FINAL

VOLUME I

REMEDIAL INVESTIGATION REPORT FOR

CONSTRUCTION DEBRIS SITES CC-IAAP-001 AND CC-IAAP-002

IOWA ARMY AMMUNITION PLANT

MIDDLETOWN, IOWA

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LIST OF ACRONYMS AND ABBREVIATIONS

ABS	Absorbed dose
ACM	Asbestos-Containing Material
AEC	Atomic Energy Commission
AMEC	AMEC Environment & Infrastructure, Inc.
AO	American Ordinance, LLC
ARAR	Applicable or Relevant and Appropriate Requirements
ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	Ambient Water Quality Criteria
BCF	Bioconcentration Factor
BERA	Baseline Ecological Risk Assessment
bgs	below ground surface
BHHRA	Baseline Human Health Risk Assessment
BW	Body Weight
CAA	Clean Air Act
CCRC-IS	Army Contracting Command - Rock Island
CC's	Critical Concentrations (CCs)
CDC	Centers for Disease Control
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COPC	Chemicals of Potential Concern
COPEC	Chemicals of Potential Ecological Concern
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
DOC	Dissolved Organic Carbon
DoD	Department of Defense
DPT	Direct Push Technology
EC20	Concentration resulting in effects on 20% of the test population
Eh	Oxidation-reduction potential
ELCR	Excess Lifetime Cancer Risk
EPA	United States Environmental Protection Agency
EPC	Exposure Point Concentration
°F	Degrees Fahrenheit
FFA	Federal Facility Agreement
f_{oc}	Fraction of organic carbon in soil
ft	feet
GIS	Geographic Information System
GPS	Global Positioning System
HI	Hazard Index
HQ	Hazard Quotient
IAAP	Iowa Army Ammunition Plant (used in site identifiers)
IAAAP	Iowa Army Ammunition Plant
ID	Inner diameter
IDNR	Iowa Department of Natural Resources
IDW	Investigation Derived Waste
IEUBK	Integrated Exposure Uptake Biokinetic Model
IRIS	Integrated Risk Information System

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

K_d	Soil-Water Distribution Coefficient
K_{oc}	Organic Carbon Partition Coefficient
K_{ow}	Octanol/Water Partition Coefficient
LAP	Load, Assemble, and Pack
LC50	Lethal concentration effecting 50% of the test population
LD50	Lethal dose effecting 50% of the test population
LELs	Lowest Effects Levels
LOAEL	Lowest Observed Adverse Effect Level
MCL	Maximum Contaminant Level
MDC	Maximum Detected Concentration
MF	Modifying factor
mg/kg	Milligrams per kilogram
mg/L	Milligrams per Liter (parts-per-million)
MI	Mobility Index
MPRSA	Marine Protection, Research, and Sanctuaries Act
MWH	MWH Americas, Inc.
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOAEL	No Observed Adverse Effect Level
NOEC	No-Observed-Effect-Concentration
OMOE	Ontario Ministry of the Environment
ORNL	Oak Ridge National Laboratory
PAH	Polynuclear Aromatic Hydrocarbon
PALs	Project Action Limits
Pb	Lead
PCBs	Polychlorinated biphenyl
pH	Measure of acidity or basicity
PID	Photo-ionization Detector
PIKA	PIKA International, Inc.
pKsp	Negative logarithm of Solubility Product
PNEC	Predicted No Effect Concentration
PPE	Personal Protective Equipment
PVC	Poly-Vinyl Chloride
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RDX	1,3,5-Trinitroperhydro-1,3,5-triazine
Redox	Oxidation-reduction
RfC	Reference Concentration
RfC_ss	Subchronic Reference Concentrations
RfD	Reference Dose
RfD_ss	Subchronic Reference Doses
RME	Reasonable Maximum Exposure
RI	Remedial Investigation
RSL	Regional Screening Level
S	Water Solubility
SCV	Secondary Chronic Value

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

SDWA	Safe Drinking Water Act
SLERA	Screening-Level Ecological Risk Assessment
SSLs	Soil screening levels
SVOC	Semi-volatile Organic Compound
TEC	Threshold Effects Concentration
TOC	Total organic carbon
TRV	Toxicity Reference Values
TSCA	Toxic Substances Control Act
UF	Uncertainty Factor
µg/dL	Microgram per deciliter
µg/l	Microgram per liter (parts-per-billion)
UCL	Upper confidence limit
UR	Unit Risk
USCS	Unified Soil Classification System
USGS	United States Geological Survey
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
UXO	Unexploded Ordnance
VOA	Volatile organic analysis
VOC	Volatile Organic Compound
VP	Vapor pressure
WP	Work Plan
$\Sigma ESBTU_{fcv}$	Sediment Benchmark Toxic Unit

LIST OF DEFINITIONS

Absorbed Dose - The amount of a substance penetrating the exchange boundaries of an organism after contact. Absorbed dose is calculated from the intake and the absorption efficiency. It usually is expressed as mass of a substance absorbed into the body per unit body weight per unit time (e.g., mg/kg-day).

