Interim Draft

Human Health and Ecological Risk Assessment Work Plan

FWA 102 Former Communications Site
Fort Wainwright, Alaska

Prepared for

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U.S. Army Corps of Engineers,
Alaska District

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Contract No. W911KB-05-D-0010
Task Order 0009

October 2007

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ANC/TP20261.DOC/071350023

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Abbreviations

ABS	absorption factor
ADEC	Alaska Department of Environmental Conservation
atm-m^3/mole	atmosphere-cubic meters per mole
bgs	below ground surface
cm^2	square centimeter(s)
CEM	conceptual exposure model
COPC	chemical of potential concern
°F	degrees Fahrenheit
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
EPH	extractable petroleum hydrocarbons
ERA	ecological risk assessment
FCS	Former Communications Site
GI	Gastrointestinal
HEAST	Health Effects Assessment Summary Tables
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IEUBK	Integrated Exposure Uptake Biokinetic Model for Lead in Children
IRIS	Integrated Risk Information System
m^3	cubic meter(s)
MEC	Munitions or Explosives of Concern
MDLs	method detection limits
mg	milligram(s)
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram per day
mg/L	milligrams per liter

PAHs	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
POL	petroleum, oil, and lubricant
PPRTV	Provisional Peer Reviewed Toxicity Value
RA	risk assessment
RfD	reference dose
RI	remedial investigation
SF	slope factor
TCDD	2,3,7,8-Tetrachlordibenzo-p-Dioxin
TEFs	toxicity equivalence factor
TEQs	toxicity equivalent
µg/dL	micrograms per deciliter
UCL	upper confidence limit
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
UTL	upper tolerance limit
VF	volatilization factor
VPH	volatile petroleum hydrocarbon
VOC	volatile organic compound

SECTION 1

Introduction

1.1 Objectives

This work plan describes the approach to be used for the human health and ecological risk assessment (RA) for the Former Communications Site (FCS) at Fort Wainwright, Alaska. The risk assessment will seek to determine the nature, magnitude, and probability of actual or potential harm to public health, safety, or welfare by the threatened or actual release of hazardous chemical substances. The assessment will identify and characterize the toxicity of the chemicals of potential concern, the potential exposure pathways, the potential human and ecological receptors, and the likelihood and extent of impact or threat under current and reasonably anticipated future land and water use conditions. The methods for assessment of hazards associated with Munitions or Explosives of Concern (MEC) is included as part of a separate section of the revised *Remedial Investigation* (RI) *Work Plan* (CH2M HILL, 2007).

This RA work plan describes the approach for evaluation of the site-specific exposure pathways. The results of the risk assessment, along with other factors, will serve as the basis for risk management decisions. The overall objective of the RA will be to identify whether any risk to human health or the environment posed by the site is of sufficient magnitude to support one of three decisions:

- Acquire additional site characterization data to refine the conceptual site model
- Proceed with an evaluation of remedial options for locations with identified unacceptable risk
- No further action for locations with no identified unacceptable risk, where unacceptable risk is defined as by a point of departure range of 10^{-6} to 10^{-4} that is generally used by regulatory agencies and hazard index values exceeding 1.0 for toxicologically similar chemicals.

Due to the sampling and risk assessment strategy to be employed as described in this report, these decisions will be made for each decision unit (for example, with evaluations based on individual housing units).

1.2 Work Plan Organization

This RA work plan includes the following components:

- **Section 2: Site Background Summary.** Includes a site description, history of the site and operations, and summary of the environmental setting.
- **Section 3: Conceptual Exposure Model.** Characterizes the current and future land uses, provides information about beneficial water uses and the climate, and identifies the pathways by which human and ecological receptors could be exposed to contaminants.

- **Section 4: Human Health Risk Assessment Methodology.** Describes the methods that will be used to calculate potential human health risk.
- **Section 5: Ecological Risk Assessment Methodology.** Describes the methods that will be used to screen for potential risk to the environment.
- **Section 6: References.** Lists the references used in writing this RA work plan.

SECTION 2

Site Background Summary

This section describes the site, provides information about its history and operations, and discusses the current understanding of its environmental setting. A more detailed description of the site is provided in Sections 1 and 2 of the *RI Work Plan*.

2.1 Site Description and History

The FCS is currently the site of Taku Gardens, a subdivision which includes 110 new, presently unoccupied residences intended to house Fort Wainwright military personnel and their families. Little written documentation exists that describes historical activities occurring at the FCS over the course of its use, although there is evidence of varied uses in the area, including:

- A salvage/reclamation yard occupying much of the FCS
- Disposal of debris/salvage material in the dry Chena River oxbow which extends through the site, in trenches in the salvage yard area, and possibly in other local depressions
- Garden plots
- Possible fire fighting training activities (as evidenced by potential circular fire pits and a partially dismembered aircraft)
- Barracks and company headquarters extending into the northwest corner of the site
- Ammunition storage
- Communications and radar systems

When site clearing commenced for the housing area construction in 2003, onsite personnel began encountering metal debris on the ground surface; this resulted in the first geotechnical investigations. During the construction, contractors discovered additional metal debris, munitions (and munitions-related materials), fuel, and polychlorinated biphenyl (PCB) contamination, which resulted in further investigation into historic past uses of the area and limiting site access to authorized personnel. One area where PCBs have been detected at high concentrations has been made an exclusion zone with additional access restrictions. The housing development covers approximately 54 acres; however, the contamination associated with past uses of the FCS may expand beyond the boundaries of this area.

Historical activities and investigations conducted at the FCS to date are provided in Table 2-1 of the *RI Work Plan*.

2.1.1 Geology

Soil types at FCS are typical of those in the Fort Wainwright area and consist primarily of glacial outwash and fluvial deposits of gravel, sand, and silt. Soil borings drilled during the investigation (typically to depths of fifteen feet) document primarily sandy-silt with vegetative layers at various depths (North Wind, 2006).

2.1.2 Hydrogeology

The Fort Wainwright area is located above a shallow groundwater aquifer known as the Tanana Basin Alluvium Aquifer. This aquifer is generally highly transmissive, with areas of lower transmissivity associated with areas of higher silt content or permafrost (which is discontinuous beneath the thaw zone across the site) (Oasis, 2007). Groundwater at FCS is typically encountered 12-15 feet below ground surface (bgs) (North Wind, 2006).

Groundwater flow at the FCS is generally to the west-northwest during most of the year. Groundwater flow direction at Fort Wainwright is primarily driven between the differences in the river stage of the Tanana, which has an east to west course south of the main cantonment area, and the Chena River, which also follows a meandering path generally from east to west about a quarter mile north of the FCS. The river stage of the Tanana is higher than the Chena most of the year with the exception of a period in the spring when winter snowmelt and rains combine to cause high stage conditions in the Chena. During this period, groundwater flow reverses as water flows from the Chena into the aquifer (Oasis 2007).

2.1.3 Environmental Setting

The FCS is bordered by residential housing to the west, Alder Avenue to the south, the Alaska Railroad to the east, and the School Age Services property to the north. The FCS is located in the Tanana-Kuskokwim Lowlands, and consists of relatively flat terrain with no active surface water bodies. Man-made drainage swales have been installed south to north along the west side between the existing housing and Taku Gardens, and also east to west along northwest section (North Wind, 2006). These swales are expected to contain flowing water only for a short time during the spring runoff season each year.

2.1.3.1 Habitat and Wildlife Occurrences

The FCS site is currently almost completely devoid of vegetation because of clearance activities to support construction. The area is also surrounded by a 6-foot chain link fence topped with 3-strand barbed wire. Because access to the area by larger terrestrial organisms is limited by the fence and very little vegetation exists on site to provide food or cover for birds or smaller terrestrial organisms, the area is considered generally inadequate habitat for wildlife species. As development and occupation continues, this will further discourage use of the site by wildlife.

