APPENDIX G

Human Health and Ecological Risk Assessment Methodology

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Human Health and Ecological Risk Assessment Methodology

This appendix presents the methodology that will be used for the baseline human health and ecological risk assessment for the Former Galena Forward Operating Location (FOL) for sites where a Remedial Investigation (RI) or a Site Characterization (SC) has been completed. Section 1.0 describes the methodology for the human health risk assessment (HHRA) and Section 2.0 describes the methodology for the ecological risk assessment (ERA).

This section describes the HHRA methodology. Section 1.1 presents the exposure assessment approaches associated with soil, soil gas, and groundwater, including the means to be used to estimate exposure point concentrations. The sources of toxicity values are provided in Section 1.2, and the details for calculating risks are described in Section 1.3.

1.1 Human Health Exposure Assessment

Site-related constituents detected in soil, soil gas, and groundwater that are identified as chemicals of potential concern (COPCs) will be carried forward to a quantitative risk assessment. Samples collected from the site will be evaluated to determine whether they provide sufficient spatial coverage of the respective exposure areas (as identified in the conceptual site models [CSMs] for the site) to be pooled for a risk assessment (that is, whether each area is small enough to be reasonably evaluated as a single data group).

The general CSM for potential human exposures is depicted in Figure G-1, and is formulated according to applicable guidance, with the use of professional judgment and site-specific information on land use, water use, contaminant sources, release mechanisms, routes of migration, potential exposure points, potential routes of exposure, and potential receptor groups associated with the site. In accordance with the CSM, risk will be evaluated for the following potential human exposure scenarios:

- **Excavation/Construction Workers:** Potential exposure of excavation/construction workers to constituents in soil to 15 feet below ground surface (bgs)[1] and shallow groundwater by incidental ingestion, dermal contact, and inhalation of ambient dust and vapors.
- **Current and Future Occupational Workers:** Potential exposure of current and future occupational workers to constituents in soil to 2 feet bgs by incidental ingestion, dermal contact, and inhalation of ambient dust and vapors in ambient air; and inhalation of vapors migrating from subsurface soil and groundwater to indoor air. Potential consumption of groundwater.

[1] If groundwater levels are less than 15 feet bgs, risk will be evaluated using soil results down to the groundwater table.

- **Hypothetical Future Residents:** Potential exposure of hypothetical future residents to constituents in soil to 15 feet bgs by incidental ingestion, dermal contact, and inhalation of ambient dust and vapors in ambient air; and inhalation of vapors migrating from subsurface soil and groundwater to indoor air. Although future residential land use is not anticipated at some sites, this scenario will address the possibility for restrictions on land use in the future. Potential domestic use of groundwater.

The exposure scenarios selected for evaluation are anticipated to account for the range of reasonably anticipated exposures under current and future conditions at the Former Galena FOL. The scenarios selected will be sufficiently conservative to adequately address other less common scenarios for soil, soil gas, and groundwater.

The exposure assumptions to be used for chemical intake are presented in Tables G1 and G2 for soil and groundwater, respectively (tables are located at the end of this appendix. Estimated exposures for occupational workers will be based on the assumption that an adult would contact surface soil for 50 weeks (250 work days) per year over a 25-year duration. Estimated exposures for excavation/construction workers will be based on the assumption that an adult would contact subsurface soil for one month (20 work days) per year over a 6.6-year duration. Estimated exposure for future hypothetical residents will be based on the assumption that an adult would contact soil for 350 days per year over a 6-year span as a child and a 24-year span as an adult.

1.1.1 Intake Equations for Ingestion of Soil

The following equations will be used to calculate the intake (expressed as milligrams per kilogram [mg/kg] per day) associated with the incidental ingestion of carcinogenic and noncarcinogenic contaminants in soil under the excavation/construction worker and occupational worker exposure scenarios:

$$Intake = \frac{C_s \times IRS_a \times 10^{-6}\,kg/mg \times EF \times ED_a}{BW_a \times AT} \quad (1)$$

The following age-weighted equation will be used to calculate the intake associated with the incidental ingestion of carcinogenic and noncarcinogenic contaminants in soil under the residential exposure scenario:

$$Intake = \frac{C_s \times IFS_{adj} \times EF \times 10^{-6}\,kg/mg}{AT} \quad (2)$$

where:

$$IFS_{adj} = \frac{ED_c \times IRS_c}{BW_c} + \frac{ED_a \times IRS_a}{BW_a} \quad (3)$$

where:

C_s = chemical concentration in soil (mg/kg)
IFS_{adj} = age-adjusted soil ingestion factor [(mg-year)/(kg-day)]

IRS_a = adult soil ingestion rate (milligrams [mg]/day)
IRS_c = child soil ingestion rate (mg/day)
EF = exposure frequency (days/year)
ED_a = adult exposure duration (years)
ED_c = child exposure duration (years)
BW_a = adult body weight (kilograms [kg])
BW_c = child body weight (kg)
AT = averaging time (days)

The exposure assumptions for estimating chemical intake from the ingestion of contaminants in soil are presented in Table G1.

1.1.2 Intake Equations for Dermal Contact with Soil

The following equations will be used to calculate the intake from dermal contact with carcinogenic and noncarcinogenic contaminants in soil under the excavation/construction worker and occupational worker exposure scenarios:

$$Intake = \frac{C_S \times ABS \times SA_a \times AF_a \times EF \times ED_a \times 10^{-6}\, kg/mg}{BW_a \times AT} \quad (4)$$

The following age-weighted equation will be used to calculate the intake from dermal contact with carcinogenic and noncarcinogenic contaminants in soil under the residential exposure scenario:

$$Intake = \frac{C_S \times SFS_{adj} \times ABS \times EF \times 10^{-6}\, kg/mg}{AT} \quad (5)$$

where:

$$SFS_{adj} = \frac{ED_c \times AF_c \times SA_c}{BW_c} + \frac{ED_a \times AF_a \times SA_a}{BW_a} \quad (6)$$

where:

C_s = chemical concentration in soil (mg/kg)
ABS = absorption fraction (unitless)
SFS_{adj} = age-adjusted dermal contact factor [(mg-year)/(kg-day)]
SA_a = adult exposed skin surface area (square centimeters [cm^2])
SA_c = child exposed skin surface area (cm^2)
AF_a = adult soil-to-skin adherence factor (mg/cm^2)
AF_c = child soil-to-skin adherence factor (mg/cm^2)
EF = exposure frequency (days/year)
ED_a = adult exposure duration (years)
ED_c = child exposure duration (years)
BW_a = adult body weight (kg)
BW_c = child body weight (kg)
AT = averaging time (days)

The exposure assumptions for estimating exposure from dermal contact with soil are presented in Table G1. Dermal absorption factor values will be obtained from the dermal assessment guidance (U.S. Environmental Protection Agency [EPA], August 2004).

1.1.3 Intake Equation for Ingestion of Groundwater

The following age-weighted equation will be used to calculate the intake of carcinogenic and noncarcinogenic constituents associated with the ingestion of groundwater under the residential exposure scenario:

$$Intake = \frac{C_w \times IFW_{adj} \times EF}{AT} \quad (7)$$

where:

$$IFW_{adj} = \frac{ED_c \times IRW_c}{BW_c} + \frac{ED_a \times IRW_a}{BW_a} \quad (8)$$

where:

C_W = chemical concentration in groundwater milligrams per liter (mg/liter [L])
IFW_{adj} = age-adjusted water ingestion factor [(L-year)/(kg-day)]
IRW_a = adult groundwater ingestion rate (L/day)
IRW_c = child groundwater ingestion rate (L/day)
EF = exposure frequency (days/year)
ED_a = adult exposure duration (years)
ED_c = child exposure duration (years)
BW_a = adult body weight (kg)
BW_c = child body weight (kg)
AT = averaging time (days)

The exposure assumptions for estimating chemical intake from the ingestion of groundwater are presented in Table G2.

1.1.4 Intake Equation for Dermal Contact with Groundwater

The following age-weighted equation will be used to calculate the intake associated with dermal contact with carcinogenic and noncarcinogenic constituents in groundwater under the residential exposure scenario:

$$Intake = \frac{C_w \times SFW_{adj} \times Kp \times EF \times ET \times CF}{AT} \quad (9)$$

where:

$$SFW_{adj} = \frac{ED_c \times SA_c}{BW_c} + \frac{ED_a \times SA_a}{BW_a} \quad (10)$$

where:

C_W = chemical concentration in groundwater (mg/L)
SFW_{adj} = age-adjusted water dermal contact factor [(cm^2-year)/kg]
Kp = dermal permeability coefficient (centimeters [cm]/hour)
EF = exposure frequency (days/year)
ET = exposure time (hours)
CF = conversion factor (0.001 L/cubic centimeter)
ED_a = adult exposure duration (years)
ED_c = child exposure duration (years)
SA_a = adult exposed skin surface area (cm^2)
SA_c = child exposed skin surface area (cm^2)
BW_a = adult body weight (kg)
BW_c = child body weight (kg)
AT = averaging time (days)

The exposure assumptions used to estimate exposure from dermal contact with groundwater are presented in Table G2. Chemical-specific dermal permeability coefficients (Kp) will be obtained from the Oak Ridge National Laboratory (ORNL) Risk Assessment Information System (ORNL, 2009). ORNL provides Kp values calculated using the EPA's Dermwin™ tool, which is a program that estimates the Kp.

1.1.5 Intake Equations for Inhalation of Ambient Dust or Vapors

The following equation will be used to calculate the intake of carcinogenic and noncarcinogenic contaminants associated with inhalation of ambient vapor or dust emissions from soil under the excavation/construction worker and occupational worker exposure scenarios:

$$Intake = \frac{C_s \times INH_a \times \left(\frac{1}{PEF} + \frac{1}{VF}\right) \times EF \times ED_a}{BW_a \times AT} \quad (11)$$

The following age-weighted equation will be used to calculate the intake of carcinogenic and noncarcinogenic contaminants associated with inhalation of vapor or dust emissions from soil under the residential exposure scenario:

$$Intake = \frac{C_s \times INHF_{adj} \times \left(\frac{1}{PEF} + \frac{1}{VF}\right) \times EF}{AT} \quad (12)$$

where:

$$INHF_{adj} = \frac{ED_c \times INH_c}{BW_c} + \frac{ED_a \times INH_a}{BW_a} \quad (13)$$

where:

C_s = chemical concentration in soil (mg/kg)
$INHF_{adj}$ = age-adjusted inhalation factor [(cubic meters [m^3]-year)/(kg-day)]
INH_a = adult inhalation rate (m^3/day)
INH_c = child inhalation rate (m^3/day)
EF = exposure frequency (days/year)
ED_a = adult exposure duration (years)
ED_c = child exposure duration (years)
BW_a = adult body weight (kg)
BW_c = child body weight (kg)
PEF = particulate emission factor (m^3/kg)
VF = volatilization factor (m^3/kg)
AT = averaging time (days)

The volatilization factors (VFs) for volatile organic compounds (VOCs) identified as COPCs in soil are calculated using the Jury Model presented in the soil screening guidance (EPA, July 1996). The exposure assumptions used to estimate exposure from inhalation of dust and vapors in ambient air are presented in Table G1.

1.1.6 Intake Equations for Inhalation of Vapors from Groundwater

The following age-weighted equation will be used to calculate the intake of carcinogenic and noncarcinogenic contaminants associated with inhalation of vapors from showering or other household activities under the residential exposure scenario:

$$Intake = \frac{C_w \times INH_{adj} \times VF \times EF}{AT} \quad (14)$$

where:

$$INH_{adj} = \frac{ED_c \times INH_c}{BW_c} + \frac{ED_a \times INH_a}{BW_a} \quad (15)$$

where:

C_w = chemical concentration in water (mg/L)
INH_{adj} = age-adjusted inhalation factor [(m^3-year)/L-day)]
INH_a = adult inhalation rate (m^3/day)
INH_c = child inhalation rate (m^3/day)
EF = exposure frequency (days/year)
ED_a = adult exposure duration (years)
ED_c = child exposure duration (years)
BW_a = adult body weight (kg)
BW_c = child body weight (kg)
VF = volatilization factor (L/m^3) (Andelman, 1990)
AT = averaging time (days)

The exposure assumptions used to estimate exposures from inhalation of volatile constituents are listed Table G2. Volatile constituents considered for the inhalation pathway are operationally defined as those COPCs with a Henry's Law constant greater than 10^{-5} atmosphere-cubic meters per mole [atm-m^3/mole] and a molecular weight less than 200 grams per mole (EPA, April 22, 1991).

1.1.7 Inhalation Intake Equations for Inhalation of Soil Gas Migrating into Indoor Air

In addition to addressing exposure from inhalation of ambient air, COPC concentrations in sub-slab soil gas will be used to evaluate the potential for migration of volatile contaminants into indoor air in current or future buildings. The following equation will be used to calculate the intake associated with the inhalation of vapors emanating from subsurface soil gas and migrating into indoor air by hypothetical future residents:

$$Intake = \frac{C_{SG} \times ATF_{res} \times INH_{adj} \times EF}{AT} \quad (16)$$

where:

$$IN_{adj} = \frac{ED_c \times INH_c}{BW_c} + \frac{ED_a \times INH_a}{BW_a} \quad (17)$$

where:

C_{SG} = concentration in soil gas (mg/m^3)
ATF_{res} = soil gas to indoor air attenuation factor (unitless)
INH_{adj} = age-adjusted inhalation factor [(m^3-year)/L-day)]
INH_a = adult inhalation rate (m^3/day)
INH_c = child inhalation rate (m^3/day)
EF = exposure frequency (days/year)
ED_a = adult exposure duration (years)
ED_c = child exposure duration (years)
BW_a = adult body weight (kg)
BW_c = child body weight (kg)
AT = averaging time (days)

In accordance with the Alaska Department of Environmental Conservation (ADEC) guidance in *Draft Vapor Intrusion Guidance for Contaminated Sites* (ADEC, July 2009), an attenuation factor may be derived using default values; modeling approaches such as the EPA's vapor intrusion models based on *The Johnson and Ettinger (1991) Model for Subsurface Vapor Intrusion into Buildings* (EPA, 2003); or site-specific measurements.

1.1.8 Estimating Exposure Point Concentrations for the Human Health Risk Assessment

For each data group (exposure area), exposure point concentrations (EPCs) for risk estimation will be calculated using the best statistical estimate of an upper bound on the average exposure concentrations, in accordance with EPA guidance for statistical analysis of

monitoring data (EPA, December 1989, 1992b, 2002b). These guidance documents consider the 95 percent upper confidence limit (UCL) on the mean concentration as a conservative upper bound estimate that is not likely to underestimate the mean concentration and most likely overestimates that concentration. EPCs will be calculated for each analyte using the EPA's statistical program ProUCL, Version 4.00.02 (EPA, 2009). This procedure identifies the statistical distribution type (that is, normal, lognormal, or non-parametric) for each constituent within the defined exposure area and computes the corresponding 95 percent UCL for the identified distribution type. The maximum detected concentration will be used in place of the 95 percent UCL when the calculated 95 percent UCL is greater than the maximum detected value. Factors affecting the distribution of the data (resulting in the selection of the maximum detected value rather than the 95 percent UCL) include small sample size, low frequency of detection, and/or wide variability. Using maximum detected values for EPCs may contribute to overestimation of risk.

1.2 Sources of Toxicity Values

In accordance with EPA guidance (EPA, December 5, 2003), toxicity values (cancer slope factors and reference doses [RfDs]) used in the risk assessment will be obtained from the following sources:

- The Integrated Risk Information System (IRIS) database available through the EPA Environmental Criteria and Assessments Office in Cincinnati, Ohio. IRIS, prepared and maintained by the EPA, is an electronic database containing health risk and EPA regulatory information on specific chemicals (EPA, 2010).
- The EPA's Provisional Peer Reviewed Toxicity Values (PPRTVs), provided by the Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center (which develops these values on a chemical-specific basis when requested under the EPA's Superfund program).
- The Health Effects Assessment Summary Tables (HEAST), provided by the EPA Office of Solid Waste and Emergency Response (EPA, July 1997), which is a compilation of toxicity values published in various health effects documents issued by the EPA.

The primary source of toxicity values will be the IRIS database. If a toxicity value is not available from IRIS, toxicity values will be obtained from the EPA Regional Screening Levels (RSLs) table (EPA, December 2009). When toxicity values are not available from either of these sources, the latest available HEAST value will be used. If a toxicity factor for a constituent is not available from a reliable source, the constituent will be evaluated by comparing results to structurally similar compounds or classes of compounds.

1.3 Risk Quantification Methodology

This section summarizes the methods to be used for calculating human health risks.

1.3.1 Noncancer Hazard Estimation

Potential health risks associated with exposure to noncarcinogenic compounds will be evaluated by calculating a hazard quotient (HQ). The potential HQ will be calculated as the ratio of the intake to the RfD, as follows:

$$HQ = Intake / RfD \quad (18)$$

If the estimated daily intake for any single constituent is greater than its RfD, the HQ will exceed 1. An HQ that exceeds 1 indicates that there is a potential for adverse health effects associated with exposure to that constituent.

A hazard index (HI) is calculated to assess the potential for noncancer effects posed by more than one constituent. The HI approach assumes that simultaneous sub-threshold exposures to several constituents could result in an adverse health effect. It also assumes that the magnitude of the adverse effect will be proportional to the sum of the ratios of the sub-threshold exposures to the acceptable exposure (the RfD). The HI is equal to the sum of the HQs, and is calculated as follows:

$$HI = \sum_{1}^{N} Intake_i / RfD_i \quad (19)$$

where:

$Intake_i$ = the exposure level for the i^{th} constituent (mg/kg-day)
RfD_i = the reference dose for the i^{th} constituent (mg/kg-day)

Intake and RfD, which are expressed in the same units, represent the same exposure period (that is, chronic, subchronic, or short term).