Applicable or Relevant and Appropriate Requirements - Any standard, requirement, criterion, or limitation under any Federal environmental law, such as the Toxic Substances Control Act (TSCA), the Safe Drinking Water Act (SDWA), the Clean Air Act (CAA), the Marine Protection, Research, and Sanctuaries Act (MPRSA), and the Resource Conservation and Recovery Act (RCRA). Or, any promulgated standard, requirement, criterion, or limitation under a State environmental or facility-siting law, including those contained in USEPA-approved programs that have been identified by the State to the USEPA in a timely manner.

Bioavailability - subcategory of absorption and is the fraction of an administered dose of unchanged chemical that reaches the systemic circulation

Bioconcentration factor (BCF) - An indication of the potential for a chemical to bioconcentrate in lipids (fatty tissue) of organisms and is used as a surrogate for bioaccumulation in higher trophic levels of the food web;

Cancer Slope Factor - A plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The slope factor is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of a potential carcinogen.

Chemicals of Potential Concern - Chemicals that are potentially site-related and whose data are of sufficient quality for use in the quantitative risk assessment.

Chronic Reference Dose – An estimate (with uncertainty spanning perhaps and order of magnitude or greater) of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime.

Excess Lifetime Cancer Risk - Potential carcinogenic effects that are characterized by estimating the probability of cancer incidence in a population of individuals for a specific lifetime from projected intakes (and exposures) and chemical-specific dose-response data (i.e., slope factors). By multiplying the intake by the slope factor, the ELCR result is a probability.

Exposure - Contact of an organism with a chemical or physical agent. Exposure is quantified as the amount of the agent available at the exchange boundaries of the organism (e.g., skin, lungs, gut) and available for absorption.

LIST OF DEFINITIONS (Continued)

Exposure Assessment - The determination or estimation (qualitative or quantitative) of the magnitude, frequency, duration, and route of exposure.

Exposure Parameter (or Factor) - Factors related to organism behavior and characteristics that help determine its exposure to an agent from the source, a transport/exposure medium (e.g., air) or media (in cases of intermedia transfer) also is included.

Exposure Point Concentration - The representative medium-specific chemical concentration a receptor.

Exposure Pathway - The course a chemical or physical agent takes from a source to an exposed organism. An exposure pathway describes a unique mechanism by which an individual or population is exposed to chemicals or physical agents at or originating from a site. Each exposure pathway includes a source or release from a source, an exposure point, and an exposure route. If the exposure point differs may contact at an exposure point over the exposure period.

Exposure Point/Area - A location of potential contact between an organism and a chemical or physical agent.

Exposure Route - The way a chemical or physical agent comes in contact with an organism (e.g., by ingestion, inhalation, dermal contact).

Hazard Index - The sum of more than one hazard quotient for multiple substances and/or multiple exposure pathways. The HI is calculated separately for chronic, subchronic, and shorter-duration exposures.

Hazard Quotient - The ratio of a single substance exposure level over a specified time period (e.g., subchronic) to a reference dose for that substance derived from a similar exposure period.

Inhalation Unit Risk - The upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 µg/L in water, or 1 µg/m3 in air.

Intake - A measure of exposure expressed as the mass of a substance in contact with the exchange boundary per unit body weight per unit time (e.g., mg chemical/kg body weight-day). Also termed the normalized exposure rate; equivalent to administered dose.

Lifetime Average Daily Dose/Intake - Exposure expressed as mass of a substance contacted per unit body weight per unit time, averaged over a lifetime.

LIST OF DEFINITIONS (Continued)

Lowest Observed Adverse Effect Level - In dose-response experiments, the lowest exposure level at which there are statistically or biologically significant increases in frequency or severity of adverse effects between the exposed population and its appropriate control group.

Mobility index (MI) - A quantitative assessment of mobility that uses water solubility (S), vapor pressure (VP), and the organic carbon partition coefficient (Koc) to predict the mobility of contaminants in the environment.

