposited non-Hg2+ is assumed to undergo methylation at a rate of 1 percent, twice the median of project baseline data, but reflecting the mean of paired soil samples collected in 2014.

Increases in sulfate concentrations in natural systems with low concentrations of sulfate (as within the study area) will increase concentrations of methylmercury. The reviewed literature indicates that the factor increase in methylmercury is 0.5 to 1.0 times the factor increase in sulfate, or in other words, the increase in methylation rate would be of a similar magnitude to the increase in sulfate concentrations in systems where sulfate is initially at low concentrations. The estimated sulfate emissions from the project are predicted to increase atmospheric sulfate concentrations by 0.04 µg/m^3 at the Core Operating Area boundary, which equates to a 3 percent increase in atmospheric sulfate. A conservative assumption would be that this increase was the same throughout the region, and all sulfate produced is deposited locally as aqueous sulfate increasing local annual load by 3 percent. Applying this assumption in calculating methylation rate of existing soil total mercury, and newly deposited non-Hg2+, increases the initial estimated methylation rate of 1 percent to a rate of 1.03 percent.

Compounding these factors would result in soil total mercury concentrations increasing by a factor of 1.01, and methylmercury increasing by a factor of 1.05. Mercury concentrations and methylation rate values are similar between soil and sediment datasets, implying similar processes and rates for both systems. Thus, to estimate future concentrations in aquatic systems, the same factor increase computed for soil systems is used to derive total mercury and methylmercury in sediments. Changes in sediment mercury content are then proportionally reflected in surface water total mercury and methylmercury concentrations. Using this analysis, future surface water total mercury concentrations are predicted to be below the EPA-approved Alaska state water quality criterion of 12 ng/L.

- Bioaccumulation Factors. Because future concentrations of the constituents in subsistence food items cannot be measured, they were estimated by developing BAFs. Project-specific baseline data, other regional studies, and the general literature were reviewed to determine appropriate BAFs for the HHRA. Unlike arsenic and antimony, mercury can biomagnify in biota, and the biomagnification is much higher for organic forms of mercury compared to inorganic forms. Therefore, differences in the bioavailability between inorganic and organic mercury forms were considered in deriving BAFs. BAFs were developed this way to account for potential changes in bioavailable mercury in the soil. Methylmercury is readily bioavailable and taken up by biota whereas the bioavailability of total mercury is more variable. Therefore, deriving methylmercury to total mercury BAFs allows for some accountability of increasing future concentrations of methylmercury in soil.

Compared to other literature or regional information, the project-specific BAFs are high, suggesting BAFs may be overestimated. Reasons for the higher project-specific BAFs are not known, but may in part be due to the nature of the sampling events during baseline collection, which sought to characterize the more mineralized areas of the study area. These more mineralized areas are not representative of the HHRA study area as a whole.

- Exposure Point Concentrations. An EPC is the concentration of a constituent in an exposure medium at the location where a receptor may contact that medium, and is representative of the time period over which exposure may occur.

  For media with empirical data, EPA guidance was used to calculate baseline EPCs. Media that did not have empirical data included small mammals, waterfowl, and arsenic and antimony concentrations in berries; EPCs were estimated for these media using BAFs. Air concentrations were based on baseline analyses completed by Environ (2015). Future EPCs are based on modeling estimates, which generate mean estimates. Therefore, mean baseline EPCs were used in computations of baseline risk.

  Future air EPCs were estimated from modelling completed by Environ (2015) and Air Sciences (2017). Future soil EPCs were estimated following EPA methods for calculating constituent concentrations in soil due to atmospheric dust deposition (EPA 2005a). Future dust deposition into sediments was also estimated using EPA (2005a). Changes in surface water mercury were estimated as proportional to future soil and sediment concentrations, as surface water concentrations would reflect inputs by sediment dissolution into surface water and/or soil runoff.