1.3.2 Cancer Risk Estimation

Individual cancer risk is calculated as the product of exposure to a constituent (in mg/kg-day) and the slope factor (SF) for that constituent (in mg/kg-day)-1, as follows:

$$Risk = Intake \times SF \quad (20)$$

Cancer risk from exposure to multiple carcinogens and multiple pathways is assumed to be additive, based on the *Guidelines for Carcinogen Risk Assessment* (EPA, March 2005).

Each SF is accompanied by a weight-of-evidence classification, which considers the available data for a constituent in order to evaluate the likelihood that the constituent is a potential human carcinogen. The evidence is characterized separately for studies in humans and studies in laboratory animals as sufficient, limited, inadequate, no data, or evidence of noncarcinogenicity. The U.S. Environmental Protection Agency recommends that cancer risk estimates should always be accompanied by a weight-of-evidence classification to indicate the strength of evidence that a constituent is a human carcinogen (EPA, December 1989).

1.3.3 Health Risk Characterization for Lead

Potential risks from lead concentrations will be evaluated using methods different from those conventionally used for other carcinogens and noncarcinogens. Risks resulting from uptake of lead will be evaluated by comparing the 95 percent UCL concentration with Method 2 Cleanup Levels (Table B1 in ADEC, 2008). The Method 2 values used will be those representative of a site that receives mean annual precipitation of less than 40 inches each year (Under 40-Inch Zone).

1.3.4 Potential Exposure to Petroleum, Oils, and Lubricants

In accordance with ADEC's Oil and Other Hazardous Substances Pollution Control (ADEC, 2008), soil concentrations for petroleum hydrocarbons will be compared with Method 2 Petroleum Cleanup Levels (Table B2 in ADEC, 2008). The Method 2 values used will be those representative of a site that receives mean annual precipitation of less than 40 inches each year (Under 40-Inch Zone).

SECTION 2

Ecological Risk Assessment Methodology

This section describes the ERA methodology for the Former Galena FOL. Figure G2 depicts a flowchart for the data collection, evaluation, and decision documents for the Former Galena FOL. The ERA approach will primarily follow guidance ADEC provided in the *Risk Assessment Procedures Manual* (ADEC, February 18, 2009). This guidance provides for a phased approach to the risk assessment that includes a scoping evaluation (Step 1), followed by a preliminary screening evaluation (Step 2), a Screening-level ERA (Step 3), and a baseline ERA (Step 4), as warranted (Figure G3). Figure G2 shows these phases or steps, as they will be applied to the Former Galena FOL.

Step 1 of the process (Scoping Evaluation) has been conducted at the Former Galena FOL. Briefly, sites identified at the Former Galena FOL were evaluated using *Ecoscoping Guidance* (ADEC, March 2009) to determine if further ecological evaluation was warranted. The sites have been categorized into the following four groups:

- Sites with no complete pathways at the site (including no potential surface water transport to nearby habitat) and no complete groundwater pathways from the site to or near the Yukon River, and therefore will not be further evaluated
- Sites with potentially complete terrestrial and/or aquatic pathways at the site or nearby habitat affected by surface water transport and will need to be further evaluated
- Sites with no potentially complete pathways at the site or nearby habitat affected by surface water transport, but will be further evaluated to determine if an aquatic pathway of groundwater from the site can daylight near or in the Yukon River
- Sites with potentially complete pathways at the site or nearby habitat affected by surface water transport that will be further evaluated, in addition to determining if an aquatic pathway of groundwater from the site can daylight near or in the Yukon River

The completed Ecoscoping Forms for most sites and the results are reported in the Preliminary Assessment (PA) Report (CH2M HILL, 2010). Ecoscoping Forms for the Environmental Restoration Program (ERP) sites are provided as Attachment G-1 to this appendix. Those sites that require evaluation beyond the PA are summarized in Worksheet #10 in the main text of this Work Plan. Based on that assessment, two categories of sites were carried forward for evaluation in the Site Inspection (SI) and are included in this Work Plan:

1. Sites lacking ecological exposure pathways that were carried forward for other reasons (for example, human health screening levels were exceeded)
2. Sites with ecological exposure pathways potentially present (in addition to being carried forward for other reasons)

Sites with no ecological pathways will not be further evaluated in an ERA. For sites with potential ecological pathways, existing media contaminant concentration data or limited media data collected during the SI (for sites lacking sufficient data) will be evaluated against ecological screening levels (ESLs) and water quality standards provided in ADEC (March 2009) or 18 AAC70 for soil and water and, if appropriate, to threshold effects level (TEL) and probable effects level (PEL) Sediment Quality Guidelines (SQGs) in the Screening Quick Reference Tables (SQuiRTs; Buchman, 2008) for freshwater sediment published by the National Oceanic and Atmospheric Administration (NOAA) as recommended in ADEC (March 2009) guidance. This screening will represent Steps 2 and 3 shown on Figure G3, and will be presented in the SI Report and in a refinement of this baseline ERA (BERA) Work Plan. Sites that do not have exceedances of the ESLs will not be further evaluated beyond the SI report. Those sites that either have exceedances of ESLs or have bioaccumulative chemicals as indicated in ADEC (March 2009) will be carried forward for evaluation in the BERA (Step 4 on Figure G3), as appropriate. The BERA will be included in the RI report (for sites following the Comprehensive Environmental Recovery, Compensation, and Liability Act [CERCLA] regulatory pathway) or in the SC report (for sites following the ADEC regulatory pathway). A refinement of this Work Plan outlining the methods and approaches for the Step 4 BERA will be developed based on the screening results and identified data gaps (which will be addressed as part of a follow-up sampling event). The BERA will be conducted according to ADEC (February 18, 2009) guidance, as well as the following additional guidance ADEC and the EPA have provided:

- User's Guide for Selection and Application of Default Assessment Endpoints and Indicator Species in Alaskan Ecoregions (ADEC, June 1999a)
- Technical Background Document for Selection and Application of Default Assessment Endpoints and Indicator Species in Alaskan Ecoregions (ADEC, June 1999b)
- Policy Guidance on Developing Conceptual Site Models (ADEC, November 30, 2005)
- Ecoscoping Guidance (ADEC, March 2009)Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final (EPA, June 1997a)
- EPA Region 10 Supplemental Ecological Risk Assessment Guidance for Superfund (EPA, June 1997b)
- Final Guidelines for Ecological Risk Assessment (EPA, April 1998)
- The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments (EPA, June 2001)

For sites with chlorinated contaminants or other hazardous substances, the EPA guidance for ERA at Superfund sites (EPA, June 1997a), as provided under CERCLA, will be followed (Figure G2). Conversely, petroleum-only sites will continue along the ADEC regulatory pathway (ADEC, February 18, 2009). In both cases, components of the BERA will include Problem Formulation, Analysis, and Risk Characterization (including Uncertainties) as outlined in the EPA (June 1997a) and ADEC (February 18, 2009) guidance. It should be noted that ADEC guidance generally follows the EPA (April 1998).

The following sections describe Problem Formulation, Analysis, and Risk Characterization, as well as the approach proposed for the Former Galena FOL.

2.1 Problem Formulation

The problem formulation integrates available information (sources, contaminants, effects, and environmental setting) and provides focus to the ERA. According to ADEC (February 18, 2009), this section includes a description of the site history and environmental setting; documentation of site visits; identification of contaminants known or suspected to be at the site; information about receptors likely to be present at the site; contaminant transport and fate; a preliminary ecotoxicity evaluation; and identification of exposure pathways. The end product of the problem formulation is an ecological CSM that describes the contaminant sources and transport mechanisms, evaluates potential exposure pathways, and identifies the representative species that will be used to assess ecological risk, assessment endpoints (the values to be protected), measures (the means to evaluate potential adverse effects on the assessment endpoints), and available data.

2.1.1 Site History and Environmental Setting

2.1.1.1 Site History

The City of Galena is located in traditional Koyukon Athabaskan Indian territory. It was established in 1919 as a supply and transshipment point for the lead ore (galena) mining prospects south of the Yukon River. Since 1941, the Federal Aviation Administration (FAA) has maintained and operated facilities at Galena Airport. The Civil Aeronautics Authority (CAA; now Federal Aviation Administration) began constructing an airfield at Galena late in 1941 as part of an overall civilian airport construction program in Alaska. Originally, Galena and 11 other mostly interior airfields were intended to serve civilian needs. However, negotiations with the Soviet Union for the lend-lease transfer of American aircraft to the Soviet Union led to the establishment of the Alaska-Siberia route that ran from Great Falls, Montana, north through northwestern Canada, then west across Alaska to Nome, and finally across Siberia to the Eastern Front. Galena supported the Alaska-Siberia route from August 1942 until September 1945 as a refueling and service airfield (Earth Tech, May 2007).

Under the Alaskan Air Command (AAC), Galena became part of a defense system to defend against the Soviet bomber threat. The AAC negotiated an agreement with the CAA in early 1951 for joint use of Galena Airport, and a construction program was begun to upgrade the facilities to base a squadron of interceptors there. Although these plans were later dropped, the AAC began to use the airfield as a forward operating base, deploying 200 intercepts of Soviet flights made between 1961 and 1993 (Earth Tech, May 2007). The AAC was replaced and absorbed by the 11th Air Force with the Pacific Air Force (PACAF) as the Major Command (MAJCOM).

The federal government transferred the airport to the State of Alaska in 1966, in compliance with provisions of the 1958 Statehood Act. The U.S. Army, and then the U.S. Air Force (USAF), retained control of the land on which military facilities were located. The land was shared with the Bureau of Land Management (BLM) and the FAA, which maintained offices on the base. Various buildups, repairs, and upgrades occurred in the intervening years, with

the primary focus on refueling and servicing aircraft, until the Base Realignment and Closure (BRAC) Commission voted unanimously to recommend the closure of the Former Galena FOL on August 25, 2005 (Earth Tech, May 2007).

The USAF was required to permanently close all USAF facilities by September 30, 2008, as part of the 2005 BRAC. The USAF demolished former USAF facilities that the State or City of Galena had not scheduled for re-use, with the exception of the Combat Alert Cell (Hangar) (Building 1428) and the Radar Approach Control (RAPCON) facility (Building 1568). The USAF retained these two facilities pending completion of environmental investigations and final decisions on the Combat Alert Cell (Hangar).

The State of Alaska currently owns and operates the Galena Airport. The U.S. Air Force-controlled property at Galena Airport has been in caretaker status since August 1993. All former USAF buildings and infrastructure (for example, power plant/steam heating plant, water treatment plant, sewage treatment plant, sewage treatment system, lodging, supply, offices, school, dining facilities, building and grounds maintenance, fuel maintenance and storage, and vehicle maintenance) have been transferred to the City of Galena or other entities. Non-USAF entities use most of the buildings at the airport, such as:

- City of Galena or Galena Interior Learning Academy (education, dormitory, storage, utilities)
- State of Alaska Department of Transportation and Public Facilities (administrative, storage, maintenance)
- Alaska State Troopers (administrative, storage)
- BLM (lodging, administrative, storage)
- FAA (storage, administrative)
- Alaska Department of Fish and Game (storage)
- U.S. Fish and Wildlife Service (USFWS) (administrative, storage) (AECOM, 2009)

2.1.1.2 Environmental Setting

The following subsections summarize the environmental setting, including surface water types, fisheries, sensitive areas/wetlands, and habitat and associated wildlife at the Former Galena FOL.

Groundwater. The Integrated Natural Resources Management Plan (INRMP) identified two aquifers at Galena; one is a deep aquifer, presumably beneath the permafrost zone, that supplies potable water for Former Galena FOL, and the other is a shallow unconfined aquifer, lying above the permafrost zone that has been used in the past at the Former Galena FOL site and the village of Old Galena (USAF, 2008). The water table elevation for the shallow aquifer ranges from 15 to 30 feet below grade. The general groundwater flow direction is to the south-southwest in the direction of the Yukon River; however, the flow gradient and water table elevation fluctuate in response to Yukon River changes in stages of change. Groundwater recharge occurs from precipitation, infiltration, and normal groundwater movement from recharge areas near slopes of surrounding highlands.

Groundwater is discharged into the Yukon River and local surface streams and sloughs. Flow paths for groundwater movement are influenced by discontinuous permafrost acting as an impermeable barrier. Area-wide variability in the presence of permafrost accounts for the local occurrence of sub-, intra-, and supra-permafrost groundwater.

Surface Water Types. Construction of the airfield and numerous buildings on the Former Galena FOL altered natural drainage patterns. Water may pool within the containment berms for tanks, but there are no significant surface water bodies on the property. Surface flow is generally to the south by overland flow into sloughs, with discharge to the Yukon River (primarily by the stormwater pump [Storm Drain Pump Station]).

The U.S. Environmental Protection Agency granted the USAF an exclusion from permitting (No Exposure Certification) under the terms and conditions imposed by the EPA's Stormwater Multi-Sector General Permit for USAF activities at the Former Galena FOL. The No Exposure Certification for the USAF at the Former Galena FOL began in February 2006 (EPA, 2006).

Old Town Galena and the Former Galena FOL are located adjacent to the Yukon River, which generally flows from east to west. The maximum low-water river stage on the Yukon River is generally observed in early May, before the spring breakup. With the onset of spring breakup, the river stage abruptly rises to peak water-level elevations, which generally occur in late May or June. The river stage steadily declines throughout the early summer months following breakup. The river stage typically rises again during the late summer months in response to precipitation events, and eventually returns to low-water conditions with the onset of river freeze-up in October (Radian, October 2002).

Fish, Amphibians, and Reptiles. Fish are absent within the Former Galena FOL site, but about 20 species of fish inhabit a wide variety of wetlands and river systems on the nearby Koyukuk National Wildlife Refuge and the adjacent Yukon River (ADEC, June 1999). Both anadromous and resident fishes are common. Anadromous species include dolly varden; inconnu (sheefish); and chinook, coho, and chum salmon that may spawn in the Bottomlands Subregion (but unlikely adjacent to Galena) or migrate farther upstream. Resident species are northern pike, grayling, whitefish, sucker, burbot, and stickleback. Although wood frogs are relatively common amphibian inhabitants of the Interior Subregion, no reptiles are found in the subregion.

The USAF (2008) also determined that there is no fish habitat and likely little to no amphibian habitat in the cantonment area and airfield of the Former Galena FOL site. However, ABR Inc., found wood frogs to be abundant in most moist and aquatic habitats around the Former Galena FOL during the late-June 2005 site visit for the INRMP. A list of fish and amphibian species present in the area is provided in Table B2, Appendix B to the INRMP.

Sensitive Areas/Wetlands. The U.S. Fish and Wildlife Service (2010) did not report any threatened, endangered, or sensitive species within the boundaries of Galena Airport (Attachment G-2). The Alaska Natural Heritage Program (ANHP 2010) provided a list of twelve species of various sensitivities that could occur in the project vicinity (Attachment G-3). From this list, the Alaska tiny shrew (*Sorex yukonicus*) and American

peregrine falcon (*Falco peregrinus anatum*) are the only species ranked as "sensitive" (state ranked as rare or uncommon in state (21-100 occurrences) and rare or uncommon in state (21-100 occurrences), breading status, respectively) with available habitat at or near potentially contaminated sites. Although both species could occur within the Former Galena FOL, the shrew has not been observed in the project area (USAF 2008) and most likely does not occur at the site. Furthermore, the falcon would be considered a transient, flying over the project area, and most likely would not be adversely affected by any potential contamination. The U.S. Fish and Wildlife Service (1999) identified wetlands on the National Wetlands Inventory Map (Figure G5) for the Former Galena FOL area. Wetlands that could be affected by potentially contaminated sites were evaluated in the Ecoscoping Forms (Attachment G-1). No critical habitat or other sensitive areas (such as spawning grounds, nursery habitat, rookeries, or marine mammal haul-out areas) are present on the Former Galena FOL (Figures G4 and G5).

The Yukon River (which is offsite, but potentially affected by groundwater seeps from onsite) is among the many streams in Alaska that have been identified in the Fish Distribution Database as being important for the spawning, rearing, or migration of anadromous fish (Alaska Department of Fish and Game, 2009a). Koyukuk National Wildlife Refuge is located about 6 miles north of the Former Galena FOL, and the Northern Unit of Innoko National Wildlife Refuge is just across the Yukon River, about 1 mile south of the site. Although nearby, those refuges are not expected to be affected by site-related contamination, and no other parks, preserves, or refuges were identified in the project vicinity.

Habitat and Wildlife. At most sites, habitat that could be affected by site-related contamination at the Former Galena FOL provides limited support for wildlife, including valued species (that is, species that are regulated, used for subsistence, have ceremonial importance, have commercial value, or provide recreational opportunity) as well as other species. The Former Galena FOL "triangle" and much of the airfield are maintained facilities (including mowing of the airfield) where habitat values are minimal. Areas along or outside the levee (for example, Parcel Q, west of TU001 Area, and landfills) have vegetation more characteristic of the Interior Bottomlands Subregion of the Interior Ecoregion of Alaska (described in the next paragraph). Within the airfield, most vegetated areas are mowed, and there was no sign of animal activity during the October 2009 site reconnaissance visit. The main exception was the drainage swale south of the runway (including the ST010 Southeast Runway Fuel Spill vicinity), where extensive signs of vole activity were observed.
The Interior Bottomlands include about 38,600 square miles of flat or nearly flat lands along the central and/or lower portions of the Yukon, Koyukuk, Tanana, and Kuskokwim rivers (ADEC, June 1999a,b). The bottomlands are marshy basins dotted with meandering streams and many thaw and oxbow lakes. Forested lowlands and wetlands characterize this area, and permafrost is widespread across the bottomlands.