The Chena River supports seasonal populations of fish for recreation and provides spawning areas for salmon. Mammals found on the installation include grizzly bears, black bears, wolverines, Dahl sheep, caribou, fox, weasel, lynx, and beaver, although none of these species would be expected to frequent the investigation area. The only amphibian found at Fort Wainwright is the wood frog. Several upland game species are found on the installation

as well as many other bird species. The *Integrated Natural Resources Management Plan for U.S. Army Garrison Alaska* (Army, 2006a) provides a complete list of natural resources occurring at Fort Wainwright.

SECTION 3

Conceptual Exposure Model

A conceptual exposure model (CEM) provides a framework for understanding site-specific features and physical processes that influence the potential for risk and describes potential human and ecological exposure pathways for site-related constituents. Contaminant sources and chemicals of potential concern (COPCs) for the five subareas defined within the FCS were described in Section 2. The development of the CEM is dynamic process that is based on currently available site information, the latest understanding of reasonably anticipated future land and water uses, and reasonably anticipated future exposure scenarios. The current CEM for the FCS includes the following components:

- **Sources** of chemicals of potential concern. These are identified in more detail in Section 2, based on known historic uses, practices, and releases at the FCS.
- **Receptors**. These are human and ecological populations potentially exposed to the chemicals of potential concern at or in the locality of the FCS.
- **Pathways** that describe the mechanism through which a chemical could come into contact with receptors. An exposure pathway is considered complete when a contaminant can be tracked from its source to a receptor.

In order to define plausible exposure pathways for the site, it is critical to understand factors that influence exposure, such as current and reasonably anticipated future land use, beneficial water uses, and climate. These site-specific factors are described in the following subsections:

- Characterization of current and future land use
- Water beneficial uses
- Climate
- Potentially complete human exposure pathways

3.1 Characterization of Current and Future Land Use

The FCS is zoned and planned for future residential uses for Army families that will be stationed at the base. The site is currently vacant and fenced, preventing current use. In addition to the specific yard areas near the residential buildings, the site construction design indicates that there will be other common areas and open space that could be used by all residents or other site visitors. These include recreational areas such as playgrounds, a sledding hill, and ice-skating rink. The berms along portions of the eastern the southern boundaries of the residential area are anticipated to be fenced on both sides, and therefore inaccessible for general use by the public.

3.2 Water Beneficial Uses

3.2.1 Groundwater

Groundwater is used as the main drinking water source at the Fort Wainwright. The main drinking water supply system wells are located in the area of Buildings 3559A and 3559B, about 100 feet from the FCS eastern perimeter fence. Two emergency backup wells also are located near the FCS, at Buildings 3564 and 3565. The downgradient emergency backup well closest to the FCS is located less than 1,000 feet northwest of the FCS at Building 4065. The depths of the water supply wells range from 80 to 182 feet deep (Army, 1997), and support a capacity of 1.5-2.5 million gallons of drinking water per day. Regional groundwater also serves as recharge to the Chena River during most of the year.

3.2.2 Surface Water

The Chena River is located about 1/4 mile north of the FCS, draining approximately 2,000 square miles, and flows into the Tanana River approximately 8 miles west-southwest of Fort Wainwright. The river is seasonally used for recreational hunting and fishing, trapping, subsistence, and boating. The Chena River supports seasonal populations of fish for recreation and provides spawning areas for salmon. Fishing in the river is catch and release only, regulations established by Alaska Department of Fish and Game for protection arctic grayling in the river.

3.3 Climate

Table 3-1 provides a summary of the monthly temperatures and precipitation at Fort Wainwright. The climate is characterized by average high summer temperatures ranging from the 60s to 70s degrees Fahrenheit (°F), and low winter temperatures down to an average in January of -13°F. Average precipitation is 11.7 inches per year, with most as snowfall from October through March. Fort Wainwright and Fairbanks are in the Central Alaskan region of discontinuous permafrost. Discontinuous permafrost refers to a region in which some areas are underlain by permafrost and neighboring areas are not perennially frozen, with unfrozen zones potentially isolated or interconnected (U.S. Geological Survey [USGS], 1999).

3.4 Potentially Complete Exposure Pathways

For an exposure pathway to be considered complete, it must have all of the following components:

- A constituent source
- A mechanism for constituent release
- An environmental transport medium
- An exposure point (a receptor location)
- A route of intake

TABLE 3-1
Fort Wainwright Climate

Month	Average High	Average Low	Mean	Average Precipitation	Record High	Record Low
January	2°F	-13°F	-5°F	0.61 in.	47°F (1981)	-60°F (1969)
February	10°F	-10°F	0°F	0.44 in.	49°F (1980)	-52°F (1999)
March	26°F	1°F	14°F	0.34 in.	57°F (1998)	-41°F (1971)
April	44°F	19°F	31°F	0.20 in.	71°F (2005)	-24°F (1986)
May	61°F	35°F	48°F	0.60 in.	88°F (1960)	3°F (1964)
June	71°F	47°F	59°F	1.68 in.	94°F (1991)	29°F (1970)
July	73°F	50°F	62°F	1.96 in.	92°F (1993)	32°F (1957)
August	67°F	45°F	56°F	1.95 in.	93°F (1994)	24°F (1987)
September	55°F	34°F	44°F	1.32 in.	82°F (1957)	5°F (1992)
October	32°F	16°F	24°F	1.01 in.	71°F (2003)	-27°F (1975)
November	12°F	-2°F	5°F	0.78 in.	49°F (1976)	-45°F (1990)
December	5°F	-9°F	-2°F	0.82 in.	44°F (2001)	-66°F (1961)

Source: http://www.weather.com/weather/climatology/monthly/USAK0089

In the absence of any one of these components, an exposure pathway is considered incomplete and, by definition, there is no risk associated with that particular exposure pathway.

3.4.1 Contaminant Sources and Release Mechanisms

The primary sources of contaminants and release mechanisms at FCS include those associated with former operations at the various sites. These sources include the following:

- Spillage and leakage from storage tanks, transformers, and drums
- Substances in historic landfills
- Substances in fire training areas
- Leaking pipelines

The purpose of the risk assessment will be to evaluate the remaining constituents that have been associated with past operations which include petroleum, oil, and lubricants (POLs), PCBs, pesticides, solvents, polynuclear aromatic hydrocarbon (PAHs), metals, and munitions/explosive residues.

3.4.2 Environmental Transport Mechanisms and Media

According to the CEM, there are six mechanisms potentially transporting site-related constituents to environmental media, as follows:

1. Infiltration/percolation and leaching of contaminants to shallow groundwater
2. Discharge of shallow groundwater to offsite surface water and sediment
3. Migration of shallow groundwater to offsite Post production wells
4. Surface drainage and runoff during storm events or snowmelt
5. Volatilization of vapors from shallow groundwater and subsurface soil to soil gas and indoor air
6. Dust or vapors generated from wind or mechanical erosion

In addition to contaminant migration from the original release areas to potential exposure points, receptors could directly contact contaminated surface soil or, during excavation activities, contaminated subsurface soil (as illustrated in the CEM on Figure 3-1).