  The potential solubility of arsenic and antimony into surface water from sediments or soil runoff was assumed to be negligible, particularly after factoring the contribution of treated water from the water treatment plant, which will be at concentrations less than 0.005 mg/L (below water quality criteria). Therefore, future concentrations of arsenic and antimony in surface water were assumed to be unchanged from baseline concentrations.

- Exposure Factors. Exposure factors define the magnitude, frequency, and duration of exposure for the populations and pathways selected for quantitative evaluation. Exposure factors are combined with EPCs to calculate dose. Exposure factors were selected based on a “RME” scenario that combines upper-bound and average values that reflect exposures somewhere between the 90th and 98th percentile of the range of possible exposures that reasonably can be expected to occur for a given population (EPA 1989).

  Exposure equations from the Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Part A (EPA 1989) were followed in the HHRA. Consumption (i.e., ingestion) rates of food items were based on Brown et al. (2012), a subsistence study that reported harvesting data for the Kuskokwim River subsistence population in the area around the Mine Site. As stated previously, the HHRA evaluated a generalized subsistence population conceptualized to evaluate exposures in the HHRA. This generalized population was assumed to live in the village of Crooked Creek (thus exposed to air and soil concentrations year around) and to hunt, fish, and gather only within the study area for beaver, mallard ducks, berries, and northern pike.

Consumption (i.e., ingestion) rates of food items were based on Brown et al. (2012), a subsistence study that reported subsistence harvesting data for eight Kuskokwim River communities. Because no information is available to estimate the proportion of harvested food that was subsequently consumed, it was assumed, for the purposes of the HHRA, that all harvested food items were consumed by the harvester. The use of harvest rates to estimate consumption rates is an overestimate; the study indicates that people do not consume all of each animal harvested (e.g., often just the fish fillet is consumed, not the entire fish), and further, people may not necessarily consume the total amount of subsistence food harvested (e.g., primary subsistence providers frequently share with others who may reside in the area or in other distant communities). However, by utilizing the harvested amount to estimate intake, this HHRA provides a "health-protective" estimate of potential exposures from this pathway: if no incremental risk is indicated by this approach, then groups ingesting only a portion of harvested foods are unlikely to be at risk.

For other intake rates and other exposure factors (e.g., body weights and averaging times), ADEC (2015) exposure factors for subsistence receptors, or, where not available, EPA (2014) exposure factors for residential receptors were used to develop exposure rates.

HHRA Toxicity Assessment – Exposure to constituents can result in cancer and/or non-cancer effects, which are characterized separately. EPA's Integrated Risk Information System (IRIS) system is the source for the toxicity values (reference doses [RfDs], reference concentrations [RFCs], cancer slope factors [CSFs], and inhalation unit risks [IURs]) of all COPCs evaluated in the HHRA.

HHRA Risk Characterization -

As described in Section 3.3, non-cancer risks were estimated by calculating HQs for each COPC (antimony, arsenic, and mercury) and each exposure pathway. These HQs were then summed across all exposure pathways and COPCs to estimate an HI for each receptor. Additionally, the potential for carcinogenic effects of arsenic was evaluated by estimating the probability of developing cancer over a lifetime. The interpretation of HQs or HIs is typically that exposures at or below the reference level (i.e., HQ=1) are unlikely to be associated with adverse health effects, while exposures above the reference level increase the potential for adverse effects.

Non-cancer risk estimates (were all at or less than 1 for both baseline and future risks. Even with the conservative assumptions of the HHRA, HQs and HIs indicate that non-cancer effects are unlikely.

The baseline risk estimates in the HHRA are consistent with a mercury hair study completed by the ADHSS in 2012, whose results indicate that baseline exposure to mercury in communities studied by ADHSS is below levels of public health concern. The ADHSS tested methylmercury in hair samples from pregnant women in selected communities, including the Kuskokwim River communities in the area around the Mine Site. The hair mercury level for every study participant was below both the Agency for Toxic Substances and Disease Registry No Observed Adverse Effect Level (15.3 parts per million) and the Environmental Public Health Program level for follow-up (5 parts per million) (ADHSS 2013, as cited in the EIS).