Vegetation within the Interior Bottomlands consists mainly of closed stands of needleleaf, broadleaf, and mixed forests with intermixed tall scrub-shrub communities and smaller areas of bogs, marshes, and wet grassy meadows (ADEC, June 1999a,b). Needleleaf forests include white spruce in drier areas and black spruce in poorly drained areas. Broadleaf species include quaking aspen and balsam poplar. The tall scrub-shrub community occurs both as an understory to the dominant forests, and as separate vegetation stands where

needleleaf and broadleaf species are absent. Constituents of the scrub-shrub community include resin birch, alder, and willow, with prickly rose, Labrador tea, and berries. The forest herb layer frequently includes bluejoint, bluebell, horsetail, and mosses. The bogs, marshes, and wet meadow species principally include Labrador tea, dwarf Arctic birch, berries, sedges, rushes, horsetail, and mosses.

Former Galena FOL and surrounding habitat mapped by ABR, Inc. (Figure 5.2) included 1,209 acres (489 hectares) along the Yukon River on an old river terrace (USAF, 2008). The area is well-drained to moderately well-drained, and is primarily flat terrain in riverine and lowland situations. Artificial habitats, including structures, roads, and regularly-manipulated vegetation, such as runway rights-of-way, Former Galena FOL, and part of the town and surrounding area comprise 39.3 percent (474.7 acres, 192.1 hectares) of the study area.

USAF (2008) identified the most predominant wildlife habitat in the study area as Lowland Tall Open Scrub, which comprises 20.1 percent of the mapped area (242.5 acres, 98.1 hectares). Other common habitats identified in the Former Galena FOL area include Lowland Open Needleleaf Forest (142.9 acres, 57.8 hectares), lowland Open Broadleaf Forest (110.4 acres, 44.7 hectares), and Lowland Tall Closed Scrub (102.2 acres, 41.4 hectares). Few waterbodies or aquatic habitat types occur in the vicinity of the Former Galena FOL, but they are used by waterfowl, particularly dabbling ducks, and shorebirds, such as Wilson's snipe and solitary sandpiper. Abundant forest and tall shrub habitats surrounding the Former Galena FOL are used by a variety of passerine bird species for nesting and foraging, including chickadees, and several thrushes, warblers, and sparrows. Three swallow species use many artificial structures at the Former Galena FOL for nesting, and swallows forage in open habitats surrounding these areas.

Wetlands around the Former Galena FOL are patchy in occurrence, often in low-lying portions of abandoned floodplain channels (USAF 2008). Most of the Former Galena FOL has been modified (filled) by development. The cantonment area is mostly not vegetated, except for a Lowland Tall Closed Scrub and a Lowland Tall Open Scrub that averages about 150 feet wide on the western edge. There is also a strip of Lowland Tall Open Scrub outside the eastern installation boundary of the cantonment area. The airfield area is primarily upland grasses in non-paved areas with remnant wetlands in ditch drainage ways and Lowland Tall Open Scrub east of the airport ramp. Wetlands are scattered throughout the area adjacent to the Former Galena FOL, outside of the dyke, and consist predominately of scrub shrub or combined emergent and scrub shrub (seasonally flooded types). Dominant emergent plant species include sedges, equisetum, and grasses (for example, *Carex aquatilis*, *C.utriculata*, *Equisetum fluviatile*, and *Calamagrostis canadensis)*. The most common shrub occurring in wetlands throughout the area is thinleaf alder (*Alnus tenuifolia)*.

Invertebrates are expected to be numerous in the Interior Bottomlands because of the large amounts of surface water and relatively warm summers (ADEC, June 1999). Mosquitoes are abundant, and other species of Diptera, Trichoptera, Coleoptera, Hemiptera, and arachnids are also likely to be present. Freshwater aquatic/benthic invertebrates might include species of Plecoptera, Ephemeroptera, Diptera, Trichoptera, Hymenoptera, Lepidoptera, Collembola, Oligochaeta, copepods, rotifers, and cladocerans.

Numerous bird species stop to feed and rest on the Yukon River and nearby Innoko and Koyukuk National Wildlife Refuges, which provide nesting habitat and migration resting areas for waterfowl and shorebirds (USAF 2008). Forty bird species were observed at the Former Galena FOL during the 2005 survey for the INRMP. Observations included species such as the American wigeon; common goldeneye; spruce and ruffed grouse; sandhill crane; Wilson's snipe; olive-sided and alder flycatchers; and orange crowned, yellow, yellow-rumped, and blackpoll warblers. Several raptors, notably the bald eagle, osprey, red-tailed hawk, great grey owl, short-eared owl, and peregrine falcon, are also found in the area. Passerine species include the American robin, yellow warbler, yellow-rumped warbler, hermit thrush, cliff swallow, and white-crowned sparrow. Aquatic birds include mew, herring, and glaucous gulls. Bird species observed or potentially occurring in the Former Galena FOL area are provided in Table B4, in Appendix B of the INRMP.

The Interior Bottomlands provide waterfowl resting, staging, and breeding habitat (ADEC, June 1999). The principal species include scaup, pintail, scoters, wigeon, mallards, shovelers, green-winged teal, and canvasbacks. Swans, geese, loons, grebes, and sandhill cranes also are common. Birds of prey such as the rough-legged hawk, sharp-shinned hawk, red-tailed hawk, kestrel, raven, great-horned owl, and short-eared owl are all common to the area. The peregrine falcon also inhabits the area. The spruce grouse, ruffed grouse, and ptarmigan may be found in drier areas. Passerines and other small birds are also common in the subregion and include gray jay, chickadees, robins, thrushes, warblers, redpoll, pipits, and sparrows, among many others. Nesting and rearing are likely to occur in June and July, respectively. Migratory birds depart for warmer climates by late September and early October.

The Galena area supports terrestrial wildlife species typical for interior Alaska (USAF 2008). Representative mammals include beaver, black bear and the less common brown/grizzly bear, caribou, North American lynx, marten, mink, moose, muskrat, red fox, snowshoe hare, wolf, wolverine, and several small rodent species. Table B3, in Appendix B to the INRMP, identifies mammals found in and around the Former Galena FOL area.

Mammals inhabiting the Interior Bottomlands include brown and black bears, caribou, wolves, weasels, marten, hares, squirrels, voles, and shrews (ADEC, June 1999a,b). Moose are abundant in the subregion. Caribou may be common in localized areas. Many of these species are resident, but may hibernate or migrate locally to optimum foraging grounds. Semi-aquatic mammals such as muskrat, mink, and beaver are common in the myriad water bodies in the subregion.

Further information about habitats of the region and species lists for birds and mammals are available at the Web sites for the Koyukuk and Innoko National Wildlife Refuges (http://alaska.fws.gov/nwr/koyukuk/index.htm [USFWS, 2009a] and http://alaska.fws.gov/nwr/innoko/index.htm [USFWS, 2009b]). It is unlikely that species that the Alaska Department of Fish and Game, USFWS, or National Marine Fisheries Service have identified as threatened or endangered, under consideration for protection, or Alaska species of special concern (listed at http://www.adfg.state.ak.us/special/esa/esa_home.php [Alaska Department of Fish and Game, 2009b]) are present on the Former Galena FOL other than as transients (for example, peregrine falcon). However, some species

that are used for subsistence, have ceremonial importance, have commercial value, or provide recreational opportunity (such as moose and snowshoe hare) are found in wooded areas around the site.

2.1.2 Documentation of Site Visits

A site reconnaissance visit was performed in October 2009. Documentation of this site visit, as provided in the Ecoscoping Forms, is included in the PA Report (CH2M HILL, 2010) and summarized in Worksheet #10 in the main text of this Work Plan.

2.1.3 Identification of Contaminants of Potential Ecological Concern

Chemicals of potential ecological concern (COPECs) are those chemicals present at the site in concentrations that may exceed toxicity thresholds for ecological receptors. These chemicals are identified by the evaluation of known site practices and analytical results. Based on historical site use as an airfield with the primary activities of refueling and aircraft servicing, primary sources of potential contamination are the spill and release of fuels or solvents from fuel handling, pipelines, tanks, floor drains, waste disposal/storage facilities, and the Fire Protection Training Area (Parcel I) (Site FT001). Additionally, aggressive application of pesticides may have occurred in some areas of the Former Galena FOL. Therefore, COPECs for the site are likely to be petroleum fuels (for example, diesel, jet-propulsion fuel grade 4 [JP-4], and jet-propulsion fuel grade 8 [JP-8]), oils and lubricants used for maintenance of aircraft and vehicles, polychlorinated biphenyls (PCBs; used in transformers), solvents (for example, trichloroethene [TCE]), and organochlorine pesticides (for example, dichlorodiphenyl-trichloroethane [DDT]). Additionally, based on existing data and data collected during the SI, several metals (for example, lead) may be considered COPECs.

2.1.4 Conceptual Site Model

The ecological CSM is a written and visual presentation of predicted relationships among stressors, exposure pathways, and assessment endpoints. It includes a description of the potentially complete ecological exposure pathways and outlines the potential routes of exposure for each assessment endpoint. ADEC provides guidance for the development of the CSM (ADEC, November 30, 2005). The CSM diagram for the Former Galena FOL was developed according to this guidance and is presented on Figure G6.

The primary sources of potential contaminants are soils at work and storage locations related to the historical activities of aircraft refueling, aircraft and vehicle maintenance, fire protection training, and pesticide use. Primary release mechanisms include spills/leakage, leaching, and infiltration of COPECs from fuel handling, pipelines, tanks, floor drains, waste disposal/storage facilities (aboveground and underground), and Site FT001, as well as application, spills/leakage, leaching, and infiltration of pesticides. Another primary release mechanism for the transfer of contaminants from soil to groundwater is the substantial water table fluctuations (up to 20 feet) that occur at the site.

Secondary sources of potential contaminants are surface and subsurface soils and groundwater. Although surface water usually is not present on the site, surface water may pool at Site FT001, and groundwater plumes that extend from upgradient sites toward the

vicinity of the Yukon River may result in exposures of aquatic organisms or wildlife drinking the water (for example, at seeps [if present] and discharge points to the Yukon River). Groundwater plumes will be evaluated for potential ecological exposures if they exist within 1,000 feet of the Yukon River. Sediment may also be a potential secondary source at seeps. Transport mechanisms include discharge/runoff, leaching, and wind erosion from contaminated soils to surface soils and sediment (at seeps), volatilization to air, leaching to groundwater, and surface discharge from groundwater.

Potentially complete exposure pathways from contaminated surface soil, sediment, biota, and groundwater to ecological receptors may exist at several sites, and surface water may pool at Site FT001. Contaminants in soil may be directly bioaccumulated by terrestrial plants or soil invertebrates resident in site soils. Aquatic plants may be exposed via contaminated sediment (primarily wetland plants) or contaminated surface water (for example, algae and free-floating plants). Wetland habitat is not present onsite; therefore, sediment-associated aquatic plants will not be evaluated. Surface water-associated aquatic plants may occur during portions of the year at Site FT001 or at groundwater seeps or discharges to the Yukon River, and will be evaluated at these sites only. Although benthic invertebrates, fish, and amphibians may be exposed to contaminants via surface water or sediment, benthic invertebrates are primarily exposed through sediment, and fish and amphibians are primarily exposed through surface water. Fish are not present onsite and will not be evaluated at Site FT001 or the groundwater seeps. However, groundwater that discharges to the Yukon River may result in exposures to fish, so surfacing groundwater at these locations will be evaluated for fish.

Terrestrial and aquatic wildlife (for example, herbivores, omnivores, invertivores, and carnivores) may be exposed directly to contaminants in surface water through ingestion and to contaminants in soil or sediment by incidental soil or sediment ingestion, by dermal contact, or by the inhalation of wind-borne particles. Terrestrial and aquatic invertebrates, fish, and wildlife (that is, amphibians, birds, and mammals) may also receive contaminant exposure through food-web transfer of chemicals from lower trophic levels (for example, plants to herbivores, plants and prey animals to omnivores, etc.). As previously noted, surface water does not exist onsite, except occasionally at Site FT001. Therefore, the surface water pathways (for example, ingestion) will not be evaluated for most sites. However, surfacing groundwater will be evaluated for risks to aquatic plants and invertebrates where there is a potential for groundwater seeps to occur and for exposure to aquatic plants, aquatic invertebrates, and fish at points of groundwater discharge to the river. Aquatic and semi-aquatic birds and mammals are not generally present onsite and will not be evaluated for exposures to sediment associated with surfacing groundwater because of the very small areas where that may occur. However, semi-aquatic birds may opportunistically forage on aquatic plants or invertebrates (if present) in pooled surface water at Site FT001, and will be evaluated at that site.

2.1.5 Assessment Endpoints

Assessment endpoints are an expression of the important ecological values that should be protected at a site (Suter, 1990, 1993; EPA ,April 1998; Suter et al., 2000). Assessment endpoints are developed based on known information concerning the contaminants present, the study

area, the ecological CSM, and risk hypotheses/questions. Each assessment endpoint has three components: an *entity* (for example, migratory birds), an *attribute* of that entity (for example, individual survival), and a *measure* (for example, a measurable value, such as an effect level). The measures described here follow the general description of assessment endpoints (EPA, April 1998, Suter et al., 2000).

The assessment endpoint entities for the Former Galena FOL will be selected using guidance provided by ADEC (June 1999a,b) and based on the following principal criteria (ADEC February 18, 2009):

- Ecological relevance
- Relevance to management goals
- Susceptibility (or high exposure) to known or potential stressors at the site

The attribute selected for each entity will be based on the organizational level of the entity and the primary criteria that are used to select it. Entities and attributes will be selected for community, population, and individual (if special-status species are present) levels of assessment.

The maximum acceptable adverse effect levels generally selected for population- and community-level assessment endpoints are lowest observed effect concentrations (LOECs) or lowest observed adverse effects levels (LOAELs). For individual-level assessment endpoints (for example, threatened and endangered species), there is no acceptable adverse effect level. Consequently, no observed effect concentrations (NOECs) or no observed adverse effects levels (NOAELs) typically are used for these endpoints. However, as noted previously, no threatened or endangered species are known to occur in the vicinity of the Former Galena FOL. Therefore, such species will not be included as receptors of concern. However, risks based on NOECs/NOAELs will be presented for the selected receptors to provide a range of estimated risks that risk managers may use in making risk-management decisions following the ERA.

Based on Alaska regulatory guidance (ADEC, June 1999a,b), the Former Galena FOL is in the Interior Bottomlands subregion of the Interior ecoregion. Table G3 lists the default assessment endpoints for the Interior ecoregion. Surface water habitat is not present on any site on a permanent basis, but may pool at Site FT001 during wet periods. Therefore, receptors associated with freshwater and freshwater sediment are generally not planned for evaluation. However, at Site FT001 and in areas where groundwater contamination plumes may extend to within 1,000 feet of the river, surfacing groundwater in seeps and discharges to the Yukon River will be evaluated using water screening values provided in ADEC (March 2009). These screening values are protective of aquatic plant, aquatic invertebrate, fish, and amphibian communities. Additionally, the benthic invertebrate community will be an assessment endpoint for sediments associated with the seeps (if present). Aquatic and semi-aquatic birds and mammals are not present onsite and will not be evaluated. However, because semi-aquatic birds may opportunistically forage on aquatic plants or invertebrates (if present) in pooled surface water at Site FT001, they will be evaluated at that site only. For terrestrial habitats, default receptors include terrestrial plant and soil invertebrate communities and terrestrial birds and mammals (herbivores, invertivores, and carnivores).

As appropriate, representative ecological receptors (that is, specific species) will be selected from these communities based on ADEC guidance (June 1999a,b) to fulfill as many of the following criteria as possible:

- Species that are known to occur or are likely to occur at the site
- Species that relate to the assessment endpoints selected
- Species that are likely to be maximally exposed to the site-related COPECs
- Sedentary species or species with a small home range
- Species with high reproductive rates
- Species that are known to play an integral role in the ecological community structure at the site
- Species that are known or likely to be especially sensitive to the site-related COPECs, and thus are an indication of ecological change
- Species that are representative of the foraging guild (that is, a group of species with similar ecological resource requirements and foraging strategies and, therefore, similar roles in the ecosystem) or that serve as food items for higher trophic levels

The bird and mammal receptors include species representative of trophic levels and foraging guilds (for example, herbivores, invertivores, and carnivores). Sensitive environments and special-status species have not been observed onsite. The representative receptors will be selected based on the habitat at the site.

- Areas where short grasses and forbs predominate (many sites are mowed) are assumed to have representative avian species such as the ground-feeding herbivorous dark-eyed junco and invertivorous American robin, as well as the carnivorous northern shrike (Table G3).
- Mammalian receptor species may include the herbivorous vole (the red-backed vole has been documented onsite and will likely be a better choice than the tundra vole), the invertivorous masked shrew, and the carnivorous least weasel.
- Wooded areas at some sites may provide habitat for the wood frog, which is an assessment endpoint for the Interior ecoregion (Table G3).
- At times, water pools at Site FT001 provide potential foraging habitat for herbivorous and invertivorous semi-aquatic birds such as the mallard and common snipe, respectively (Table G3).
- The snowshoe hare and moose are not default receptors for this ecoregion. However, these species are used for subsistence, have ceremonial importance, have commercial value, or provide recreational opportunities, and are found in wooded areas around the site. Therefore, the snowshoe hare and moose may also be selected as receptors for the wooded areas.

Final selection of assessment endpoints and representative receptors will be determined during discussion with State and federal agencies during a risk assessment scoping meeting.

2.1.6 Measures

Measures (formerly referred to as measurement endpoints) are measurable attributes used to evaluate the risk hypotheses that are predictive of effects on the assessment endpoints (EPA, April 1998). The three categories of measures are:

- **Exposure**. These measures are used to evaluate levels at which exposures may be occurring.
- **Effects**. These measures are used to evaluate the response of the assessment endpoints when exposed to the stressors.
- **Ecosystem and receptor characteristics**. These measures are used to evaluate the ecosystem characteristics that influence the assessment endpoints, the distribution of stressors, and the characteristics of the assessment endpoints that may affect exposure or response to the stressor.