3.4.3 Potential Human Receptors and Exposure Routes

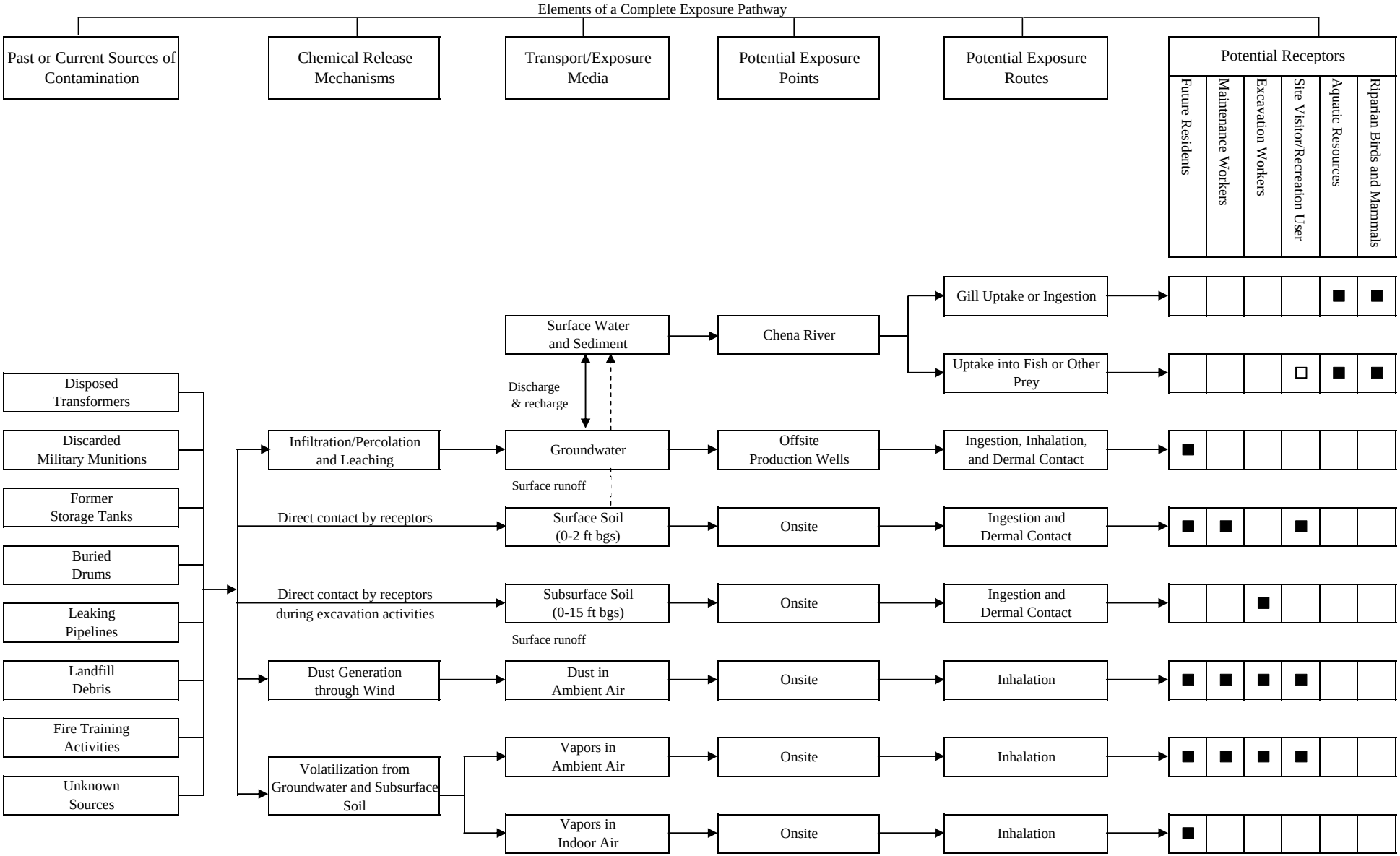
Based on current understanding of land and water beneficial use conditions at or near Taku Gardens, the most plausible exposure scenarios will be considered for characterizing human health risks, including the following:

- **Future Residential Scenario**–Given the current understanding of reasonably anticipated future land uses at Taku Gardens, residents are expected to live at the site. For surface soil (0 to 2 feet bgs), the plausible exposure routes for the future resident would include incidental soil ingestion, dermal contact with soil, and inhalation of ambient dusts and vapors. For soil gas, the plausible exposure route would be inhalation of volatile organic compound (VOC) vapors emanating from shallow groundwater or subsurface soil into

Figure 3-1

Conceptual Site Model for Potential Human and Ecological Exposures

Risk Assessment Work Plan



■ = Potentially complete pathway (to be addressed quantitatively)

□ = Pathway considered minor (to be addressed qualitatively)

Blank = Incomplete pathway

indoor air. Additionally, should contaminants in groundwater from the site migrate to the Fort Wainwright water supply well, then exposure to contaminants in drinking water and during showering/bathing activities would represent complete pathways. Although it is plausible that residents could consume home-grown fruits and vegetables, this exposure pathway may be considered complete unless digging restrictions are implemented at the site following occupation.

- **Future Recreational/Site Visitor Scenario**–Future recreationalists and site visitors will use common areas and open space that surrounds the residential areas of Taku Gardens. The current site plans indicate that there are plans for playground areas, and a sledding hill, and an ice-skating rink. For surface soil (0 to 2 feet bgs), the plausible exposure routes would include incidental soil ingestion, dermal contact with soil, and inhalation of ambient dusts and vapors.
- **Future Maintenance Worker Scenario**–Under future site conditions, workers could potentially be exposed to surface soil during maintenance activities at the site. Potential routes of exposure to surface soil (0 to 2 feet bgs) for the maintenance worker would include incidental soil ingestion, dermal contact with soil, and inhalation of ambient dusts and vapors.
- **Future Excavation Worker Scenario**–Under future site conditions, excavation workers could potentially be exposed to subsurface soil during infrequent excavation activities at the site. These activities could include placement or repair of utilities or other construction activities involving digging. Potential routes of exposure to subsurface soil[1] (0 to 15 feet bgs) for the excavation worker would include incidental soil ingestion, dermal contact with soil, and inhalation of ambient dusts and vapors generated during excavation activities.

3.4.4 Potential Ecological Receptors and Exposure Routes

Based on the EcoScoping Forms for the FCS presented in Appendix F of the *Preliminary Source Evaluation 1 Narrative Report* (Oasis, 2007), plausible ecological exposure pathways based on the COPCs, available habitat, and available food sources at the FCS are the following:

- Direct uptake of site-related constituents from surface water, sediment, and groundwater (assuming migration to the river occurs), in the Chena River, by aquatic organisms
- Direct contact with surface sediment (0 to 2 feet bgs) in offsite areas that contain suitable habitat for mammals and birds (assuming migration via the drainages swale to the river occurs)
- Potential ingestion of site-related bioaccumulative chemicals via the food chain, by piscivorous mammals and birds foraging along the Chena River.

[1] Subsurface soil will be considered from 0 to 15 feet bgs or to the water table, whichever is shallower.

SECTION 4

Human Health Risk Assessment Methodology

The human health risk assessment will present an analysis of the potential for adverse human health effects potentially associated with contaminants at FCS. Note that the methods for assessment of additional hazards, such as those associated with munitions or explosives of concern are included as Section 2 of the *RI Work Plan*.

The human health risk assessment will include the following components:

- **Human health risk assessment guidance**. Will summarize the guidance documents used to develop the RA work plan.
- **Identification of chemicals of potential concern.** Will identify the chemicals detected at the site that are considered to contribute to risk at FCS.
- **Human exposure assessment.** Will describe the pathways by which potential human exposure could occur and will estimate the magnitude, frequency, and duration of the exposure.
- **Human health toxicity assessment.** Will summarize the toxicity of the selected chemicals and the relationship between the magnitude of exposure and adverse human health effects.
- **Human health risk characterization.** Will integrate the toxicity and exposure assessments to estimate the potential risks to public health from exposure to chemicals in environmental media.

These components will be completed as described in the following subsections.