In the case of cancer risk estimates for arsenic (the only carcinogenic COPC), both baseline and future risk estimates are $5x10^{-5}$, which is within the EPA risk management range of $1x10^{-4}$ to

$1x10^{-6}$. Future estimates of cancer risks changed from baseline results by less than $1x10^{-6}$, indicating essentially no unacceptable change in risk.

Arsenic is a naturally occurring metal often found at concentrations above “background”, as referred to in regulatory cleanup levels in 18 AAC 75.341. Baseline concentrations of arsenic in the study area are naturally occurring and consistent with regional, state and nationally published studies of naturally occurring arsenic in soil (Gough et al. 1988). Due to the prevalence of naturally occurring arsenic in Alaskan soil, ADEC recommends that cumulative risk calculations do not include risk contributions from naturally occurring arsenic sources (ADEC 2009). Statistical comparisons of significance between baseline and future arsenic concentrations cannot be made because only a single future soil arsenic concentration was estimated. However, if baseline cancer risk estimates were subtracted from future cancer risk estimates, the resulting cancer risk for adults would be $5x10^{-7}$, well below acceptable risk thresholds.

Further, cancer slope factors were used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to arsenic. Upper-bound estimates conservatively exaggerate the risk to ensure that the risk is not underestimated if the underlying model is incorrect. The arsenic ingestion slope factor is based on one affected population in Taiwan concerning non-fatal skin cancer incidence, age, and level of exposure to arsenic via drinking water rather than food (EPA 2017a). The predominant form of arsenic in the drinking water was in an inorganic form (arsenic trioxide), which is a highly toxic form of arsenic and not the predominant form of arsenic that occurs in the study area. The confidence in the oral slope factor is considered to be low overall. Studies that show the strongest link between ingestion of arsenic and cancer involve ingestion of inorganic arsenic at elevated levels in drinking water (Naujokas et al. 2013). Arsenic in soil is less bioavailable, and an adjustment is made to the soil exposure concentration accordingly. There are additional uncertainties estimating cancer risk from arsenic because the mechanism of action in causing human cancers is not known, and studies on arsenic mutagenicity are inconclusive (EPA 2017a). However, safety factors included in the slope factor provide a conservative estimate of risk.

The low confidence in the arsenic slope factor, and the safety factors applied to the slope factor overall, may lead to an overestimate of potential cancer risk due to arsenic in the current environment, in addition to exposure assumptions that overestimate the amount of arsenic ingested by receptors. Further, the incremental changes in cancer risk due to future estimated arsenic exposures are very small. Given that the overestimated potential current and future risks are within the risk management range and are related to naturally occurring levels of arsenic, an unacceptable increase in cancer risk due to site-related arsenic exposure is unlikely.

Risks Due to Fish Consumption. The HHRA evaluated risks due to northern pike fish consumption. Resident fish were incorporated into the HHRA because of their relatively greater exposure period compared to migratory fish. Northern pike, a large, relatively long-lived upper trophic-level predator that is found in the Crooked Creek watershed, was used to estimate fish EPCs and assess risk associated with subsistence fishing. Top-level predators, such as northern pike, also bioaccumulate mercury to a greater degree than lower-trophic level fish species. Tissue burdens for northern pike were estimated by applying trophic transfer factors to sculpin data collected for the project. Estimates for northern pike indicate that both baseline and future HQs are at or less than 1, indicating that noncancer effects are unlikely from northern pike consumption. As noted previously, the estimated incremental cancer risk is less than 1 x 10-6.

Estimates of future northern pike mercury concentrations are lower than State of Alaska (2016) fish consumption advisories for northern pike harvested from the Kuskokwim River in the vicinity of the project. The mean northern pike tissue mercury concentrations from different water bodies identified in the advisory range from 0.11 to 0.61 mg/kg ww. The mercury concentration in the one adult northern pike tissue sample collected within the study area falls within this range (0.421 mg/kg ww). When mean mercury concentrations in northern pike range from >0.34 to 0.46 mg/kg ww, the State of Alaska (2016) recommends limiting fish consumption to 0.068 kg/day. This consumption rate is higher than the estimated adult consumption rate for northern pike that was used in the HHRA (0.0091 kg/day), which is the average consumption rate of northern pike for eight communities in the Central Kuskokwim River Drainage (Brown et al. 2012). Therefore, subsistence populations currently consume northern pike at rates well below the northern pike consumption advisory level for the State of Alaska, and consumption would be expected to remain below the advisory level in the future.