For the Screening-level ERA and BERA, measures of exposure and effects will be the primary measures used, with measures of ecosystem and receptor characteristics used only if identified as a data gap and developed in the Step 4 refinement of this Work Plan.

2.1.6.1 Measures of Exposure

Measures of exposure can be an EPC of a chemical in an environmental medium or food item, or a related dose estimate. Concentrations of COPECs in soil, sediment (at seeps only), and groundwater will serve as measures of exposure in the screening evaluation. An additional measure of exposure may include tissue concentrations (generally in prey items, such as plants and invertebrates). The need for this measure for the BERA will be evaluated through the sampling and data evaluation in the SI.

2.1.6.2 Measures of Effects

Measures of effects include media-specific ecological benchmarks (the ESLs) and toxicity reference values (TRVs). Because site-related chemicals can induce ecotoxicological effects in exposed receptors if present at sufficiently high concentrations, ecotoxicity-based benchmarks and TRVs are also measurement endpoints. As previously indicated, ESLs in the screening evaluation will be represented by published literature-based screening benchmarks (ADEC, March 2009; Buchman, 2008). For the BERA, TRVs will be developed in the Step 4 refinement of this Work Plan. Typically, the TRVs will consist of NOECs and NOAELs, as well as LOECs and LOAELs.

An additional measure of effect may include site-specific toxicity of soil, sediment, or water. The need for this measure for the BERA will be evaluated through the sampling and data evaluation in the SI.

2.1.6.3 Measures of Ecosystem and Receptor Characteristics

Measures of ecosystem and receptor characteristics include site-specific studies of the diversity and abundance of receptors and/or quantitative or qualitative evaluations of the

habitat quality and functioning at the site. These measures are not generally included in screening-level assessments. The need for this measure for the BERA will be evaluated through the sampling and data evaluation in the SI.

2.1.7 Available Data

Available data for the screening evaluation will consist of existing contaminant concentrations in site media (soil and groundwater) and data gathered during limited sampling in the SI at sites with insufficient existing datasets. Typically, an additional five soil and five water samples will be needed at each site to calculate the reasonable maximum exposure concentrations for evaluation in the BERA.

For the screening evaluation, toxicity data will be derived from the literature as represented by screening benchmarks for soil and water (ADEC, March 2009) and sediment (Buchman, 2008). TRVs for the BERA will also be developed from the literature as discussed in the Subsection 2.2.2, Effects Assessment. In addition, avian and mammalian life-history parameters required for calculation of exposure estimates in the BERA (for example, body weight, food ingestion rates, and dietary components) will be derived from the literature.

2.2 Analysis

The analysis phase consists of the technical evaluation of chemical and ecological data to determine the potential for ecological exposure and adverse effects. The analysis phase includes the characterization of exposure and the assessment of effects.

2.2.1 Exposure Characterization

The exposure characterization describes and quantifies the nature and magnitude of the interaction between COPECs (in soil, sediment, surface water, or groundwater) and ecological receptors. The following subsections describe the preliminary exposure models and assumptions for each receptor at the Former Galena FOL.

2.2.1.1 Terrestrial Plants and Soil Invertebrates

Terrestrial plants and soil invertebrates experience exposure primarily through the soil in which they live. This exposure occurs as a consequence of living in a contaminated medium (that is, receptors are directly exposed to COPECs). Although other exposure pathways (for example, dietary exposure for invertebrates or foliar uptake) may contribute to total exposure for these receptors, exposure through the soil predominates. Consequently, estimates of exposure for terrestrial plants and soil invertebrates will be represented by the concentration of COPECs in the soil (mg/kg).

The EPCs for the initial screening will be the maximum measured concentration (detected or non-detected) of the COPEC in soils collected from 0 to 2 feet at the site. For the BERA, the EPCs may be represented by the entire distribution of values for the retained COPECs, resulting in a point-by-point evaluation. Additionally, the soil exposure depth will be re-evaluated and a more ecologically relevant depth (for example, 0 to 4 feet as a potential rooting depth for plants or 0 to 0.5 foot for birds and mammals, because deep burrowing wildlife are not present at the site) will be selected. Details of the evaluation for the BERA

will be included in the Step 4 refinement of this Work Plan to be completed after the initial screening evaluations.

2.2.1.2 Aquatic Plants, Aquatic Invertebrates, Amphibians, and Fish

Although permanent surface water is not present at the site (see Subsection 2.1.1), temporarily pooled water (at Site FT001) and surfacing groundwater (at seeps or in discharges to the Yukon River) will be evaluated using the surface water screening values that are considered protective of these aquatic receptors. Aquatic plants, aquatic invertebrates, fish, and amphibians experience exposure primarily through the medium where they live. Although aquatic plants (such as algae and free-floating plants) and invertebrates, fish, and amphibians are exposed to COPECs in both surface water and sediment, the primary exposure medium is surface water. For these receptors, exposure occurs as a consequence of living in a contaminated medium (that is, receptors are directly exposed to COPECs). Although other exposure pathways (for example, direct exposure to water or dietary exposure for invertebrates or fish) may contribute to total exposure for these receptors, exposure through surface water predominates. Consequently, estimates of exposure for aquatic plants and invertebrates, fish, and amphibians will be represented as the concentration of COPECs in surface water (micrograms per liter [µg/L]).

Therefore, EPCs for the initial screening estimates (Steps 2 and 3) are the maximum detected or non-detected measured concentration for each COPEC in water. Either the total or dissolved concentration will be used in the screening, depending on the applicability of the screening benchmarks (that is, some are developed for use with total metals concentrations and others for use with dissolved metals concentrations). For COPECs that fail the screening assessment, EPCs in the BERA may be represented by the entire distribution of values, resulting in a point-by-point evaluation for each of these receptors. Details of the evaluation for the BERA will be included in the Step 4 refinement of this Work Plan to be completed after the initial screening evaluations.

2.2.1.3 Benthic Invertebrates

Generally, benthic invertebrates are not receptors at most Former Galena FOL sites. However, if seeps are identified, the sediment associated with the seep will be evaluated for risks to benthic invertebrates. As with aquatic plants, aquatic invertebrates, fish, and amphibians, benthic invertebrates at the site experience exposure primarily through the medium where they live. Benthic invertebrates are exposed to COPECs in both surface water and sediment; however, the primary exposure medium is sediment. Although other exposure pathways (for example, direct exposure to water or dietary exposure for invertebrates) may contribute to total exposure for these receptors, exposure through sediment predominates. Consequently, estimates of exposure for benthic invertebrates will be represented as the concentration of COPECs in sediment (mg/kg).

Initial screening estimates will use the maximum measured detected or non-detected sediment concentration. For COPECs that fail the screening assessment, EPCs in the BERA may be represented by the entire distribution of values, resulting in a point-by-point evaluation for these receptors. Details of the evaluation for the BERA will be included in the Step 4 refinement of this Work Plan to be completed after the initial screening evaluations.

2.2.1.4 Birds and Mammals

Birds and mammals experience exposure through multiple pathways, including ingestion of abiotic media (surface water and sediment/soil) and biotic media (food), as well as inhalation and dermal contact. To address this multiple pathway exposure, modeling is required. The end product, or exposure estimate, for birds and mammals is a dosage (amount of chemical in milligrams per kilogram receptor body weight per day [mg/kg body weight/day]) rather than a media concentration, as is the case for the other receptors. This is a function of both the multiple pathway approach and the typical methods used in toxicity testing for birds and mammals.

In the screening-level evaluation, the soil screening values provided in ADEC (March 2009) include birds and mammals as soil-associated receptors, and are considered to be protective of birds and mammals. Therefore, a media concentration (that is, soil, represented as mg/kg) rather than a dose will be used to represent exposure to birds and mammals in the screening-level assessment. In the BERA, an oral exposure estimate will be modeled for comparison to oral TRVs. The general form of the model that will be used in the BERA to estimate exposure of birds and mammals to COPECs in surface water, sediment/soil, and food items is as follows (Suter et al., 2000):

$$E_t = E_o + E_d + E_i \quad (21)$$

where:

E_t = the total chemical exposure experienced by wildlife
E_o, E_d, and E_i = oral, dermal, and inhalation exposure, respectively

Oral exposure occurs through the consumption of contaminated food, water, or sediment/soil; dermal exposure occurs when contaminants are absorbed directly through the skin; and inhalation exposure occurs when volatile compounds or fine particulates are inhaled into the lungs.

Although methods are available for assessing dermal exposure to humans (EPA, 1992), data necessary to estimate dermal exposure generally are not available for wildlife (EPA, 1993). Similarly, methods and data necessary to estimate wildlife inhalation exposures are poorly developed (EPA, 1993) or limited (that is, some data are available through the EPA IRIS database). Additionally, a wildlife receptor's exposure to contaminants by inhalation and dermal contact usually contributes little to its overall exposure. In the case of the Former Galena FOL, because burrowing receptors (for example, burrowing owls, badgers) are not present, inhalation exposure is not a pathway of primary concern for the site. Dermal exposure also is likely to be low, even in burrow-dwelling animals, because of the presence of protective dermal layers (for example, feathers, fur, or scales). Therefore, for the purposes of this assessment, both dermal and inhalation exposure will be assumed to be negligible.

Because dermal and inhalation exposures are excluded, total chemical exposure experienced by wildlife (E_t) is equal to oral exposure (E_o). By replacing E_o with a generalized exposure model modified from Suter et al. (2000), the previous equation can be rewritten as follows:

$$E_t = \left[\left[\sum_{i=1}^{n} B_{ij} \times P_i \times FIR\right] + \left[Soil_j \times P_s \times FIR\right] + \left[Water_j \times WIR\right]\right] x\, AUF \qquad (22)$$

where:

E_t = total exposure (mg/kg-day)
$Soil_j$ = chemical (j) concentration in sediment/soil (mg/kg dry weight)
P_s = sediment/soil ingestion rate as proportion of diet (unitless)
FIR = food ingestion rate (kg food/kg body weight/day)
B_{ij} = chemical (j) concentration in biota type (i) (mg/kg wet weight)
P_i = proportion of biota type (i) in diet (unitless)
$Water_j$ = chemical (j) concentration in water (mg/L)
WIR = water ingestion rate (L water/kg body weight/day)
AUF = area use factor (area of site/home range of receptor) (unitless)

2.2.1.5 Model Parameterization

To apply the exposure model, appropriate model parameters (for example, EPCs, life history parameters, and bioaccumulation models) must be defined. These model parameters will be detailed in the Step 4 refinement of this Work Plan to be developed for the BERA.

2.2.2 Effects Assessment

The ecological effects assessment evaluates available toxicity or other effects information that can be used to relate the exposures to COPECs and adverse effects in ecological receptors. Data that can be used include literature-derived or site-specific single-chemical toxicity data, site-specific ambient-media toxicity tests, and site-specific field surveys (Suter et al., 2000). For the Former Galena FOL, the screening-level assessment will use single-chemical toxicity data from literature sources. As previously indicated, these will include screening values for soil and water from ADEC (March 2009) and TEL and PEL for sediment from the SQuiRTs developed by Buchman (2008). A determination of whether to collect site-specific single-chemical toxicity data or to perform site-specific ambient-media toxicity tests or site-specific field surveys for the BERA will be based on sampling and data evaluation in the SI.

For the BERA, TRVs will be developed and detailed in the Step 4 refinement of this Work Plan. Generally, the TRVs for birds and mammals will be derived using the following approach. Single-chemical toxicity data for birds and mammals consist of NOAEL and LOAEL TRVs. Appropriate toxicity studies will be selected based on several criteria:

- Studies are of chronic exposures or exposures during a critical stage of life (for example, reproduction)
- Exposure is oral through food so that data are representative of oral exposures expected for wildlife in the field

- Emphasis will be placed on studies of reproductive impacts so that they will be relevant to population-level effects
- Studies present adequate information to evaluate and determine the magnitude of exposure and effects (or no-effects concentrations)

Specifically, toxicity studies will be selected to serve as the TRV if exposure is chronic or during reproduction (a critical lifestage), the dosing regime is sufficient to identify both an NOAEL and an LOAEL, and the study considers ecologically relevant effects (for example, growth, reproduction, or survival). If multiple studies for a given COPEC meet these criteria, the study generating the lowest reliable toxicity value will be selected to be the TRV.

2.3 Risk Characterization

In the risk characterization, exposure and effects data are integrated to draw conclusions concerning the presence, nature, and magnitude of effects that may exist at the site. This section outlines the process by which exposure and effects data will be integrated to estimate risk at the screening level and likely methods for this process at the baseline level. The sections included here describe procedures to develop the risk estimate and the risk description.

2.3.1 Risk Estimate

According to the EPA (June 1997a, April 1998) and ADEC (February 18, 2009) guidance, risks at the site will be evaluated based on the ratio of exposure concentrations or doses to TRVs, resulting in HQs that are described by the following equations:

$$HQ = MEC/Benchmark \text{ or } Dose/TRV \quad (23)$$

where:

HQ	=	ecological hazard quotient (unitless)
MEC	=	measured environmental concentration (µg/L for water and mg/kg for sediment/soil)
Dose	=	estimated chemical intake by wildlife receptor (mg/kg-day)
Benchmark	=	ecological screening level (ESL) (µg/L or mg/kg)
TRV	=	toxicity reference value (mg/kg-day)

For the screening evaluation, HQs for all receptors will be based on MECs and benchmarks. HQ values less than 1.0 will be considered to indicate that adverse effects associated with exposure to a given analyte are unlikely (EPA, June 1997a). These analytes will not be considered to present unacceptable risk and will be excluded from further evaluation. Because the screening benchmarks are primarily derived from effects data, an HQ equal to or greater than 1.0 will be considered to indicate a potential for adverse ecological effects. These analytes will be retained for further evaluation in the BERA. Additionally, bioaccumulative COPECs will be retained following the Screening-level ERA for evaluation in the BERA. COPECS for which appropriate toxicity data are unavailable will not be further evaluated, but will be retained as uncertainties.

In contrast to the conservative approach used for the initial screening-level evaluation, the baseline evaluation focuses on the more reasonable potential for exposure of target species to COPECs. The reasonable potential for exposure and adverse effects will be evaluated through assessment of the available chemical (magnitude of HQ, cumulative risk, and frequency of detection and exceedance) and biological (habitat quality and bioavailability of the COPEC) information. Examples of these evaluations (or lines of evidence) that may be included in the BERA include the following:

- **Background screen**. Concentrations of inorganics measured at the site will be screened against background values. Because inorganics naturally occur in the environment, comparison of measured site concentrations to background values is appropriate. The U.S. Environmental Protection Agency identifies statistical methods for conducting a background screening evaluation (EPA, 2001). Additionally, the EPA ProUCL software (EPA, 2009) can be used to calculate upper tolerance limits (UTLs) from the background data. Inorganics with concentrations that are not significantly different from background or with maximum concentrations that do not exceed the background UTL will not be included in the calculation of unacceptable risk.

- **Point-by-point analysis**. For directly exposed receptors (aquatic plants, aquatic invertebrates, benthic invertebrates, fish, amphibians, terrestrial plants, and soil invertebrates), a point-by-point analyses may be performed using the entire distribution of data. This allows for an evaluation of the frequency and magnitude of exceedances.

  – *Frequency of exceedance*. A low frequency of exceedance of the TRVs may indicate that risk is not widespread and may not be unacceptable for population- and community-level receptors.

  – *Magnitude of exceedance.* The magnitude of exceedance is considered a general indication of the magnitude of risk, but it is not an exact estimation of risk. For example, other factors may cause the risk due to a chemical with an HQ of 70 to be less than that for a chemical with an HQ of 20. Therefore, the HQ is considered to be a binary measure in which non-exceedance indicates no potential for risk and exceedance indicates a potential for risk. However, if a COPEC has a low HQ, and the other evaluations (that is, frequency of detection, habitat quality) indicate that the potential for exposure to the COPEC is low, then the COPEC may not be considered to pose an unacceptable risk.

- **Frequency of detection**. The frequency of detection of COPECs serves as an indicator of the extent of contamination across the study area. A low frequency of detection may indicate that the contamination is limited to small portions of the site (hot spots) or even only in a single location where the sample was collected. If the frequency of detection for a COPEC is low, the results of the other qualitative evaluations (that is, magnitude and frequency of HQ exceedances and habitat quality) will be used to determine whether the chemical may pose a risk.

- **Cumulative risk**. For analytes with similar toxicological endpoints (for example, polycyclic aromatic hydrocarbons [PAHs] associated with fuels), the HQs will be summed to determine the HI.

- **Habitat quality**. Habitat quality affects site use by receptors and may be used as an indication of the potential for exposure. However, risks cannot be excluded based on this evaluation. Instead, this evaluation may be used to support the results of other evaluations.
- **Exposure parameters**. Exposure estimates for birds and mammals may be calculated using more realistic exposure parameters to determine risks in the BERA. This may include use of the 95 UCL for media concentrations, use of median of literature-derived bioaccumulation factors (BAFs), or use of site-specific BAFs. Additionally, the bioavailability of individual COPECs may be considered (screening assessments assume 100 percent bioavailability), as may diet and percent use of the site (area use).
- **Site-specific data.** Based on the sampling and data evaluation in the SI, site-specific data (such as co-located soil concentrations and tissue concentrations in prey items [used to develop site-specific BAFs]) or media samples for site-specific toxicity testing (used to develop site-specific toxicity values) may be collected. Methods for these additional data collections, if warranted, will be outlined in the Step 4 refinement of this Work Plan.

These evaluations or lines of evidence will be considered in the risk characterization using a weight-of-evidence approach to determine the potential for risk.