4.1 Human Health Risk Assessment Guidance

This risk assessment will be conducted using the following regulatory guidance documents:

- *Risk Assessment Procedures Manual* (Alaska Department of Environmental Conservation [ADEC] , 2005a)
- *Evaluation of Vapor Intrusion Pathway at Contaminated Sites* (ADEC, 2004c)
- *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual, Part A* (Interim Final) (U.S. Environmental Protection Agency [EPA], 1989)
- *Risk Assessment Guidance for Superfund - Volume I: Human Health Evaluation Manual* (Part E, Supplemental Guidance for Dermal Risk Assessment, Final) (EPA, 2004a)

4.2 Identification of Chemicals of Potential Concern

Available site data will be reviewed to identify a set of data that is of acceptable quality for the human health risk assessment (see Section 4.2.1). Following a data usability evaluation, analytical data will be screened to identify those constituents most important to the human health evaluation. These constituents, or COPCs, will be quantitatively addressed in the human health risk assessment. COPCs will be identified using the screening criteria (see Section 4.2.2). In addition, exposure point concentrations will be calculated (see Section 4.2.3).

4.2.1 Data to be Used in the Risk Assessment

The analytical data to be generated during this investigation (discussed in the *RI Work Plan*), as well as historical data, will be evaluated for appropriateness and representativeness to determine whether they can be used for risk assessment. A data usability evaluation will be conducted to evaluate whether the available current and historical data should be used in the risk assessment, and to help identify potential data gaps. This determination will be based on two lines of evaluation:

1. Identification of the adequacy of method detection limits (MDLs) for current and historical data to detect potential risks.
2. Evaluation of the spatial, chemical, and temporal representativeness of the available analytical data, and an assessment of whether these data are relevant to plausible exposure pathways at FCS.

For the first step, MDLs will be compared to risk-based screening criteria. Note that MDLs may exceed criteria as a result of low screening-level concentrations and limitations of the analytical methods used.

For the second step, the representativeness of the data will be evaluated using the criteria defined below.

- **Chemical representativeness**–Identifies whether analyses were conducted for constituents expected to be present, on the basis of an understanding of historical processes or practices and potential releases at the FCS.
- **Exposure representativeness**–Identifies whether environmental media were evaluated where receptor exposure is most feasible.
- **Spatial representativeness**–Identifies whether samples were collected with a sufficient density and areal coverage that the detected constituent concentrations represent a geographically-integrated exposure for the receptors of concern.
- **Temporal representativeness**–Identifies whether samples were collected within a time frame such that detected constituent concentrations indicate current site conditions.

Where appropriate, the most recent data will be used to provide the most current picture of potential exposure to contamination.

4.2.2 Criteria for Selection of COPCs for Human Health

In accordance with EPA guidance, factors to be considered in identifying COPCs at the FCS are:

- Identification and frequency of detected constituents
- Background concentration levels of inorganics
- Identification of essential nutrients
- Availability of toxicity factors

COPCs will be identified separately for surface soil, subsurface soil, soil gas, groundwater, and sediment from each defined exposure area[2]. Evaluation of the human health risk assessment data using these criteria is discussed in the following subsections.

4.2.2.1 Identification and Frequency of Detected Constituents

If a constituent is detected in more than 5 percent of samples analyzed in each data grouping, the constituent will be carried to the following step in the COPC selection process. If there were fewer than 20 samples, the constituents that are detected at least once in a particular exposure medium will be carried to the following step in the COPC selection process. Constituents that were not detected in a particular exposure medium will not be selected as COPCs for that medium and the suitability of the detection limits for these compounds will be qualitatively discussed in the RA uncertainty section.

4.2.2.2 Comparison to Background Concentration Levels

The inorganic chemicals found at the FCS occur naturally at varying background levels. Sampling conducted previously to establish background concentrations in soil present at Fort Wainwright (*Background Data Analysis for Arsenic, Barium, Cadmium, Chromium, and Lead on Fort Wainwright* [U.S. Army Corps of Engineers (USACE), 1994]) will be used for background levels. Preference will be given to these background values when available. Available background data from the *Chemical Data Report Foundation Study HTRW Survey (Revised), Replace Family Housing (FTW-283) Fort Wainwright, Alaska* (USACE, 2004a) or other applicable sources will also be used to provide an indication of naturally occurring levels of metals.

Maximum detected contaminant concentrations that meet data evaluation criteria and that exceeded the upper tolerance limit (UTL) or Postwide background values for inorganics in soils will be carried on to the next step of the COPC selection process.

4.2.2.3 Identification of Essential Nutrients

Essential nutrients are those constituents considered essential for human nutrition. Recommended daily allowances are developed for essential nutrients to estimate safe and adequate daily dietary intakes (National Academy of Sciences, 1989). Since calcium, iron, magnesium, potassium, and sodium are considered to be naturally occurring essential nutrients and are generally recognized as being of low toxicity, they will be excluded from further consideration as COPCs.

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[2] For small exposure areas, such as individual residential units at Taku Gardens, COPCs will be identified separately for each unit.

4.2.2.4 Availability of Toxicity Factors

Only those constituents that have a toxicity factor available from a reliable source (as defined in Section 4.4) will be included in the risk assessment as COPCs. For some chemicals without toxicity factors, a surrogate toxicity factor for a structurally similar chemical may be used. When appropriate, surrogates will be identified based on degree of structural and/or toxicological similarity. In cases where the species of metal is unknown, for example for chromium, the risk assessment will conservatively assume the most toxic form (hexavalent chromium) is present.

4.2.3 Calculation of Exposure Point Concentrations

Exposure point concentrations (EPCs) are estimated chemical concentrations that a receptor may contact and are specific to each exposure medium. For the incidental ingestion and dermal routes, EPCs will be represented by concentrations directly measured in site media. For the inhalation route, EPCs for ambient and indoor air pathways will be estimated from soil, groundwater, and/or soil gas using the modeling approaches described in the following subsection.

4.2.3.1 Estimation of Soil EPCs

The EPCs for aggregate risk estimation at the FCS will be calculated by using the best statistical estimate of an upper bound on the average exposure concentrations, in accordance with ADEC and EPA guidance for statistical analysis of monitoring data (ADEC, 2005a; EPA, 1989, 1992, 2002a). The 95 percent upper confidence limit (UCL) on the mean concentration is considered by these guidance documents as a conservative upper bound estimate that is not likely to underestimate the mean concentration and most likely overestimates that concentration. 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. EPCs will be calculated for each analyte using EPA's statistical program ProUCL, Version 4.0 (EPA, 2007a). The procedure identifies the statistical distribution type (that is, normal, lognormal, or nonparametric) for each constituent within the defined exposure area, and computes the corresponding 95 percent UCL for the identified distribution type. For non-detections, one-half the detection limit will be used when calculating the UCL.

EPCs for risk estimation will be calculated for each receptor type as follows:

- EPCs for the future residential scenario will be calculated by aggregating analytical data analytical data collected at each residential property for surface soil (0 to 2 feet bgs)
- EPCs for the future recreational user/site visitor user scenario will be calculated by aggregating analytical data for surface soil (0 to 2 feet bgs) at each playground and common area[3]
- EPCs for the future maintenance worker will be calculated by aggregating analytical data for surface soil (0 to 2 feet bgs) in common areas and the sound barrier berm

[3] Note: Areas where at least 2 feet of clean fill have been added would eliminate surface soil pathways and will not require risk evaluation.