As reflected in the Draft EIS comments, there is public concern regarding constituents in salmon species, which are a primary subsistence food in the region. Salmon species are present within the study area, including coho salmon. However, within the HHRA study area, only juvenile coho (and other species of) salmon reside within the Crooked Creek drainage system for extended periods. Adults, rather than juvenile species, are harvested for consumption. Juveniles migrate out of the freshwater system at an early age, spending the majority of their lifetimes in marine environments. These migratory fish gain the bulk of their body mass over a much larger exposure area (marine waters) that is entirely outside the HHRA study area.

In a study by Baker et al. (2009), mercury accumulation in juvenile (smolt life stage) and adult sockeye salmon from Bristol Bay, Alaska, was compared to estimate the mercury load, and long-range dispersal dynamics of mercury in fish. The study found that the total mercury concentration in juvenile salmon was higher than the concentration in adults. Outgoing smolt salmon concentrations were also shown to decline with season. Both of these trends reflect a high rate of body mass accumulation relative to the rate of mercury intake (faster growth rates yield proportionally less accrual of mercury per unit growth). Juvenile salmon data collected within Crooked Creek tributaries would reflect potential juveniles at the beginning of their outward migration, and therefore would be expected to have higher relative concentrations of mercury compared to later season concentrations.

Because the exposure conditions of salmon are largely unrelated to the study area, and because juvenile concentrations do not coincide with adult concentrations which are then harvested and consumed, the HHRA did not quantify risk due to salmon ingestion.

HHRA Uncertainties – Conservative assumptions were incorporated into the HHRA to prevent Type II errors, which are erroneous conclusions that a constituent, area, or activity can be eliminated from further consideration, when in fact, there should be a concern (i.e., false-negative conclusion). In the risk assessment process, uncertainties are addressed by making assumptions that increase estimates of exposure to be health-protective. This strategy is more likely to produce false-positive conclusions, i.e. Type I, errors (where a constituent, area, or activity is considered further even though public health concerns are not actually significant) than false-negative errors. A number of conservative estimates were made to assure that risk predictions would more likely produce false-positive conclusions than false negative conclusions.

HHRA Conclusions – The HHRA demonstrated that the small increases in constituent concentrations estimated to occur outside of the Core Operating Area due to project-related activities are not expected to result in unacceptable risks to human populations who would have the highest exposure. Based on the exposures to the conservatively defined receptors analyzed in the health-protective HHRA, other human populations, such as residents in the region, would not be expected to be exposed to unacceptable risk due to exposure to project-related concentrations of mercury, arsenic, or antimony.

AB.7 FRA SUMMARY AND CONCLUSIONS

The evaluation of impacts on human health is a required component of the NEPA as it pertains to negative and beneficial consequences of a proposed project on potentially affected communities. There are laws and regulation, such as the CWA, CAA, and various Alaska statutes that have been enacted to ensure protection of human health. Compliance with health laws and regulations are taken into consideration in the evaluation of health impacts. The preparation of an HIA to support a NEPA evaluation and the use of ADHSS guidelines to do so are not mandatory in Alaska, but are decisions that are made on a project-specific basis (ADHSS 2015).

Section 3.22 (Human Health) was developed to be consistent with the ADHSS HIA methodology and provides a comprehensive overview of health categories that are generally applicable to the evaluation of impacts related to a proposed program, project, policy, or plan under consideration by decision-makers in Alaska. The HIA developed under ADHSS leadership (Newfields 2015, 2016) was used as one of the primary resources for the Human Health section of the EIS. Although the HIA (Newfields 2015, 2016) and Section 3.22 (Human Health) of the EIS describe all of the broad HECs included in the ADHSS guidelines, numerous comments on the Draft EIS were received tied to HEC 3 (human health) in the Draft EIS (Section 3.22.4.2.3), with exposure to mercury as a dominant concern.