2.3.2 Risk Description

The risk description will employ a weight-of-evidence approach in which all lines of evidence are considered to determine the potential for risk. It should be noted that not all lines of evidence will be given equal weight in this analysis. For example, the background analysis may be used to exclude risks from inorganics with site concentrations that do not statistically differ from background concentrations. However, other lines of evidence (for example, frequency of detection, habitat quality) must be considered together as supporting or not supporting a conclusion of risk (or in some cases low risk).

Some factors that will be considered in the risk description (as provided in ADEC, February 18, 2009) are:

- The relevance of evidence to assessment endpoints
- The relevance of evidence to the CSM
- The sufficiency and quality of the data and the study design used in the key studies
- The strength of the cause-and-effect relationships
- The relative uncertainties associated with the lines of evidence and their direction.

2.4 Uncertainties

Uncertainties, which are inherent in all aspects of an ERA, include those related to problem formulation, exposure assessment, ecological effects assessment, and risk estimation and risk characterization. They may be associated with exposure parameters, BAFs, toxicity values, and other literature-based information, as well as with site data or lack thereof. This section will list the important sources of uncertainty and describe whether they result in an under- or over-estimate of ecological risks.

SECTION 3

References

AECOM. 2009. *Draft Environmental Baseline Survey Air Force Property at Galena Airport, Alaska.*

Alaska Department of Environmental Conservation (ADEC). June 1999a. *User's Guide for Selection and Application of Default Assessment Endpoints and Indicator Species in Alaskan Ecoregions*. ADEC. Division of Spill Prevention and Response. Contaminated Sites Program.

Alaska Department of Environmental Conservation (ADEC). June 1999b. *Technical Background Document for Selection and Application of Default Assessment Endpoints and Indicator Species in Alaskan Ecoregions*. EcoRegions/Assessment Endpoint Project. ADEC.

Alaska Department of Environmental Conservation (ADEC). November 30, 2005. *Policy Guidance on Developing Conceptual Site Models*. ADEC. Division of Spill Prevention and Response. Contaminated Sites Program.

Alaska Department of Environmental Conservation (ADEC). 2008. Title 18, Chapter 75, of the *Alaska Administrative Code* (18 AAC 75), Oil and Other Hazardous Substances Pollution Control. Revised as of October 9.

Alaska Department of Environmental Conservation (ADEC). July 2009. *Draft Vapor Intrusion Guidance for Contaminated Sites*.

Alaska Department of Environmental Conservation (ADEC). February 18, 2009. *Risk Assessment Procedures Manual.*

Alaska Department of Environmental Conservation (ADEC). March 2009. *Ecoscoping Guidance.* ADEC. Division of Spill Prevention and Response. Contaminated Sites Program.

Alaska Natural Heritage Program (ANHP). April 2010. Letter Regarding the Request for List of Threatened, Endangered, and Sensitive Species or Other Species and Communities of Conservation Concerns for the Former Galena Forward Operating Location, Galena, Alaska. University of Alaska Anchorage.

Alaska Department of Fish and Game. 2009a. *Anadromous Waters Catalog*. http://www.sf.adfg.state.ak.us/SARR/AWC/index.cfm/FA/main.overview. Accessed on December 10, 2009.

Alaska Department of Fish and Game. 2009b. *Endangered Species in Alaska*. http://www.adfg.state.ak.us/special/esa/esa_home.php. Accessed on December 10, 2009.

Andelman, J. B. 1990. *Total Exposure to Volatile Organic Chemicals in Potable Water*. Eds. N.M. Ram, R.F. Christman, and K.P. Cantor. Lewis Publishers.

Buchman, M.F. 2008. *NOAA Screening Quick Reference Tables, NOAA HAZMAT Report 99-1*, Seattle, WA, Coastal Protection and Restoration Division, National Oceanic and Atmospheric Administration.

CH2M HILL. 2010. *Preliminary Assessment Report for the Former Galena Forward Operating Location, Galena, Alaska*. Prepared for the Air Force Center for Engineering and the Environment (AFCEE). AFCEE Contract FA8903-08-D-8769, Task Order 0184.

Earth Tech, Inc. May 2007. *Final Remedial Investigation/Feasibility Study Report for United States Air Force Sites at Galena Airport and Campion Air Station, Alaska.* Prepared for the United States Air Force, 611th Civil Engineer Squadron/Environmental Restoration Element (CES/CEVR), Elmendorf Air Force Base, Alaska.

Oak Ridge National Laboratory (ORNL). 2009. *Risk Assessment Information System – Toxicity and Chemical Properties – Chemicals Database*. http://rais.ornl.gov/cgi-bin/tox/TOX_select?select=chem. Accessed April 2009.

Radian Corporation. October 2002. *Environmental Monitoring Report #7, Volume 1, Galena Airport, Alaska, Revised Draft*.

Suter, G.W., II. 1990. "Endpoints for ecological risk assessments." *Environmental Management* 14:9-23.

Suter, G.W., II. 1993. *Ecological risk assessment*. Lewis Publishers, Chelsea, MI.

Suter, G.W., II., R.A. Efroymson, B.E. Sample, and D.S. Jones. 2000. *Ecological Risk Assessment for Contaminated Sites*. Lewis Publishers, Boca Raton, Florida.

U.S. Air Force (USAF) 2008. Integrated Natural Resources Management Plan, Galena Airport Forward Operating Location Galena, Alaska, 2008 Revision. Prepared by 611th Air Support Civil Engineer Squadron, Environmental Flight.

U.S. Environmental Protection Agency (EPA). December 1989. *Risk Assessment Guidance for Superfund (RAGS). Volume I: Human Health Evaluation Manual. Part A, Interim Final.* EPA/540-1-89/002. Office of Emergency and Remedial Response.

U.S. Environmental Protection Agency (EPA). 1991a. *Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors*. OSWER Directive 9285.6-03.

U.S. Environmental Protection Agency (EPA). 1991b. *Risk Assessment Guidance for Superfund. Volume 1, Human Health Evaluation Manual*. Part B, Development of Risk-Based Preliminary Remediation Goals. EPA/540/R-92/003. Publication 9285.7-01B.

U.S. Environmental Protection Agency (EPA). April 22, 1991. *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions.* [OSWER Directive 9355.0-30.] Office of Solid Waste and Emergency Response, Washington, DC.

U.S. Environmental Protection Agency (EPA). 1992a. *Dermal Exposure Assessment: Principles and Applications.* EPA/600/8-91-011B. Office of Health and Environmental Assessment. Washington, D.C.

U.S. Environmental Protection Agency (EPA). 1992b. *Supplemental Guidance to RAGS: Calculating the Concentration Term.* Publication 9285.7-081. Office of Solid Waste and Emergency Response.

U.S. Environmental Protection Agency (EPA). 1993. *Wildlife Exposure Factors Handbook. Volume I.* Office of Research and Development. Washington, DC. EPA/600/R-93/187a.

U.S. Environmental Protection Agency (EPA). July 1996. *Soil Screening Guidance: Users Guide*. EPA540/R-96/018. Office of Emergency and Remedial Response. Washington, D.C. PB96-963505.

U.S. Environmental Protection Agency (EPA). June 1997a. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final*. Office of Solid Waste and Emergency Response. EPA 540-R-97-006.

U.S. Environmental Protection Agency (EPA). June 1997b. *EPA Region 10 Supplemental Ecological Risk Assessment Guidance for Superfund.* Office of Environmental Assessment, Risk Evaluation Unit. EPA 910-R-97-005.

U.S. Environmental Protection Agency (EPA). July 1997. *Health Effects Assessment Summary Tables (HEAST)*. Provided by the EPA Office of Solid Waste and Emergency Response (OSWER).

U.S. Environmental Protection Agency (EPA). August 1997. *Exposure Factors Handbook*. *Volume I, General Factors*. EPA/600/P-95/002Fa.

U.S. Environmental Protection Agency (EPA). April 1998. *Final Guidelines for Ecological Risk Assessment, Risk Assessment Forum.* U.S. EPA, Washington, D.C., EPA/630/R-95/002F.

U.S. Environmental Protection Agency (EPA). 2001. *Guidance for Characterizing Background Chemicals in Soil at Superfund Sites (External Review Draft)*. Office of Emergency and Remedial Response. EPA 540-R-01-003. Washington, DC.

U.S. Environmental Protection Agency (EPA). June 2001. *The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments*. Office of Solid Waste and Emergency Response, ECO Update. Intermittent Bulletin, Publication 9345.0-14, EPA 540/F-01/014.

U.S. Environmental Protection Agency (EPA). 2002a. *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*. OSWER 9355.4-24.

U.S. Environmental Protection Agency (EPA). 2002b. *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites*.

U.S. Environmental Protection Agency (EPA). 2003. *The Johnson and Ettinger (1991) Model for Subsurface Vapor Intrusion into Buildings*. http://www.epa.gov/oswer/riskassessment/airmodel/johnson_ettinger.htm

U.S. Environmental Protection Agency (EPA). December 5, 2003. *Memorandum – Human Health Toxicity Values in Superfund Risk Assessments*. OSWER Directive 9285.7-53.

U.S. Environmental Protection Agency (EPA). 2004. *Risk Assessment Guidance for Superfund. Volume I, Human Health Evaluation Manual*. Part E, Supplemental Guidance for Dermal Risk Assessment. Final.

U.S. Environmental Protection Agency (EPA). August 2004. S*upplemental Guidance for Dermal Risk Assessment.* OSWER 9285.7-02EP.

U.S. Environmental Protection Agency (EPA). March 2005. *Guidelines for Carcinogen Risk Assessment*. EPA/630/P-03/001F.

U.S. Environmental Protection Agency (EPA). 2006. Galena No Exposure Certification for exclusion from NPDES permitting. Referenced in AECOM (2009).

U.S. Environmental Protection Agency (EPA). 2009. Software for Calculating Upper Confidence Limits (UCLs) *ProUCL Version 4.00.04* [Online]. http://www.epa.gov/nerlesd1/tsc/form.htm

U.S. Environmental Protection Agency (EPA). December 2009. *Regional Screening Levels for Chemical Contaminants at Superfund Sites*. http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm.

U.S. Environmental Protection Agency (EPA). 2010. *Integrated Risk Information System (IRIS)* [Online]. http://www.epa.gov/iris/.

U.S. Fish and Wildlife Service (USFWS). 2009a. *Koyukuk National Wildlife Refuge.* http://alaska.fws.gov/nwr/koyukuk/index.htm. Accessed on December 10, 2009.

U.S. Fish and Wildlife Service (USFWS). 2009b. *Innoko National Wildlife Refuge*. http://alaska.fws.gov/nwr/innoko/index.htm. Accessed on December 10, 2009.

U.S. Fish and Wildlife Service (USFWS). 1999. National Wetlands Inventory of Base map provided by the U.S. Air force. USAF Galena Airport East, Alaska and USAF Galena Airport West, Alaska. U.S. Fish and Wildlife Service, Alaska Regional Office.

U.S. Fish and Wildlife (USFWS). April 2010. Letter regarding the request for species list for the former Galena Forward Operating Location, Galena, Alaska. U.S. Fish and Wildlife Service, Fairbanks Fish and Wildlife Field Office.

TABLE G1
Summary of Exposure Assumptions for Soil Risk Estimates

Parameter	Units	Resident	Sources	Occupational Worker	Sources	Excavation/ Construction Worker	Sources
Body Weight - Adult	kg	70	a, d	70	a, d	70	a, d
Body Weight - Child	kg	15	b, d	--	--	--	--
Carcinogenic Averaging Time	yr	70	a, d	70	a, d	70	a, d
Noncarcinogenic Averaging Time	yr	30	b, d	25		6.6	
Exposure Frequency	day/yr	270	d	250		20	
Exposure Duration - Adult	yr	24	b, d	25	b, d	6.6	
Exposure Duration - Child	yr	6	b, d	--	--	--	--
Incidental Soil Ingestion Rate - Adult	mg/day	100	b, d	100	b	330	f
Incidental Soil Ingestion Rate - Child	mg/day	200	b, d	--	--	--	--
Age-Adjusted Soil Ingestion Rate	mg-yr/kg-day	114	G	--	--	--	--
Skin Surface Area - Adult	cm^2/day	5,700	h, d	3,300	h, d	3,300	h, d
Skin Surface Area - Child	cm^2/day	2,800	h, d	--	--	--	--
Dermal Absorption Factor	unitless	Chemical-specific	i	Chemical-specific	i	Chemical-specific	i
Dermal Adherence Factor - Adult	mg/cm^2	0.07	h, d	0.2	h, d	0.2	h, d
Dermal Adherence Factor - Child	mg/cm^2	0.2	h, d	--	--	--	--
Age-Adjusted Dermal Factor	cm^2-yr/kg-day	361	j	--	--	--	--
Particulate Emission Factor	m^3/kg	1.30E+09	k	1.30E+09	k	1.30E+09	k
Volatilization Factor	m^3/kg	Chemical-specific	k	Chemical-specific	k	Chemical-specific	
Indoor Exposure Frequency	day/yr	350	a	--	--	--	--

TABLE G1
Summary of Exposure Assumptions for Soil Risk Estimates

Parameter	Units	Resident	Sources	Occupational Worker	Sources	Excavation/ Construction Worker	Sources

Sources:

[a]EPA. December 1989. *Risk Assessment Guidance for Superfund (RAGS)*. *Volume 1, Human Health Evaluation Manual. Part A, Interim Final.* EPA/540/1-89/002. Office of Emergency and Remedial Response.

[b]EPA. 1991a. *Human Health Evaluation Manual*. *Supplemental Guidance: Standard Default Exposure Factors*. OSWER Directive 9285.6-03.

[c]EPA. August 1997. *Exposure Factors Handbook*. *Volume I, General Factors*. EPA/600/P-95/002Fa.

[d]ADEC. February 18, 2009. R*isk Assessment Procedures Manual*. Table 1.

[e]Based on professional judgment; assumes receptor is on site during excavation activities for 5 days per week, 4 weeks per year, over a 6.6-year duration.

[f]EPA. 2002a. *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*. OSWER 9355.4-24.

[g]EPA. 1991b. *Risk Assessment Guidance for Superfund. Volume 1, Human Health Evaluation Manual*. Part B, Development of Risk-Based Preliminary Remediation Goals. EPA/540/R-92/003. Publication 9285.7-01B.

[h]EPA. 2004. *Risk Assessment Guidance for Superfund*. *Volume I, Human Health Evaluation Manual*. Part E, Supplemental Guidance for Dermal Risk Assessment. Final. Exhibit 3-5. EPA/540/R/99/005; OSWER 9285.7-02EP.

[i]EPA. 2004. *Risk Assessment Guidance for Superfund*. *Volume I, Human Health Evaluation Manual*. Part E, Supplemental Guidance for Dermal Risk Assessment. Final. Exhibit 3-4. EPA/540/R/99/005; OSWER 9285.7-02EP.

[j]EPA. 2004. *Risk Assessment Guidance for Superfund*. *Volume I, Human Health Evaluation Manual*. Part E, Supplemental Guidance for Dermal Risk Assessment. Final. Equation 3.21. EPA/540/R/99/005; OSWER 9285.7-02EP.

[k]EPA. July 1996. *Soil Screening Guidance: Users Guide.* EPA/540/R-96/018. Office of Emergency and Remedial Response. Washington, D.C. PB96-963505.

Notes:

kg = kilogram

yr = year

mg = milligram

cm^2 = square centimeters

m^3 = cubic meters

TABLE G2
Summary of Exposure Assumptions for Groundwater Risk Estimates

Parameter	Units	Resident	Sources
Body Weight - Adult	kg	70	a, h
Body Weight - Child	kg	15	b, h
Carcinogenic Averaging Time	yr	70	a, h
Noncarcinogenic Averaging Time	yr	30	b, h
Exposure Time - Adult	hr/day	0.58	c
Exposure Time - Child	hr/day	1.0	c
Exposure Frequency	day/yr	350	b, h
Exposure Duration - Adult	yr	24	b, h
Exposure Duration - Child	yr	6	b, h
Groundwater Ingestion Rate - Adult	L/day	2.0	a, h
Groundwater Ingestion Rate - Child	L/day	1.0	d
Age-Adjusted Groundwater Ingestion Rate	L-yr/kg-day	1.09	e
Skin Surface Area - Adult	cm^2/day	18,000	f
Skin Surface Area - Child	cm^2/day	6,600	f
Dermal permeability coefficient	cm/hour	Chemical-specific	f
Correction factor	L/cm^3	0.001	--
Age-Adjusted Dermal Factor	cm^2-yr/kg-day	2,414	g
Volatilization Factor	L/m^3	0.5	e

Sources:

[a]U.S. Environmental Protection Agency (EPA). December 1989. *Risk Assessment Guidance for Superfund (RAGS). Volume 1, Human Health Evaluation Manual. Part A, Interim Final*. EPA/540/1-89/002. Office of Emergency and Remedial Response.

[b]U.S. Environmental Protection Agency (EPA). 1991a. *Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors*. OSWER Directive 9285.6-03.

[c]U.S. Environmental Protection Agency (EPA). 1992a. *Dermal Exposure Assessment*: *Principles and Applications.* EPA/600/8-91/011B. Office of Health and Environmental Assessment. Washington, D.C.

[d]U.S. Environmental Protection Agency (EPA). August 1997*. Exposure Factors Handbook. Volume I, General Factors*. EPA/600/P-95/002Fa.

[e]U.S. Environmental Protection Agency (EPA). 1991b. *Risk Assessment Guidance for Superfund. Volume 1, Human Health Evaluation Manual*. Part B, Development of Risk-Based Preliminary Remediation Goals. EPA/540/R-92/003. Publication 9285.7-01B.