- EPCs for the future excavation worker will be calculated by aggregating analytical data for subsurface soil (0 to 15 feet bgs) in both residential and common areas
- Detected soil gas VOC concentrations from subslab samples for each residential property will be selected as EPCs for the future indoor air exposure scenario[4]
- Groundwater EPCs for domestic ingestion, bathing, and showering will be derived from measured or estimated (through groundwater transport modeling) levels at the offsite Post supply wells

4.3 Human Exposure Assessment

Potential human receptors identified in the CEM (Figure 3-1) include future residents, recreational users/site visitors, maintenance workers, and excavation workers. Potentially complete exposure pathways to these receptors have been identified in the CEM. This section describes the equations and exposure assumptions that will be used to calculate direct contact exposures related to incidental ingestion of or dermal contact with contaminants in soil, and inhalation exposures associated with ambient dusts or vapors or indoor vapor intrusion. In accordance with ADEC guidance (ADEC, 2004a and 2005a) exposure factors (when applicable) for the under 40-inch zone will be used.

4.3.1 Direct Contact Intake Calculations

This section describes the equations and exposure assumptions that will be used to calculate direct contact exposures to contaminants in soil and groundwater. For metals, default values for bioavailability will initially be assumed. If specific metals are found to contribute substantially to the FCS risk, bioavailability and speciation evaluations may be considered. Additionally, exposure assumptions provided in this RA work plan are considered reasonable maximum exposure estimates. For areas, receptors, and pathways that indicate the potential for unacceptable risk, other central tendency estimates may be considered.

4.3.1.1 Intake Equations for Ingestion of Soil

The following equation will be used to calculate the intake (expressed as milligrams per kilogram [mg/kg] per day [mg/kg-day]) associated with the incidental ingestion of carcinogenic and noncarcinogenic contaminants in soil under the maintenance worker, excavation worker, and site visitor/recreation user[5] exposure scenarios:

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

[4] Subslab soil gas samples are planned to provide an initial estimate of risk for existing buildings. If estimated risks using modeling approaches are shown to be unacceptable, then indoor air sampling may be considered.

[5] Note the site visitor/recreational user is conservatively assumed to be a small child. See Table X-1 for applicable exposure factors for this scenario.

The following 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:

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

where:

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

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 (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 (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 4-1.

4.3.1.2 Intake Equations for Dermal Contact with Soil

The following equation will be used to calculate the intake from dermal contact with carcinogenic and noncarcinogenic contaminants in soil under the maintenance worker, excavation worker, and site visitor/recreation user exposure scenarios:

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

TABLE 4-1
Summary of Exposure Assumptions for Soil Risk Estimates
Risk Assessment Work Plan

Parameter	Symbol	Units	Future Resident	Sources	Future Maintenance Worker	Sources	Future Excavation Worker	Sources	Site Visitor/ Recreational User	Sources
Body Weight - adult	BW_a	kg	70	ae	70	ae	70	ae	--	--
Body Weight - child	BW_c	kg	15	be	--	--	--	--	36.3	n
Carcinogenic Averaging Time	ATC	yrs	70	ae	70	ae	70	ae	70	ae
Noncarcinogenic Averaging Time	ATN	yrs	30*	be	3	m	6.6	c	3	m
Exposure Frequency	EF	day/yr	270	e	250	e	20	f	28	d
Exposure Duration - Adult	ED_a	yrs	24*	be	3	m	6.6	c	--	--
Exposure Duration - Child	ED_c	yrs	6*	be	--	--	--	--	3	d
Incidental Soil Ingestion Rate - Adult	IRS_a	mg/day	100	be	100	b	480	g	--	--
Incidental Soil Ingestion Rate - Child	IRS_c	mg/day	200	be	--	--	--	--	200	be
Age-Adjusted Soil Ingestion Rate	IFSadj	mg-yr/kg-day	114	h	--	--	--	--	--	--
Skin Surface Area - Adult	SA_a	cm^2/day	5,700	ie	3,300	ie	3,300	ie	--	--
Skin Surface Area - Child	SA_c	cm^2/day	2,800	ie	--	--	--	--	3800	o
Dermal Absorption Factor	ABSd	unitless	Chemical-specific	j	Chemical-specific	j	Chemical-specific	j	Chemical-specific	j
Dermal Adherence Factor - Adult	AF_a	mg/cm^2	0.07	ie	0.2	ie	0.2	ie	--	--
Dermal Adherence Factor - Child	AF_c	mg/cm^2	0.2	ie	--	--	--	--	0.2	ie
Age-Adjusted Dermal Factor	SFSadj	cm^2-yr/kg-day	361	k	--	--	--	--	--	--
Inhalation rate - Adult	INH_a	m^3/day	20	be	20	be	20	be	--	--
Inhalation rate - Child	INH_c	m^3/day	12	e	--	--	--	--	13.5	p
Age-Adjusted Inhalation Factor	InhFadj	m^3-yr/kg-day	11.7	h	--	--	--	--	--	--
Particulate Emission Factor	PEF	m^3/kg	1.32E+09	l	1.32E+09	l	1.32E+09	l	1.32E+09	l
Volatilization Factor	VF	m^3/kg	Chemical-specific	l	Chemical-specific	l	Chemical-specific	l	Chemical-specific	l

Source:

a. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual, Part A, Interim Final. Office of Emergency and Remedial Response. EPA/540/1-89/002 (EPA, 1989).
b. *Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors*. OSWER Directive 9285.6-03. (EPA, 1991).
c. Exposure Factors Handbook Volume I General Factors. EPA/600/P-95/002Fa. August 1997.
d. Based on professional judgement; assumes receptor is exposed 1 day per week, 7 months per year, over a 3 year duration
e. Table 1 of Draft Risk Assessment Procedures Manual (DEC, 2005)
f. Based on professional judgement; assumes receptor is on site during excavation activities for 5 days per week, four weeks per year, over a 6.6 year duration.
g. Represents an upper bound case for certain outdoor activities with high soil contact (e.g., construction or landscaping)(EPA Region 10, 2001).
h. 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. (EPA 1991).
i. Exhibit 3-5 of Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim. EPA/540/R/99/005. OSWER 9285.7-02EP (EPA, 2001).
j. Exhibit 3-4 of Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim. EPA/540/R/99/005. OSWER 9285.7-02EP (EPA, 2001).
k. Equation 3.21 of Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim. EPA/540/R/99/005. OSWER 9285.7-02EP (EPA, 2001).
l. Soil Screening Guidance: Users Guide. EPA/540/R-96/018. Office of Emergency and Remedial Response, Washington, D.C. PB96-963505.
m. Based on professional judgement; assumes receptor is employed onsite or visits over a 3 year period.
n. Table 7-3, Average body weight of 10 yr-old male and female children. Exposure Factors Handbook Volume I General Factors. EPA/600/P-95/002Fa. (EPA, 1997).
o. Exhibit C-1- surface area based on 10-yr old with head, hands, forearms, and lower legs exposed; RAGS, Vol 1, Part E Supplemental Guidance for Dermal Risk Assessment. Final. (EPA, 2004).
p. Table 5-23; average inhalation rate for 10-yr old male and female children. Exposure Factors Handbook Volume I General Factors. EPA/600/P-95/002Fa. (EPA, 1997)

* The exposure duration for future residents may be adjusted to account for a reasonable maximum residence time at Fort Wainwright of about 8 years.

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

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

where:

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

where:

C_s = chemical concentration in soil (mg/kg)

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 4-1. Dermal absorption factor values will be obtained from the dermal assessment guidance (EPA, 2004a).

4.3.1.3 Intake Equation for Ingestion of Groundwater

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

$$Intake = \frac{C_w \times IFW_{adj} \times EF}{AT}$$

where:

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

where:

C_W = chemical concentration in groundwater milligrams per liter (mg/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 4-2.