A focused workshop was held in December 2016 to address concerns and comments on project-related mercury impacts. Workshop participants expressed a preference to see all the health concerns related to chemicals to be addressed in a single location in the EIS, rather than dispersed through multiple chapters. To this end, this 3-step FRA was prepared to support the EIS, address these comments, and present the finding of the human health evaluation for potential chemical exposures in a single location.

Step 1 included identification of primary project sources of contamination, identification of COPCs and an exposure assessment including pathway completeness determination. Primary project sources of contamination included anticipated project sources and COPCs (e.g., Mine Site air emissions, Mine Site and Transportation Corridor fugitive dust), Based on the findings of Step 1 (Section AB.4) and as illustrated in the CSMs (Figures AB.4-1 to AB.4-3), the following complete or potentially complete exposure pathways were identified:

- Mine Site – Exposure to COPCs in ambient outdoor air, soil, surface water, sediment, and biota for subsistence consumers and residents (including recreationists).
- Transportation Corridor – Exposure to COPCs in ambient outdoor air for residents, subsistence consumers, and non-project commercial/ industrial workers. Exposure to COPCs in soil, surface water, sediment, and biota for residents and subsistence consumers.

- Pipeline – Exposure to COPCs in outdoor air for residents and subsistence consumers.

Step 2 consisted of a screening-level evaluation of the complete or potentially complete exposure pathways identified in the bullets above (see Section AB.5). Based on the screening-level evaluation, inhalation of air emissions and exposure to surface water and sediment would not be expected to pose a health concern to any of the potentially exposed human receptors. Only exposure to arsenic in soil, within the vicinity of the Mine Site and Transportation Corridor, was found to warrant further evaluation for subsistence consumer exposure based on the screening-level evaluation of soil. The tissue screening-level evaluation concluded that arsenic and mercury have the potential to bioaccumulate in berries, small mammals, fish, and waterfowl that may be consumed by residents and subsistence populations and warrant further evaluation in Step 3. In addition, since Step 2 represents a single-media, individual-chemical evaluation, representative chemicals (i.e., mercury, arsenic, and antimony), which are anticipated to contribute the most to future media increases, were retained for further evaluation in Step 3 in order to assess potential human health impacts from multi-media and multi-chemical exposure.

Step 3 is a quantitative HHRA and was performed by ERM (2017) and summarized in this FRA (see Section AB.6). The quantitative HHRA estimated risks individually and from multi-media and multi-pathway exposure to the retained COPCs (mercury, arsenic, and antimony). The HHRA demonstrated that the small increases in constituent concentrations estimated to occur outside of the Donlin Gold Mine Site ("outside the fence") due to project-related activities would not result in unacceptable risks to human populations who would have the highest exposure (i.e., subsistence hunters, fishers, or harvesters). Based on the findings of the subsistence populations, other human populations, such as residents, would also not be expected to be exposed to unacceptable incremental risk from these three metals.

Conclusion - This FRA presents the findings of the human health evaluation for potential chemical exposures from the abiotic and biotic media that may be impacted from the Donlin Gold Project. Based on these evaluations, none of the human populations, (i.e., non-mine occupational workers, residents, and subsistence consumers) would be expected to have unacceptable health impacts due to cumulative exposure and incremental risk from the release of project-related pollutants to air, soil, groundwater, surface water, sediments, and subsistence foods (berries, upland game, fish). There are uncertainties that are inherent in predicting future concentrations in the various exposure media. However, in addition to the conservative assumptions used in modeling, some of the future uncertainty is also mitigated by the compliance requirements for permitting programs (e.g., air and water permits). Monitoring of some exposure media such as fish tissue that are not covered under other permitting programs may serve to confirm the low potential for risk to human health and allay stakeholder concerns.

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