[f]U.S. Environmental Protection Agency (EPA). 2004. *Risk Assessment Guidance for Superfund. Volume I, Human Health Evaluation Manual*. Part E, Supplemental Guidance for Dermal Risk Assessment. Final. Exhibit 3-2. EPA/540/R/99/005; OSWER 9285.7-02EP.

[g]U.S. Environmental Protection Agency (EPA). 2004. *Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual.* Part E, Supplemental Guidance for Dermal Risk Assessment. Final. Equation 3.21. EPA/540/R/99/005; OSWER 9285.7-02EP.

TABLE G2
Summary of Exposure Assumptions for Groundwater Risk Estimates

Parameter	Units	Resident	Sources

[h]Alaska Department of Environmental Conservation (ADEC). February 18, 2009. *Risk Assessment Procedures Manual*. Table 1.

Notes:

L = liter

yr = year

kg = kilogram

cm^2 = square centimeter

cm^3 = square centimeter

TABLE G3
Default Assessment Endpoints and Primary Indicator Species for the Interior Ecoregion Potentially Applicable to Former Galena Forward Operating Location (FOL)

Trophic Group/Level	Default Assessment Endpoint	Receptor	Screening-level Measure	Primary (Bold) or Other Exposure Media	Applicability to Former Galena FOL
Primary Producers (Trophic Level 0)	The potential for significant adverse effects on freshwater plant species abundance, diversity, and primary production	**Plants** that obtain nutrients primarily from fresh water	Compare media concentrations with available adjusted water quality criteria (preference for freshwater and chronic values)	**Fresh water**	Potentially present in pooled water at Site FT001, at groundwater seeps, or at groundwater discharges to the Yukon River
	The potential for significant adverse effects on freshwater semi-aquatic plant species abundance, diversity, and primary production	**Plants** that obtain nutrients primarily from freshwater sediment	Compare media concentrations with available adjusted sediment quality criteria (preference for freshwater and chronic values); site-specific TOC adjustment when appropriate	**Freshwater sediment** Fresh water	Not applicable because no vegetated wetland areas are present onsite
	The potential for significant adverse effects on terrestrial soil plant species abundance, diversity, and primary production	**Plants** that obtain nutrients primarily from soil	Compare media concentrations with lowest available phytotoxicity benchmarks for any plant species	**Surface soil**	Applicable at terrestrial sites
Herbivores and Detritivores (Primary Consumers – Trophic Levels 1 and 2)	The potential for significant adverse effects on freshwater aquatic invertebrate community abundance and diversity	Freshwater **aquatic invertebrates**	Compare media concentrations with available adjusted water quality criteria (preference for freshwater and chronic values)	**Fresh water**	Potentially present in pooled water at Site FT001, at groundwater seeps, or at groundwater discharges to the Yukon River

TABLE G3
Default Assessment Endpoints and Primary Indicator Species for the Interior Ecoregion Potentially Applicable to Former Galena Forward Operating Location (FOL)

Trophic Group/Level	Default Assessment Endpoint	Receptor	Screening-level Measure	Primary (Bold) or Other Exposure Media	Applicability to Former Galena FOL
	The potential for significant adverse effects on freshwater benthic invertebrate community abundance and diversity	Freshwater **benthic invertebrates**	Compare media concentrations with available adjusted sediment quality criteria (preference for freshwater and chronic values); site-specific TOC adjustment when appropriate	**Freshwater sediment** Fresh water	Potentially present at groundwater seeps
	The potential for significant adverse effects on soil invertebrate community abundance and diversity	**Terrestrial invertebrates**	Compare media concentrations with lowest available benchmarks for earthworms or other soil invertebrate species	**Surface soil**	Applicable at terrestrial sites
	The potential for significant adverse effects on freshwater fish detritivore abundance and diversity	Freshwater **fish**	Compare media concentrations with available adjusted water quality criteria (preference for freshwater and chronic values)	**Fresh water**	Fish are not present onsite, and will only be evaluated in locations where groundwater discharges to the Yukon River
	The potential for significant adverse effects on freshwater semi-aquatic avian herbivore abundance and diversity	**Mallard**	Model dose from ingestion of water, sediment, and sediment-associated plants; compare with appropriate toxicity reference value	**Freshwater sediment** Fresh water	May opportunistically forage on aquatic plants and/or aquatic invertebrates during flooding at Site FT001

TABLE G3
Default Assessment Endpoints and Primary Indicator Species for the Interior Ecoregion Potentially Applicable to Former Galena Forward Operating Location (FOL)

Trophic Group/Level	Default Assessment Endpoint	Receptor	Screening-level Measure	Primary (Bold) or Other Exposure Media	Applicability to Former Galena FOL
	The potential for significant adverse effects on terrestrial avian herbivore abundance and diversity	**Dark-eyed junco**	Model dose from ingestion of soil, surface water, and soil-associated plants; compare with appropriate toxicity reference value	**Surface soil** Fresh water	Applicable at terrestrial sites with short grass/forb habitat
	The potential for significant adverse effects on freshwater semi-aquatic mammalian herbivore abundance and diversity	**Northern bog lemming**	Model dose from ingestion of water, sediment, and sediment-associated plants; compare with appropriate toxicity reference value	**Freshwater sediment** Fresh water	Habitat for this receptor is not present onsite
	The potential for significant adverse effects on terrestrial mammalian herbivore abundance and diversity	**Tundra vole**	Model dose associated with ingestion of soil, surface water, and soil-associated plants; compare with appropriate toxicity reference value	**Surface soil** Fresh water	Red-backed vole has been observed at the site; therefore, this may be selected as a more appropriate receptor for this trophic group
Secondary Consumers (Trophic Level 3)	The potential for significant adverse effects on freshwater fish invertivore abundance and diversity	Freshwater **fish**	Compare media concentrations with available adjusted water quality criteria (preference for freshwater and chronic values)	**Fresh water**	Fish are not present onsite, and will only be evaluated in locations where groundwater discharges to the Yukon River

TABLE G3
Default Assessment Endpoints and Primary Indicator Species for the Interior Ecoregion Potentially Applicable to Former Galena Forward Operating Location (FOL)

Trophic Group/Level	Default Assessment Endpoint	Receptor	Screening-level Measure	Primary (Bold) or Other Exposure Media	Applicability to Former Galena FOL
	The potential for significant adverse effects on freshwater amphibian invertivore abundance and diversity	**Wood frog**	Compare media concentrations with available adjusted water quality criteria or model dose associated with ingestion of freshwater aquatic invertebrates and sediment, and compare with applicable toxicity reference value	**Fresh water** Sediment	Applicable because habitat for this receptor may be present in wooded areas of the site
	The potential for significant adverse effects on freshwater avian invertivore abundance and diversity	**American dipper**	Model dose associated with ingestion of sediment and freshwater aquatic invertebrates; compare with appropriate toxicity reference value	**Fresh water**	Habitat for this receptor is not present onsite
	The potential for significant adverse effects on freshwater semi-aquatic avian invertivore abundance and diversity	**Common snipe**	Model dose associated with ingestion of sediment and freshwater benthic invertebrates; compare with appropriate toxicity reference value	**Freshwater sediment**	May opportunistically forage on aquatic invertebrates during flooding at Site FT001
	The potential for significant adverse effects on terrestrial avian invertivore abundance and diversity	**American robin**	Model dose associated with ingestion of soil and terrestrial invertebrates; compare with appropriate toxicity reference value	**Surface soil**	Applicable at terrestrial sites with short grass/forb habitat
	The potential for significant adverse effects on terrestrial mammalian invertivore abundance and diversity	**Masked shrew**	Model dose associated with ingestion of soil and terrestrial invertebrates; compare with appropriate toxicity reference value	**Surface soil** Fresh water	Applicable at terrestrial sites

TABLE G3
Default Assessment Endpoints and Primary Indicator Species for the Interior Ecoregion Potentially Applicable to Former Galena Forward Operating Location (FOL)

Trophic Group/Level	Default Assessment Endpoint	Receptor	Screening-level Measure	Primary (Bold) or Other Exposure Media	Applicability to Former Galena FOL
Tertiary Consumers (Trophic Level 4)	The potential for significant adverse effects on freshwater fish piscivore abundance and diversity	Freshwater **fish**	Compare media concentrations with available adjusted water quality criteria (preference for freshwater and chronic values)	**Fresh water**	Fish are not present onsite, and will only be evaluated in locations where groundwater discharges to the Yukon River
	The potential for significant adverse effects on freshwater avian piscivore abundance and diversity	**Belted kingfisher**	Model dose associated with ingestion of freshwater and fish; compare with appropriate toxicity reference value	**Fresh water**	Habitat for this receptor is not present onsite
	The potential for significant adverse effects on terrestrial avian carnivore abundance and diversity	**Northern shrike**	Model dose associated with ingestion of soil and prey; compare with appropriate toxicity reference value	**Surface soil**	Applicable at terrestrial sites with short grass/forb habitat
	The potential for significant adverse effects on freshwater semi-aquatic mammalian carnivore abundance and diversity	**Mink**	Model dose associated with ingestion of fresh water, freshwater sediment, and fish; compare with appropriate toxicity reference value	**Fresh water** Sediment Surface soil	Habitat for this receptor is not present onsite
	The potential for significant adverse effects on freshwater mammalian piscivore abundance and diversity	**River otter**	Model dose associated with ingestion of fresh water and fish; compare with appropriate toxicity reference value	**Fresh water**	Habitat for this receptor is not present onsite

TABLE G3
Default Assessment Endpoints and Primary Indicator Species for the Interior Ecoregion Potentially Applicable to Former Galena Forward Operating Location (FOL)

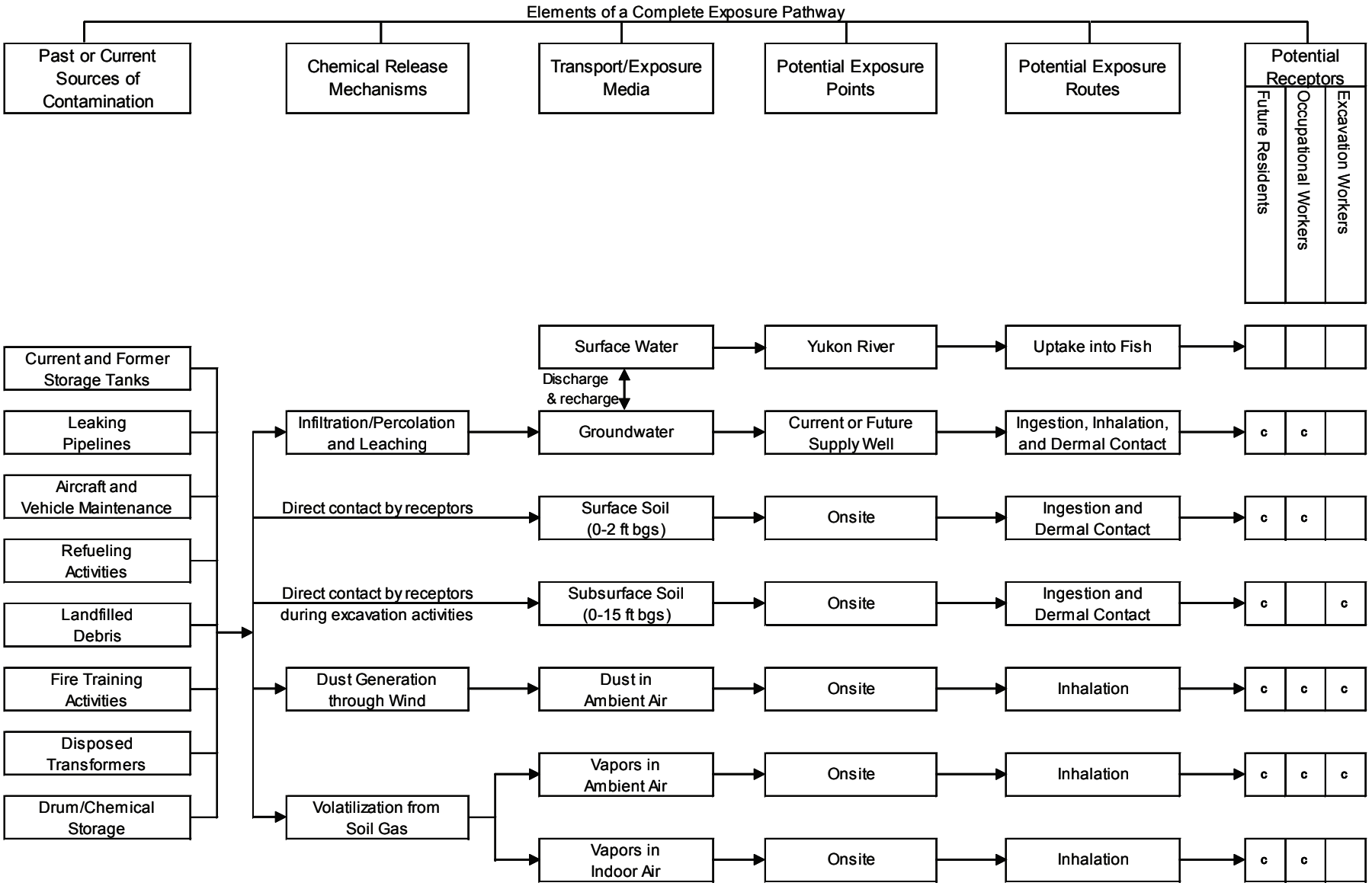
Trophic Group/Level	Default Assessment Endpoint	Receptor	Screening-level Measure	Primary (Bold) or Other Exposure Media	Applicability to Former Galena FOL
	The potential for significant adverse effects on terrestrial mammalian carnivore abundance and diversity	**Least weasel**	Model dose associated with ingestion of soil and prey; compare with appropriate toxicity reference value	**Surface soil**	Applicable at terrestrial sites

Notes:

FOL = Forward Operating Location

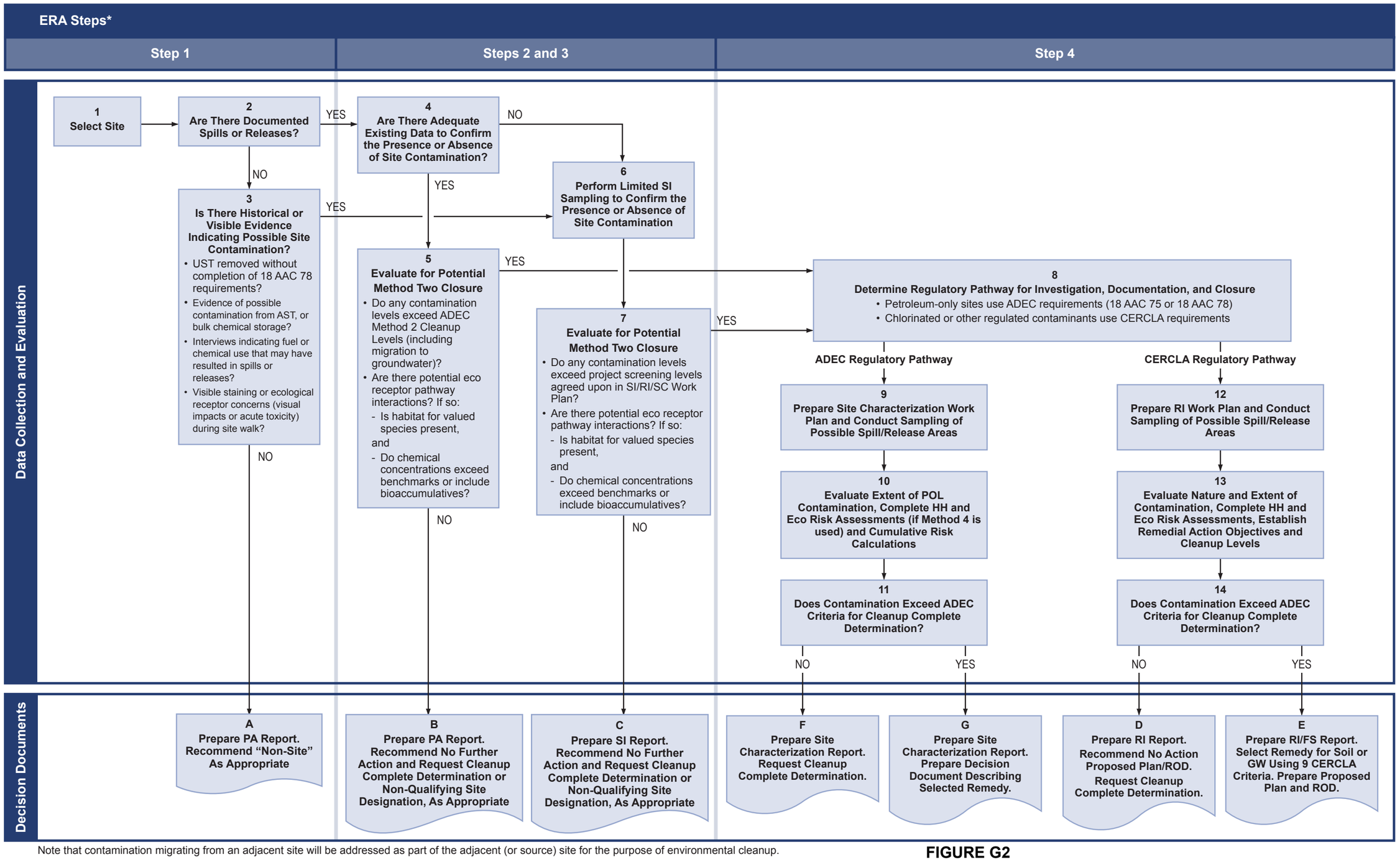
TOC = total organic carbon

Source: ADEC (June 1999a)



Notes:
c = Potentially complete pathway (addressed quantitatively)
Blank = Incomplete pathway