4.3.1.4 Intake Equation for Dermal Contact with Groundwater

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

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

where:

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

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 (cm/hour)

EF = exposure frequency (days/year)

ET = exposure time (hour)

TABLE 4-2
Summary of Exposure Assumptions for Groundwater Risk Estimates
Risk Assessment Work Plan

Parameter	Symbol	Units	Onsite Future Resident	Sources
Body Weight - adult	BW_a	kg	70	ah
Body Weight - child	BW_c	kg	15	bh
Carcinogenic Averaging Time	ATC	yrs	70	ah
Noncarcinogenic Averaging Time	ATN	yrs	30*	bh
Exposure Time	ET	hr/day	0.25	c
Exposure Frequency	EF	day/yr	350	bh
Exposure Duration - Adult	ED_a	yrs	24*	bh
Exposure Duration - Child	ED_c	yrs	6*	bh
Groundwater Ingestion Rate - Adult	IRW_a	L/day	2.0	ah
Groundwater Ingestion Rate - Child	IRW_c	L/day	1.0	d
Age-Adjusted Groundwater Ingestion Rate	IFWadj	L-yr/kg-day	1.09	e
Skin Surface Area - Adult	SA_a	cm^2/day	18,000	f
Skin Surface Area - Child	SA_c	cm^2/day	6,600	f
Dermal permeability coefficient	Kp	cm/hour	Chemical-specific	f
Correction factor	CF	L/cm^3	0.001	--
Age-Adjusted Dermal Factor	SFWadj	cm^2-yr/kg-day	8,811	g
Inhalation rate - Adult	INH_a	m^3/day	20	bh
Inhalation rate - Child	INH_c	m^3/day	12	h
Age-Adjusted Inhalation Factor	InhFadj	m^3-yr/kg-day	11.7	e
Volatilization Factor	VF	L/m^3	0.5	e

Source:

a. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual, Part A, Interim Final. Office of Emergency and Remedial Response. EPA/540/1-89/002 (EPA, 1989).
b. *Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors* . OSWER Directive 9285.6-03. (EPA, 1991).
c. Dermal Exposure Assessment: Principles and Applications. EPA/600/8-91/011B. Office of Health and Environmental Assessment, Washington, D.C. (EPA, 1992).
d. Exposure Factors Handbook Volume I General Factors. EPA/600/P-95/002Fa. August 1997.
e. 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. (EPA 1991).
f. Exhibit 3-2 of Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim. EPA/540/R/99/005. OSWER 9285.7-02EP (EPA, 2001).
g. Equation 3.21 of Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim. EPA/540/R/99/005. OSWER 9285.7-02EP (EPA, 2001).
h. Table 1 of Draft Risk Assessment Procedures Manual (DEC, 2005)

* The exposure duration for future residents may be adjusted to account for a reasonable maximum residence time at Fort Wainwright of about 8 years.

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 that will be used to estimate exposure from dermal contact with groundwater are presented in Table 4-2. Chemical-specific dermal permeability coefficients (Kp) will be obtained from the dermal assessment guidance (EPA, 2001).

4.3.2 Inhalation Intake Calculations

4.3.2.1 Intake Equations for Inhalation of Ambient Dusts 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 maintenance worker, excavation worker, and site visitor/recreation user exposure scenarios:

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

The following 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:

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

where:

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

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 VOCs identified as COPCs in soil will be calculated using the Jury Model presented in the soil screening guidance (EPA, 1996). The exposure assumptions used to estimate exposure from inhalation of dust and vapors in ambient air are presented in Table 4-1.

4.3.2.2 Intake Equations for Inhalation of Vapors in Groundwater

The following 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:

$$Intake = \frac{C_w \times INHF_{adj} \times VF \times EF}{AT}$$

where:

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

where:

C_w = chemical concentration in water (mg/L)

$INHF_{adj}$ = 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 that will be used to estimate exposure from inhalation of volatile constituents are listed Table 4-1. Volatile constituents considered for the inhalation pathway are operationally defined as those COPCs with a Henry's Law constant greater than 10^{-5} atm-m^3/mole and a molecular weight less than 200 grams per mole (EPA, 1991a).

4.3.2.3 Inhalation Intake Calculations of Vapors from Indoor Air

In addition to addressing exposure from inhalation of ambient air, soil gas will be evaluated to address the potential for migration of volatile contaminants into indoor air at each residential housing unit. The advanced *Johnson and Ettinger (1991) Model for Subsurface Vapor Intrusion into Buildings, Updated 2003* (SG-ADV Version 3.1; 02/04)(EPA, 2003a) will be used to estimate exposure from vapor intrusion. Building dimensions, foundation thickness, etc. used for the modeling will be determined based on the residential housing plans used at Taku Gardens. Many of the exposure and modeling assumptions will be the defaults as specified by the guidance. However, additional site-specific factors (temperature, soil type, etc.) will be adjusted from the default values to provide site-specific estimates of exposure to vapors at the FCS.

4.3.3 Petroleum, Oils, and Lubricants

In accordance with ADEC's *Guidance for Cleanup of Petroleum Contaminated Sites* (ADEC, 2000), maximum site media concentrations for petroleum hydrocarbon fractionation data (that is, extractable petroleum hydrocarbons [EPH] and volatile petroleum hydrocarbons [VPH]) at each area of concern will be compared to one tenth of the ADEC soil cleanup levels (Method Two - Table B2) and groundwater cleanup levels (Table 4). The screening values representative of a site that receives mean annual precipitation of less than 40 inches each year (Under 40-Inch Zone) will be used. If exceedances of the Method 2 cleanup values occur, site-specific alternative cleanup levels may be calculated in accordance with ADEC guidance (ADEC, 2004a).

It should be noted that risk from individual constituents potentially occurring as a result of petroleum contamination [e.g., benzene, benzo(a)pyrene] will be addressed using the methodologies described in the previous sections.

4.4 Human Toxicity Assessment

The toxicity assessment section of the RA will identify the types of toxic effects a constituent can exert. Constituents will be divided into two broad groups on the basis of their effects on human health: noncarcinogens and carcinogens. This classification has been selected because health risks are calculated quite differently for carcinogenic and noncarcinogenic effects, and separate toxicity values have been developed for them.

Carcinogens are those constituents suspected of causing cancer following exposure; noncarcinogenic effects cover a wide variety of systemic effects, such as liver toxicity or developmental effects. Some constituents (such as benzene) are capable of eliciting both

carcinogenic and noncarcinogenic responses; therefore, these carcinogens are also evaluated for systemic (noncarcinogenic) effects.

For cancer effects, EPA developed a carcinogen classification system (EPA, 1986) that was a weight-of-evidence approach to classify the likelihood that a constituent is a human carcinogen. Although this classification scheme has been superseded in more recent guidance, the *Guidelines for Carcinogen Risk Assessment* (EPA, 2005), it is used in this RA work plan because EPA has not fully implemented the newer guidance. Information considered in developing the classification includes human studies of the association between cancer incidence and exposure, as well as long-term animal studies under controlled laboratory conditions. Other supporting evidence considered includes short-term tests for genotoxicity, metabolic and pharmacokinetic properties, toxicological effects other than cancer, structure-activity relationships, and physical and chemical properties of the constituent. For noncancer effects, toxicity values will be derived on the basis of the critical toxic endpoint (that is, the most sensitive adverse effect following exposure). Carcinogens are classified by the EPA as known (Group A), probable (Groups B1 and B2), or possible (Group C) human carcinogens. EPA's weight-of-evidence classification system for carcinogenicity is shown in Table 4-3.

TABLE 4-3
U.S. Environmental Protection Agency Weight-of-Evidence Classification System for Carcinogenicity

Group	Description
A	Human carcinogen, based on evidence from epidemiological studies
B1 or B2	Probable human carcinogen
	B1 indicates that limited human data are available.
	B2 indicates sufficient evidence in animals and inadequate or no evidence in humans.
C	Possible human carcinogen, based on limited evidence in animals
D	Not classifiable as to human carcinogenicity
E	Evidence of noncarcinogenicity for humans

Source: U.S. Environmental Protection Agency, Guidelines for Carcinogen Risk Assessment (U.S. EPA, 1986)

4.4.1 Dose-Response Evaluation

The magnitude of toxicity of a constituent depends on the dose to a receptor, where dose refers to exposure to a constituent concentration over a specified period of time. A dose-response curve describes the relationship between the degree of exposure (the dose) and the incidence of the adverse effects (the response) in the exposed population. EPA uses this dose-response information to establish toxicity values for particular constituents, as described in the following paragraphs.

4.4.1.1 Reference Doses for Noncancer Effects

The toxicity value describing the dose-response relationship for noncancer effects is the reference dose value, or RfD. For noncarcinogenic effects, the body's protective mechanisms must be overcome before an adverse effect is manifested. If exposure is high enough and these protective mechanisms (or thresholds) are exceeded, adverse health effects can occur.

EPA attempts to identify the upper bound of this tolerance range in the development of noncancer toxicity values. EPA uses the apparent toxic threshold value, in conjunction with uncertainty factors based on the strength of the toxicological evidence, to derive an RfD. EPA defines an RfD as follows (EPA, 1989):

In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. The RfD is generally expressed in units of mg/kg of body weight each day (mg/kg-day).

The FCS human health risk assessment (HHRA) will use available chronic RfDs for the oral exposure route. Because EPA has not derived toxicity values specific to skin contact, dermal RfDs will be derived in accordance with EPA's *Supplemental Guidance for Dermal Risk Assessment* (EPA, 2004a). The RfD that reflects the absorbed dose was calculated using the following equation:

$$RfD_{ABS} = RfD_o \times ABS_{GI}$$

where:

RfD_{ABS} = Absorbed reference dose

RfD_o = Oral reference dose

ABS_{GI} = Gastrointestinal (GI) absorption efficiencies

GI absorption efficiencies will also obtained from the *Supplemental Guidance for Dermal Risk Assessment* (EPA, 2004a).

4.4.1.2 Slope Factors for Cancer Effects

The dose-response relationship for cancer effects is expressed as a cancer slope factor that converts estimated intake directly to excess lifetime cancer risk. Slope factors are presented in units of risk per level of exposure (or intake). The data used for estimating the dose-response relationship are taken from lifetime animal studies or human occupational or epidemiological studies where excess cancer risk has been associated with exposure to the constituent. However, because risk at low intake levels cannot be directly measured in animal or human epidemiological studies, a number of mathematical models and procedures have been developed to extrapolate from the high doses used in the studies to the low doses typically associated with environmental exposures. The model choice leads to uncertainty. EPA generally assumes linearity at low doses and uses the linearized multistage procedure when uncertainty exists about the mechanism of action of a carcinogen and when information suggesting nonlinearity is absent.

It is assumed, therefore, that if a cancer response occurs at the dose levels used in the studies, there is some probability that a response will occur at all lower exposure levels (that is, a dose-response relationship with no threshold is assumed). Moreover, the dose-response slope chosen is usually the UCL on the dose-response curve observed in the laboratory studies. As a result, uncertainty and conservatism are built into EPA's risk extrapolation approach. EPA has stated that cancer risks estimated by this method produce estimates that "provide a rough but plausible upper limit of risk." In other words, it is not likely that the

true risk would be much more than the estimated risk, but "the true value of the risk is unknown and may be as low as zero" (EPA, 1986).

Because EPA has not derived toxicity values specific to skin contact, dermal slope factors will be derived in accordance with EPA's *Supplemental Guidance for Dermal Risk Assessment* (EPA, 2004a). The slope factor that reflects the absorbed dose will be calculated using the following equation:

$$SF_{ABS} = \frac{SF_o}{ABS_{GI}}$$

where:

SF_{ABS} = Absorbed slope factor

SF_o = Oral slope factor

ABS_{GI} = Gastrointestinal (GI) absorption efficiencies

GI absorption efficiencies will also be obtained from the *Supplemental Guidance for Dermal Risk Assessment*.

4.4.2 Source of Toxicity Values

In accordance with EPA guidance (EPA, 2005), the toxicity values (cancer slope factors and noncancer reference doses) to be used 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 EPA, is an electronic database containing health risk and EPA regulatory information on specific chemicals (EPA, 2007b).
- 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 EPA's Superfund program.
- The Health Effects Assessment Summary Tables (HEAST), provided by the EPA Office of Solid Waste and Emergency Response (EPA, 1997b), is a compilation of toxicity values published in various health effects documents issued by EPA.

The primary source of toxicity values will be the EPA's IRIS database. If a toxicity value is not available from IRIS, then the latest available values from the other sources will be used.

4.5 Human Health Risk Characterization

This section summarizes the methods for calculating human health risk. The risk characterization for the defined exposure area will estimate risks to human health based on the identified COPCs, the exposure scenarios, and toxicity information. The assessment will include excess lifetime cancer risk (ELCR) estimates and noncancer hazard index (HI) calculations. (The noncancer HI is a comparison of intake of noncarcinogenic compounds to

acceptable intakes.) Risk characterization also will consider the nature and weight of evidence supporting these estimates, as well as the magnitude of uncertainty surrounding such estimates.

The human health risk posed by each exposure area will be calculated using a two-step process as follows:

- Calculate risk (either ELCR or noncancer hazard quotient [HQ]) from the exposure point concentrations for each contaminant
- Sum the risk estimates from all contaminants to estimate the total ELCR or noncancer HI for each exposure area

For the purposes of this FCS risk evaluation, the potential for unacceptable human health risk will be identified using the following risk thresholds:

- Excess lifetime cancer risk values will be compared to the "point of departure" range of 10^{-6} to 10^{-4} that is generally used by regulatory agencies. Excess lifetime cancer risk values within or exceeding this range require a risk management decision that includes evaluating site-specific characteristics and exposure scenario factors to assess whether remedial action is warranted.
- A ratio of chemical intake to the RfD for all constituents (HI) greater than 1 indicates that there is some potential for adverse noncancer health effects associated with exposure to the contaminants of concern (EPA, 1991a).

4.5.1 Noncancer Hazard Estimation

Potential human health risk associated with exposure to noncarcinogenic compounds will be evaluated by calculating an HQ. The potential HQ will be calculated as the ratio of the intake to the RfD, as follows:

$$HQ = \frac{Intake}{RfD}$$

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

An HI is calculated to assess the potential for noncancer effects posed by exposure to more than one chemical. The HI approach assumes that simultaneous sub-threshold exposures to several chemicals 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, which is equal to the sum of the HQs, is calculated as follows:

$$HI = \frac{Intake_1}{RfD_1} + \frac{Intake_2}{RfD_2} + \ldots \frac{Intake_i}{RfD_i}$$

Where:

$Intake_i$ = the exposure level for the ith chemical

RfD_i = the reference dose for the ith chemical

Intake and RfD are expressed in the same units (mg/kg-day) and represent the same exposure period (that is, chronic, subchronic, or short-term).

4.5.2 Cancer Risk Estimation

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

$$Risk = Intake \times SF$$

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

Each SF is accompanied by a weight-of-evidence classification, which considers the available data for a chemical in order to evaluate the likelihood that the chemical is a potential carcinogen. The evidence is characterized as "sufficient," "limited," "inadequate," "no data," or "evidence of noncarcinogenicity." Studies in humans and studies in laboratory animals are considered separately. EPA recommends that cancer risk estimates should always be accompanied by a weight-of-evidence classification to indicate the strength of evidence that a chemical is a human carcinogen (EPA, 1986). Table 4-3 presents the EPA weight-of-evidence classifications.