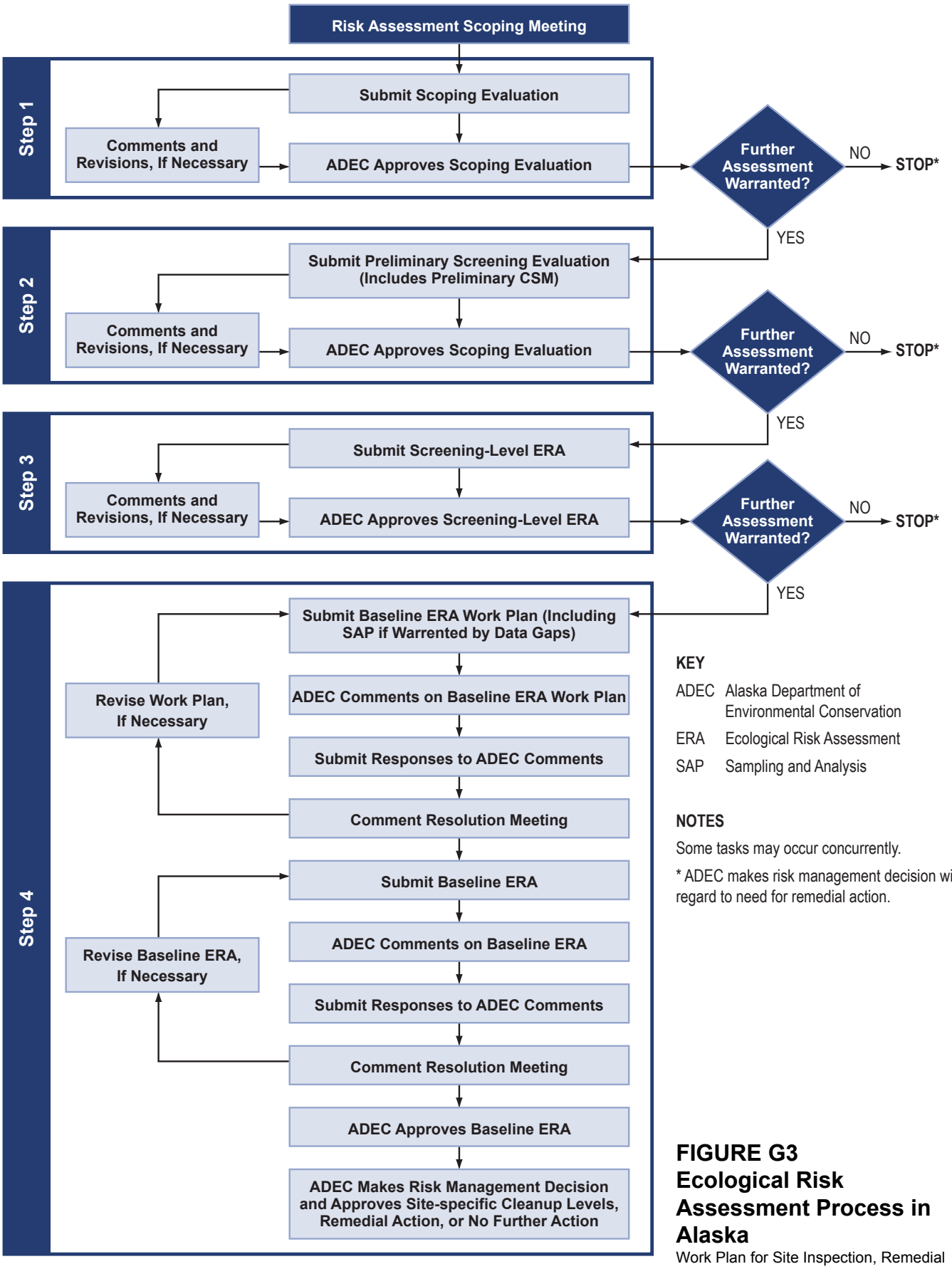
Figure G1
Conceptual Site Model for Potential Human Exposures
Work Plan for Site Inspection, Remedial Investigation, and Site Characterization
Former Galena Forward Operating Location, Alaska



Note that contamination migrating from an adjacent site will be addressed as part of the adjacent (or source) site for the purpose of environmental cleanup.

* Ecological Risk Assessment (ERA) steps as identified in the *Risk Assessment Procedures Manual* (ADEC, February 18, 2009) and presented in Figure G2.

FIGURE G2
Flowchart for Data Collection, Evaluation, and Decision Documents at the Former Galena Forward Operating Location
Work Plan for Site Inspection, Remedial Investigation, and Site Characterization
Former Galena Forward Operating Location, Alaska



KEY

ADEC Alaska Department of Environmental Conservation

ERA Ecological Risk Assessment

SAP Sampling and Analysis

NOTES

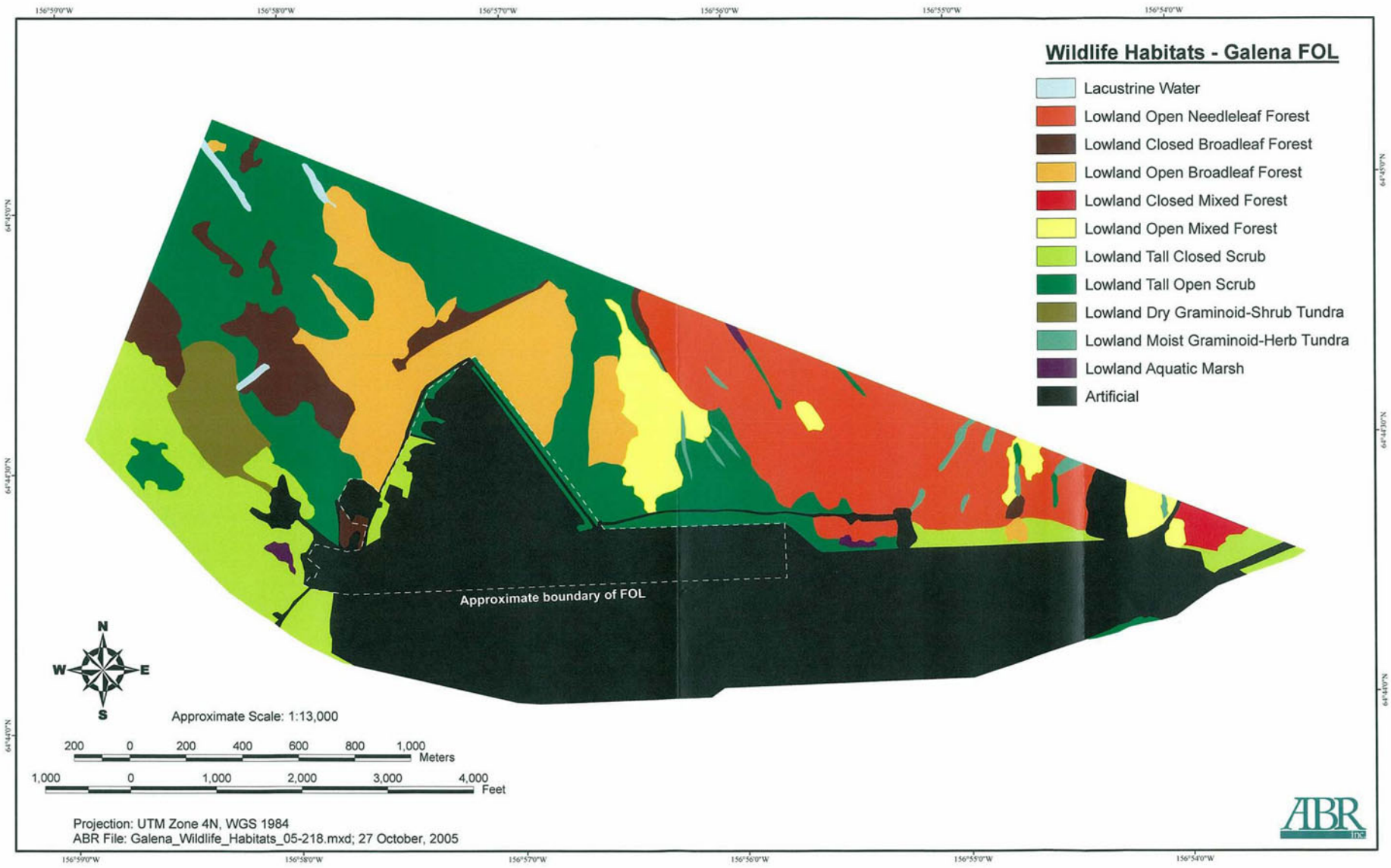
Some tasks may occur concurrently.

* ADEC makes risk management decision with regard to need for remedial action.

FIGURE G3
Ecological Risk Assessment Process in Alaska

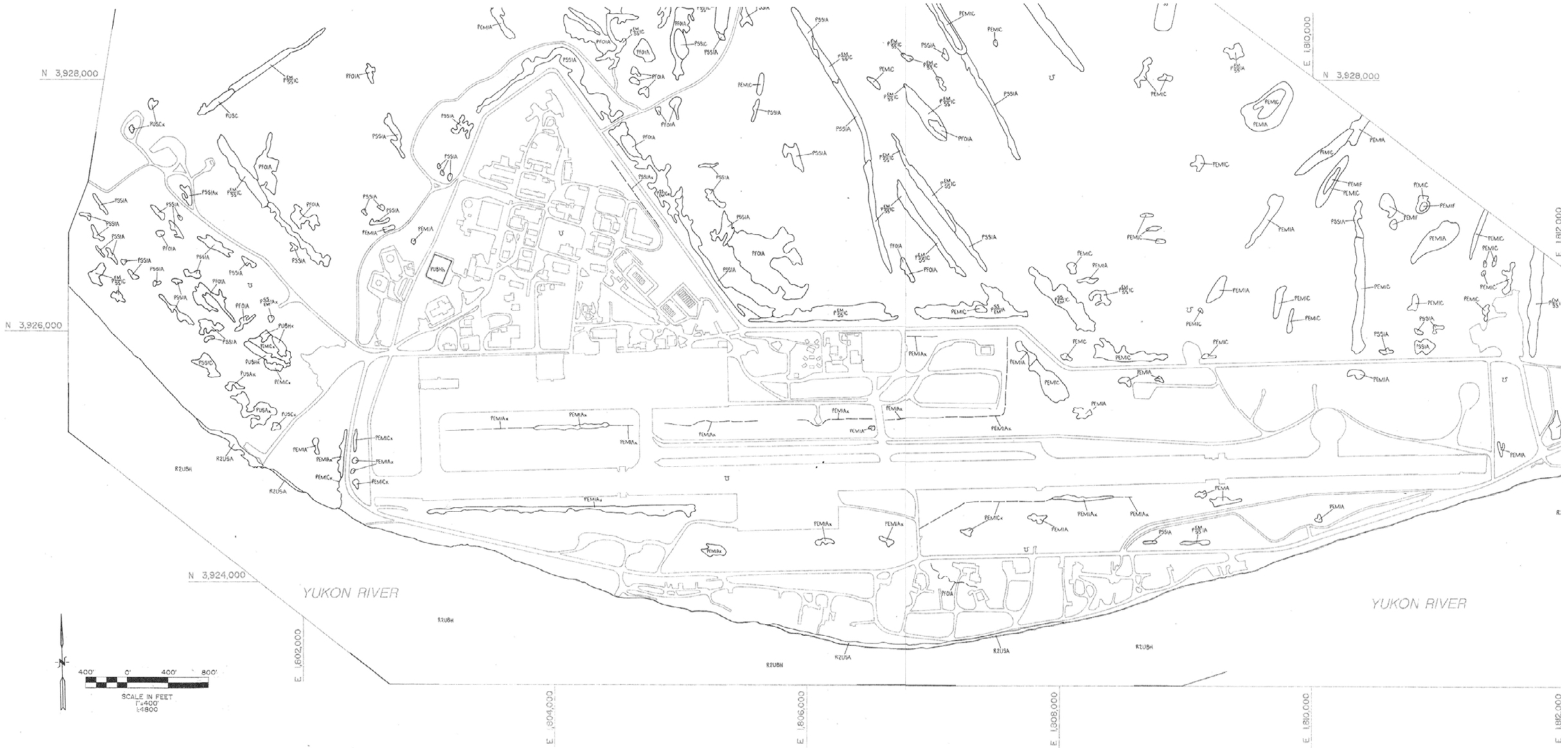
Work Plan for Site Inspection, Remedial Investigation, and Site Characterization
Former Galena Forward Operating Location, Alaska

Source: *Risk Assessment Procedures Manual* (ADEC, February 18, 2009)



SOURCE: USAF (2008)

FIGURE G4
Galena Airport Wildlife Habitat Map
Work Plan for Site Inspection, Remedial Investigation, and Site Characterization
Former Galena Forward Operating Location, Alaska



SOURCE: US DEPARTMENT OF THE INTERIOR, FISH AND WILDLIFE SERVICE, 1999

Figure G-5
Galena Airport National Wetlands Inventory Map
Work Plan for Site Inspection, Remedial Investigation, and Site Characterization
Former Galena Forward Operating Location, Alaska

Other information including a narrative report concerning the wetland resources depicted on this document may be available. For information, contact:

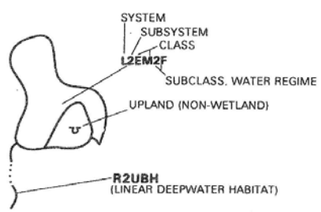
Regional Director (ARDE)
Alaska Regional Office
U.S. Fish and Wildlife Service
1011 East Tudor Road
Anchorage, Alaska 99503

SPECIAL NOTE

This document was prepared primarily by stereoscopic analysis of high altitude aerial photographs. Wetlands were identified on the photographs based on vegetation, visible hydrology, and geography in accordance with **Classification of Wetlands and Deepwater Habitats of the United States** (FWS/OBS - 79/31 December 1979). The aerial photographs typically reflect conditions during the specific year and season when they were taken. In addition, there is a margin of error inherent in the use of the aerial photographs. Thus, a detailed on the ground and historical analysis of a single site may result in a revision of the wetland boundaries established through photographic interpretation. In addition, some small wetlands and those obscured by dense forest cover may not be included on this document.

Federal, State and local regulatory agencies with jurisdiction over wetlands may define and describe wetlands in a different manner than that used in this inventory. There is no attempt, in either the design or products of this inventory, to define the limits of proprietary jurisdiction of any Federal, State or local government or to establish the geographical scope of the regulatory programs of government agencies. **Persons intending to engage in activities involving modifications within or adjacent to wetland areas should seek the advice of appropriate Federal, State or local agencies concerning specified agency regulatory programs and proprietary jurisdictions that may affect such activities.**

SYMBOLOGY EXAMPLE



U Primarily represents **upland** areas, but may include unclassified wetlands such as man-modified areas, non photo-identifiable areas and/or unintentional omissions.

NOTES TO THE USER

- Additions or corrections to the wetlands information displayed on this map are solicited. Please forward such information to the address indicated.
- Subsystems, Classes, Subclasses, and Water Regimes in *Italics* were developed specifically for NATIONAL WETLANDS INVENTORY mapping.
- Linear wetlands or deepwater habitats may be represented by either a series of dashes (— — —) or a dot-dash (— · · · · —) pattern.
- Unlabeled wetlands are to be classified as POWH or PUBH

AERIAL PHOTOGRAPHY

DATE:	5 / / 87	DATE: / /
SCALE:	1:12 000	SCALE:
TYPE:	COLOR	TYPE:

U.S. DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

Prepared by National Wetlands Inventory

Base map provided by the U.S. Air Force

1999

M — MARINE

SYSTEM	SUBSYSTEM	CLASS	Subclass
	1 — SUBTIDAL	RB — ROCK BOTTOM	1 Bedrock 2 Rubble
		UB — UNCONSOLIDATED BOTTOM	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic
		AB — AQUATIC BED	1 Algal 2 Submergent Vascular 3 Rooted Vascular 4 Floating-Leaved Vascular 6 *Unknown Submergent* 7 *Unknown Surface*
		RF — REEF	1 Coral 3 Worm
		OW — *OPEN WATER/ Unknown Bottom*	
	2 — INTERTIDAL	AB — AQUATIC BED	1 Algal 2 Submergent Vascular 3 Rooted Vascular 4 Floating-Leaved Vascular 6 *Unknown Submergent* 7 *Unknown Surface*
		RF — REEF	1 Coral 3 Worm
		RS — ROCKY SHORE	1 Bedrock 2 Rubble
		FL — FLATS	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated
		BB — BEACH/BAR	1 Cobble-Gravel 2 Sand
		US — UNCONSOLIDATED SHORE	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated

E — ESTUARINE

SYSTEM	SUBSYSTEM	CLASS	Subclass
	1 — SUBTIDAL	RB — ROCK BOTTOM	1 Bedrock 2 Rubble
		UB — UNCONSOLIDATED BOTTOM	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic
		AB — AQUATIC BED	1 Algal 2 Submergent Vascular 3 Rooted Vascular 4 Floating-Leaved Vascular 5 Floating Vascular 6 *Unknown Submergent* 7 *Unknown Surface*
		RF — REEF	2 Mollusc 3 Worm
		OW — *OPEN WATER/ Unknown Bottom*	
	2 — INTERTIDAL	AB — AQUATIC BED	1 Algal 2 Submergent Vascular 3 Rooted Vascular 4 Floating-Leaved Vascular 5 Floating Vascular 6 *Unknown Submergent* 7 *Unknown Surface*
		RF — REEF	2 Mollusc 3 Worm
		SB — STREAMBED	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated
		RS — ROCKY SHORE	1 Bedrock 2 Rubble
		FL — FLATS	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated
		BB — BEACH/BAR	1 Cobble-Gravel 2 Sand
		US — UNCONSOLIDATED SHORE	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated
		EM — EMERGENT	1 Persistent 2 Nonpersistent 5 Narrow-Leaved Persistent
		SS — SCRUB-SHRUB	1 Broad-Leaved Deciduous 2 Needle-Leaved Deciduous 3 Broad-Leaved Evergreen 4 Needle-Leaved Evergreen 5 Dead 6 *Deciduous* 7 *Evergreen*
		FO — FORESTED	1 Broad-Leaved Deciduous 2 Needle-Leaved Deciduous 3 Broad-Leaved Evergreen 4 Needle-Leaved Evergreen 5 Dead 6 *Deciduous* 7 *Evergreen*

R — RIVERINE

SYSTEM	SUBSYSTEM	CLASS	Subclass
	1 — TIDAL	RB — ROCK BOTTOM	1 Bedrock 2 Rubble
		UB — UNCONSOLIDATED BOTTOM	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic
	2 — LOWER PERENNIAL	*SB — STREAMBED	1 Bedrock 2 Rubble 3 Cobble-Gravel 4 Sand 5 Mud 6 Organic 7 Vegetated
		AB — AQUATIC BED	1 Algal 2 Submergent Vascular 3 Rooted Vascular 4 Floating-Leaved Vascular 5 Floating Vascular 6 *Unknown Submergent* 7 *Unknown Surface*
	3 — UPPER PERENNIAL	RS — ROCKY SHORE	1 Bedrock 2 Rubble
		FL — FLATS	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated
		BB — BEACH/BAR	1 Cobble-Gravel 2 Sand
	4 — INTERMITTENT	US — UNCONSOLIDATED SHORE	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated
	5 — *UNKNOWN PERENNIAL*	**EM — EMERGENT	2 Nonpersistent
		OW — *OPEN WATER/ Unknown Bottom*	

*STREAMBED is limited to TIDAL and INTERMITTENT SUBSYSTEMS, and comprises the only CLASS in the INTERMITTENT SUBSYSTEM
**EMERGENT is limited to TIDAL and LOWER PERENNIAL SUBSYSTEMS.