Risk estimates for dioxins/furans will be conducted by calculating 2,3,7,8-Tetrachlordibenzo-p-Dioxin (TCDD) toxicity equivalents (TEQs), based on toxicity equivalence factors (TEFs) as proposed by the World Health Organization, and as derived in Van den Berg et al. (2005).

4.5.3 Lead Risk Estimation

Potential risks from lead concentrations in soil will be evaluated using different methods than conventionally used for other carcinogens and noncarcinogens. For direct contact pathways, the mean lead concentration (that is, average or arithmetic mean) in soil will be used to model blood levels using EPA's *Integrated Exposure Uptake Biokinetic Model for Lead in Children* (IEUBK) (EPA, 2004b) and its Adult Lead Model Spreadsheet (EPA, 2003c). These models will identify what percentage of the potentially exposed population would be expected to have a blood lead level greater than 10 micrograms per deciliter (µg/dL).

SECTION 5

Ecological Risk Assessment Methodology

The ecological risk assessment (ERA) will present an analysis of the potential for adverse ecological effects potentially associated with contaminants at FCS. The ERA will be conducted using a phased approach in accordance with ADEC guidance (ADEC, 2005a) and EPA guidance (EPA, 1992 and 1998). Each phase is more detailed and focused than the preceding one and is structured to avoid gathering unnecessary data and focuses the ERA on the COPECs, receptors, and areas where the greatest potential for ecological exposure would be expected. After each phase in the ERA process, decision point occurs where one of the following three decisions is made:

- There are adequate data to conclude that ecological risks are negligible and there is no need for remediation based on ecological risk
- The information is not adequate to make a decision at this point and the ERA process should continue
- The information indicates potential for adverse ecological effects, and either a more thorough assessment or remediation based on ecological risk is warranted

Consistent with ADEC ERA guidance, the FCS ERA will be structured to include the following components:

- **ERA Guidance**. Will summarize the guidance documents used to develop the RA work plan.
- **Phase 1- Ecoscoping.** Will summarize the results of the ecological scoping at the FCS. Per ADEC guidance, ecological scoping forms were used to identify the potential ecological exposure pathways (Section 3.4.4).
- **Phase 2 - Screening-Level ERA.** Will initiate problem formulation for the site and provide a conservative screening to determine whether site-related constituents could pose risks to aquatic or terrestrial wildlife. Will identify COPECs requiring further evaluation.
- **Phase 3 - Baseline ERA.** If necessary, a baseline ERA will be conducted to further evaluate and to provide a perspective on the likelihood of ecological risks.

These components will be completed as described in the following subsections.

5.1 ERA Guidance

This ERA will be conducted using the following regulatory guidance documents:

- *Risk Assessment Procedures Manual* (ADEC, 2005a)
- *Ecoscoping Guidance* (ADEC, 2007)
- *Sediment Quality Guidelines* (ADEC, 2004b)

- *Guidelines for Ecological Risk Assessment* (EPA, 1998)
- *EPA Region 10 Supplemental Ecological Risk Assessment Guidance for Superfund* (EPA, 1997a)

5.2 Ecoscoping

The first phase of the FCS ERA, Ecoscoping (ADEC, 2007), provides a conservative qualitative determination of whether there is any reason to believe that ecological receptors and/or exposure pathways are present or potentially present at or in the locality of the facility. The primary purpose of Ecoscoping is to identify those areas that are obviously devoid of ecological exposures and to identify direct impacts to biota is visual (that is, acute toxicity). Ecoscoping Forms were completed as part of the PSE and are provided in Appendix F of the *Preliminary Source Evaluation 1 Narrative Report* (Oasis, 2007), and the resulting information gathered is summarized, as follows:

- Potential ecological exposure to onsite soil is considered incomplete due to the lack of suitable habitat to support ecological populations
- A screening-level ERA is warranted to evaluate potential exposures of aquatic resources and piscivorous wildlife to constituents in groundwater than may reach the Chena River.
- A screening-level ERA is warranted to evaluate risks to terrestrial wildlife (mammals and birds) potentially exposed to site-related constituents in sediment from swales adjacent to the FCS.

Screening of media-specific concentrations will be conducted as part of the second phase of the ERA as described in the following section.

5.3 Screening-Level Ecological Risk Assessment

The second phase of the FCS ERA, Screening-Level ERA, will build on the results of Ecoscoping by initiating the process of problem formulation for the site and comparing media-specific concentrations with screening levels for the potentially complete pathways identified during Phase 1 and described in the CEM (Section 3.4.4).

As in the HHRA, available site data will be reviewed to identify a set of data that is of acceptable quality for the ecological risk screening. Following a data usability evaluation, analytical data will be screened to identify those constituents most important to the ecological risk evaluation. In accordance with ADEC and EPA guidance, media-specific concentrations will be screened against the screening values from Appendix D of the *Ecoscoping Guidance* (ADEC, 2007).

The constituents exceeding screening values will be referred to as COPECs requiring further evaluation in the next phase of the ERA.

COPECs will be identified separately for groundwater and surface sediment from exposure areas with suitable habitat to support aquatic resources or wildlife. Constituents with site media concentrations exceeding both ecological screening values and background

concentrations (if applicable) will be carried forward for further evaluation as part of the third phase of the ERA, Baseline Ecological Risk Assessment.

As an initial screening for the drainage swale and shallow groundwater, data will be directly compared against available sediment screening benchmarks (e.g., National Oceanographic Atmospheric Administration Screening Quick Reference Tables [SQuiRTs]) and ambient water quality criteria, respectively. Toxicity values used for the calculation of screening-level risk-based concentrations for birds and mammals will be obtained from the following sources:

- *Ecological Soil Screening Levels* (EcoSSLs) (EPA, various dates)
- *Toxicological Benchmarks for Wildlife: 1996 Revision* (Sample et al., 1996)
- Other available literature sources

5.4 Baseline Ecological Risk Assessment

The baseline ERA includes the same basic elements found in the screening-level ERA, but in a more developed form. The baseline ERA (if necessary) will include the following three interrelated elements (ADEC, 2005a; EPA, 1998):

1. Problem formulation
2. Analysis of exposure and effects
3. Ecological risk characterization

The baseline ERA (that is, Phase 3) process starts with finalizing the problem formulation initiated in the screening level ERA (that is, Phase 2) because this element defines the objectives and scope of the ecological assessment. Problem formulation identifies site-specific ecological resources and attributes at or near the FCS as well as the stressors that could affect these attributes. The analysis of exposure and effects phase of the baseline ERA will be directed by the results the screening-level risk assessment and of problem formulation. It will present estimates of the magnitude of actual or potential ecological exposures to representative wildlife species (characterization of ecological exposure), and identify the types of ecological effects that can result from excessive exposure to COPECs (characterization of ecological effects). The output of the analysis phase will be a profile of potential exposure in the vicinity of the FCS and a profile of the toxicological properties of COPECs. These elements will provide the basis of risk characterization. The final phase of the baseline ERA, ecological risk characterization will integrate the ecological exposure and effects assessments to estimate the potential for adverse impacts to ecological receptors from exposure to site COPECs. A discussion of the lines of evidence and of the assumptions and limitations of the analyses would be included during this phase.

SECTION 6

Risk Assessment Reporting

The results of the human health and ecological risk assessment will be presented in a clear and consistent fashion in the risk assessment report, in a format consistent with the *Draft Risk Assessment Procedures Manual*, (ADEC, 2005a). The risk assessment will be conducted by individuals with experience in the technical and regulatory aspects of risk assessment. This report will be submitted to EPA and ADEC for approval in accordance with an agreed upon schedule.

SECTION 7

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