L — LACUSTRINE

SYSTEM	SUBSYSTEM	CLASS	Subclass
	1 — LIMNETIC	RB — ROCK BOTTOM	1 Bedrock 2 Rubble
		UB — UNCONSOLIDATED BOTTOM	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic
		AB — AQUATIC BED	1 Algal 2 Submergent Vascular 3 Rooted Vascular 4 Floating-Leaved Vascular 5 Floating Vascular 6 *Unknown Submergent* 7 *Unknown Surface*
		OW — *OPEN WATER/ Unknown Bottom*	
	2 — LITTORAL	RB — ROCK BOTTOM	1 Bedrock 2 Rubble
		UB — UNCONSOLIDATED BOTTOM	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic
		AB — AQUATIC BED	1 Algal 2 Submergent Vascular 3 Rooted Vascular 4 Floating-Leaved Vascular 5 Floating Vascular 6 *Unknown Submergent* 7 *Unknown Surface*
		RS — ROCKY SHORE	1 Bedrock 2 Rubble
		FL — FLATS	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated
		BB — BEACH/BAR	1 Cobble-Gravel 2 Sand
		US — UNCONSOLIDATED SHORE	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated
		EM — EMERGENT	2 Nonpersistent
		OW — *OPEN WATER/ Unknown Bottom*	

P — PALUSTRINE

CLASS	Subclass
RB — ROCK BOTTOM	1 Bedrock 2 Rubble
UB — UNCONSOLIDATED BOTTOM	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic
AB — AQUATIC BED	1 Algal 2 Submergent Vascular 3 Rooted Vascular 4 Floating-Leaved Vascular 5 Floating Vascular 6 *Unknown Submergent* 7 *Unknown Surface*
FL — FLATS	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated
US — UNCONSOLIDATED SHORE	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated
ML — MOSS-LICHEN	1 Moss 2 Lichen
EM — EMERGENT	1 Persistent 2 Nonpersistent 5 Narrow-Leaved Persistent
SS — SCRUB-SHRUB	1 Broad-Leaved Deciduous 2 Needle-Leaved Deciduous 3 Broad-Leaved Evergreen 4 Needle-Leaved Evergreen 5 Dead 6 *Deciduous* 7 *Evergreen*
FO — FORESTED	1 Broad-Leaved Deciduous 2 Needle-Leaved Deciduous 3 Broad-Leaved Evergreen 4 Needle-Leaved Evergreen 5 Dead 6 *Deciduous* 7 *Evergreen*
OW — *OPEN WATER*	*Unknown Bottom*

MODIFIERS

In order to more adequately describe wetland and deepwater habitats one or more of the water regime, water chemistry, soil, or special modifiers may be applied at the class or lower level in the hierarchy.

WATER REGIME

Non-Tidal

- A Temporarily Flooded
- B Saturated
- C Seasonally Flooded
- D *Seasonally Flooded/ Well Drained*
- E *Seasonally Flooded/ Saturated*
- F Semipermanently Flooded
- G Intermittently Exposed
- H Permanently Flooded
- J Intermittently Flooded
- K Artificially Flooded
- W Intermittently Flooded/Temporary
- Y Saturated/Semipermanent/ Seasonal
- Z Intermittently Exposed/Permanent
- U *Unknown*

Tidal

- K *Artificially Flooded*
- L Subtidal
- M Irregularly Exposed
- N Regularly Flooded
- P Irregularly Flooded
- *S Temporary-Tidal
- *R Seasonal-Tidal
- *T Semipermanent-Tidal
- *V Permanent-Tidal
- U *Unknown*

*These water regimes are only used in tidally influenced, freshwater systems.

WATER CHEMISTRY

Coastal Halinity
- 1 Hyperhaline
- 2 Euhaline
- 3 Mixohaline *(Brackish)*
- 4 Polyhaline
- 5 Mesohaline
- 6 Oligohaline
- 0 Fresh

Inland Salinity
- 7 Hypersaline
- 8 Eusaline
- 9 Mixosaline
- 0 Fresh

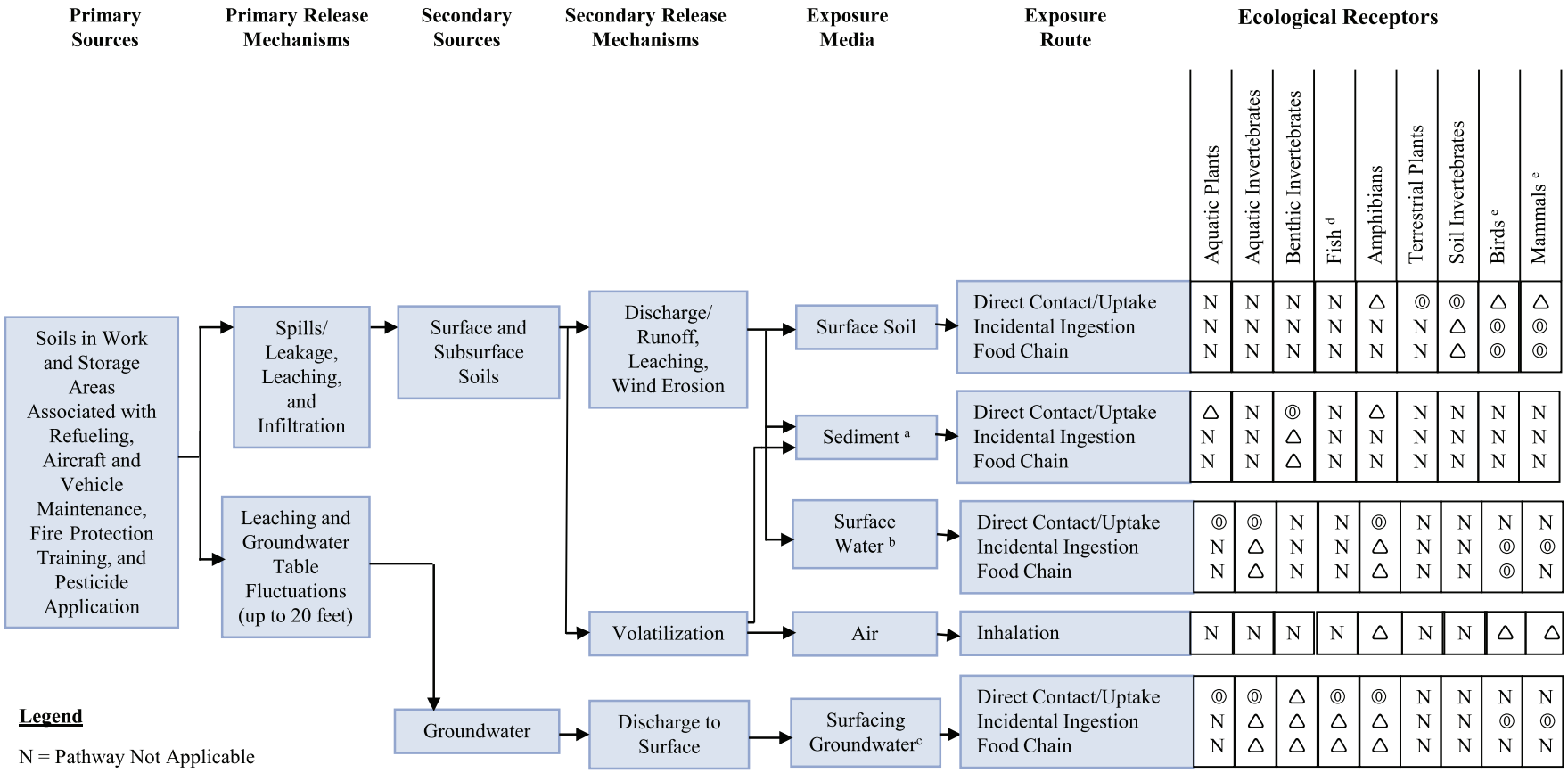
pH Modifiers for all Fresh Water
- a Acid
- i Circumneutral
- i Alkaline

SOIL
- g Organic
- n Mineral

SPECIAL MODIFIERS
- b *Beaver*
- d *Partially Drained/Ditched*
- f Farmed
- h *Diked/Impounded*
- r Artificial Substrate
- s *Spoil*
- x Excavated

SOURCE: US DEPARTMENT OF THE INTERIOR, FISH AND WILDLIFE SERVICE, 1999

Figure G5-Legend
National Wetlands Inventory Map Legend
Work Plan for Site Inspection, Remedial Investigation, and Site Characterization
Former Galena Forward Operating Location, Alaska



Legend

N = Pathway Not Applicable

⓪ = Potentially Complete Exposure Pathway

△ = Possibly Complete Exposure Pathway; likely not significant or insufficient data for analysis

Notes:

[a] Sediment will be evaluated only if groundwater seeps are identified onsite

[b] Surface water may pool at the former fire protection training area (FT001), resulting in potentially complete exposure pathways to aquatic plants, aquatic invertebrates, amphibians, and aquatic/semiaquatic birds.

[c] Groundwater will be evaluated as surface water at seeps and surface discharge to the Yukon River in areas where contaminant groundwater plumes extend to within 1,000 feet of the river.

[d] Fish are not present onsite and will only be evaluated in groundwater that discharges to the river.

[e] Aquatic and semiaquatic birds and mammals are not present onsite, except for potential opportunistic use (i.e., if aquatic plants and/or invertebrates are present) of Site FT001 by invertivorous semiaquatic birds.

FIGURE G6
Ecological Conceptual Site Model
Work Plan for Site Inspection, Remedial Investigation, and Site Characterization
Former Galena Forward Operating Location, Alaska

ATTACHMENT G-1

Ecoscoping Forms for ERP Sites

ATTACHMENT G-1

Ecoscoping Forms for ERP Sites

FT001	Fire Protection Training Area (Parcel l)
ST009	JP-4 Fill-stands
ST010	Southeast Runway Fuel Spill
OT099	Building Demolition/Drum Removal
SS005	Wilderness Hall, Building 1872
TAR	Possible Tar Pit Construction Area

ATTACHMENT G-2

U.S. Fish and Wildlife Service Letter

United States Department of the Interior

U.S. FISH AND WILDLIFE SERVICE
Fairbanks Fish and Wildlife Field Office
101 12th Avenue, Room 110
Fairbanks, Alaska 99701
April 8, 2010

Al Weilbacher,
BRAC Remedial Project Manager
Air Force Center for Engineering and the Environment
Building 171, 2261 Hughes Ave, Suite 155
Lackland AFT, TX 78236-9853

Re: request for species list for the former Galena Forward Operating Location, Galena, Alaska

Dear Mr. Weilbacher:

Thank you for your letter requesting information on endangered and threatened species, and critical habitats pursuant to Section 7 of the Endangered Species Act of 1973, as amended (Act).

Based on your letter, we understand you are working on the remedial investigation and feasibility study for the former Galena Forward Operating Location, Galena, Alaska.

No listed species occur in the project area, and there are no designated or proposed critical habitat units in the vicinity of the project area. Therefore, the Service concludes that the proposed activities are not likely to adversely impact listed species. Preparation of a Biological Assessment or further consultation under section 7 of the Act regarding this project is not necessary.

This letter applies only to endangered and threatened species under our jurisdiction. It does not preclude the need to comply with other environmental legislation or regulations such as the Clean Water Act.

Thank you for your cooperation in meeting our joint responsibilities under the Act. If you need further assistance, please contact Denise Walther at (907) 456-0277.

Sincerely,

Ted Swem
Branch Chief
Endangered Species

ATTACHMENT G-3

Alaska Natural Heritage Program Letter

To: Al Weilbacher, Air Force Centre for Engineering and the Environment, 2261 Hughes Avenue, Suite 155, Lackland ABF, TX 78236-9853

Re: Request for List of Threatened, Endangered, and Sensitive Species or Other Species and Communities of Conservation Concerns for the Former Galena Forward Operating Location, Galena, Alaska

Date: April 7, 2010

Mr. Al Weilbacher:

Please find the attached excel file which consists the list of sensitive species that occur within your area of concern.

The other attached file, RANKS.doc, explains the "sensitivity" ranking system of the Natural Heritage Programs in case you are unfamiliar with our ranking system. This is a two rank system where there is a Grank for the global status of the species plus a Srank for the state (or sub-national) rank of a species. The numbers range from 1 to 5 with 1 indicating a very sensitive species and 5 indicating an abundant and secure species.

The information provided here comes from a search of our Biotics Conservation Database. This is the best information we can provide, but it should not be considered comprehensive. While we strive to populate the Biotics database to the best of our abilities, we are not able to capture all information for all G1-G3 and S1-S3 species all the time. We hope that this information provided here will help guide you in your decision making processes, but also advise you to consult with experts in the field, who might be able to identify areas or species that we may be lacking information for.

We update the rare and sensitive species database and lists regularly. We cannot guarantee that the information provided here will be valid for more than one year from today's date. Therefore, if your company is still working in this area next year and information on rare plant/animal occurrences is needed, we would have to issue a second data request.

Please contact me if you have any further questions.

Sincerely,

Santosh K C
Data Manager
Alaska Natural Heritage Program
University of Alaska Anchorage
707 A Street Anchorage, AK 99501
Tel. 907 257 2781
Fax. 907 257 2789

Species Ranks used by The Alaska Natural Heritage Program

Species Global Rankings

G1: Critically imperiled globally. (Typically 5 or fewer occurrences)
G2: Imperiled globally. (6-20 occurrences)
G3: Rare or uncommon globally. (21-100 occurrences)
G4: Apparently secure globally, but cause for long-term concern. (Usually more than 100 occurrences)
G5: Demonstrably secure globally.
G?: Unranked.
G#G#: Rank of species uncertain, best described as a range between the two ranks.
G#Q: Taxonomically questionable.
G#T#: Global rank of species and global rank of the described variety or subspecies of the species.
GU: Unrankable.
GH: Historical Occurrence.
GX: Extinct.
HYB: Hybrid.

Species State Rankings

S1: Critically imperiled in state. (Usually 5 or fewer occurrences)
S2: Imperiled in state. (6-20 occurrences)
S3: Rare or uncommon in state. (21-100 occurrences)
S4: Apparently secure in state, but with cause for long-term concern (usually more than 100 occurrences
S5: Demonstrably secure in state.
S#S#: State rank of species uncertain, best described as a range between the two ranks.
S?: Unranked.
SH: Historical Occurrence
SU: Unrankable.
SA: Accidental.
SR: Reported from the state, but not yet verified.
SRF: Reported falsely.
SP: Occurs in nearby state. Potential to occur in the state.
HYB: Hybride.
SSYN: Synonyme.
SNA : Not Applicable —A conservation status rank is not applicable because the
Species or ecosystem is not a suitable target for conservation activities.

Qualifiers:
B: Breeding status
N: Non-breeding status
?: Inexact
Q: Questionable taxonomy

SCI_NAME	COMM_NAME	NAME_CATEGORY	GRANK	SRANK
Accipiter gentilis	Northern Goshawk	Vertebrate Animal	G5	S4
Catharus minimus	Gray-cheeked Thrush	Vertebrate Animal	G5	S4S5B
Clangula hyemalis	Long-tailed Duck	Vertebrate Animal	G5	S4B, S4N
Contopus cooperi	Olive-sided Flycatcher	Vertebrate Animal	G4	S4S5B
Cygnus buccinator	Trumpeter Swan	Vertebrate Animal	G4	S4B,S3N
Dendroica striata	Blackpoll Warbler	Vertebrate Animal	G5	S4B
Falco peregrinus anatum	American Peregrine Falcon	Vertebrate Animal	G4T2	S3B
Lynx canadensis	Canadian lynx	Vertebrate Animal	G5	S4
Melanitta nigra	Black Scoter	Vertebrate Animal	G5	S3S4B, S3N
Melanitta perspicillata	Surf Scoter	Vertebrate Animal	G5	S4B,S4N
Sorex yukonicus	Alaska Tiny Shrew	Vertebrate Animal	GU	S3
Tringa solitaria	Solitary Sandpiper	Vertebrate Animal	G5	S4B