No Observed Adverse Effect Level - In dose-response experiments, an exposure level at which there are no statistically or biologically significant increases in the frequency or severity of adverse effects between the exposed population and its appropriate control; some effects may be produced at this level, but they are not considered to be adverse, nor precursors to specific adverse effects.

Octanol/water partition coefficient (K_{ow}) - K_{ow} is a measure of the equilibrium partitioning of chemicals between octanol and water as determined under laboratory conditions.

Organic carbon partition coefficient (K_{oc}) - Provides a measure of the ability of a chemical to sorb (adhere) to the organic portion of soil, sediment and sludge under laboratory conditions.

Project Action Limit - The numerical value the decision-maker uses as the basis for choosing a remedial action at a Site. It may be a regulatory threshold such as a maximum contaminant level (MCL), a risk-based concentration level, a reference-based standard, or a technological limitation.

Reasonable Maximum Exposure - The highest exposure that is reasonably expected to occur at a site.

Reference Concentration - An estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

Riparian – The interface between land and a river or stream.

Screening benchmark - Media-specific sets of ecotoxicological benchmarks that should be used in developing a screening level assessment. These guidelines are to be used to screen exposure through routes other than food chain exposure.

Soil-water distribution coefficient (K_d) – A measure of the equilibrium distribution of a chemical in soil/water systems.

Subchronic Reference Concentration - An estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a portion of a lifetime (as a Superfund program guideline, two weeks to seven years).

LIST OF DEFINITIONS (Continued)

Subchronic Reference Doses - An estimate (with uncertainty spanning perhaps an order of magnitude or greater) of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a portion of a lifetime (as a Superfund program guideline, two weeks to seven years).

Substrate - material that rests at the bottom of a stream

Toxicity Reference Value – A concentration representing the NOAEL with uncertainty and/or modifying factors.

Transitional Zone - An area or a region distinguished from adjacent parts by a distinctive feature or characteristic

Uncertainty/variability factor (Ufs) - One of several, generally 10-fold, default factors used in operationally deriving the RfD and RfC from experimental data. The factors are intended to account for (1) variation in susceptibility among the members of the human population (i.e., inter-individual or intraspecies variability); (2) uncertainty in extrapolating animal data to humans (i.e., interspecies uncertainty); (3) uncertainty in extrapolating from data obtained in a study with less-than-lifetime exposure (i.e., extrapolating from subchronic to chronic exposure); (4) uncertainty in extrapolating from a LOAEL rather than from a NOAEL; and (5) uncertainty associated with extrapolation when the database is incomplete.

Unit Risk - The upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 µg/L in water, or 1 µg/m3 in air.

Upper Confidence Limit - The upper boundary (or limit) of a confidence interval of a parameter of interest such as the population mean.

USEPA Remedial Goals – An excess upper-bound lifetime cancer risk to an individual of between 10^{-4} to 10^{-6} lifetime excess cancer risk and, noncancer risk such that exposures present no appreciable risk of significant adverse effects to individuals, based on comparison of exposures to the concentration associated with reliable toxicity information such as USEPA's reference doses (i.e., an HI of 1.0).

Vapor pressure - The tendency for chemical volatilization from both solid and aqueous matrices;

Water solubility−Henry's Law constant - The maximum amount of the chemical that will dissolve in pure water at a specified temperature;

Weight of Evidence Classification - A USEPA classification system for characterizing the extent to which the available data indicate that an agent is a human carcinogen.

1.0 EXECUTIVE SUMMARY

This Remedial Investigation (RI) Report characterizes the nature and extent of contamination, evaluates the fate and transport of contaminants, and assesses the potential risk to human health and the environment from Construction Debris Sites CC-IAAP-001 and CC-IAAP-002 at the Iowa Army Ammunition Plant (IAAAP), Middletown, Iowa. The RI was conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Iowa Army Ammunition Plant (IAAAP) Federal Facility Agreement (FFA). This RI Report describes the procedures, findings, and recommendations that resulted from the implementation of the approved *RI Work Plan for Construction Debris Sites CC-IAAP-001 and CC-IAAP-002, Iowa Army Ammunition Plant, Middletown, Iowa* (PIKA, 2013).

The information collected during the RI was used to:

- Define the horizontal and vertical extent of the debris;
- Characterize the nature of chemicals of potential concern (COPC);
- Define potential transport pathways and receptor populations;
- Provide data for a Baseline Human Health Risk Assessment (BHHRA) and Screening Level Ecological Risk Assessment (SLERA), and
- Provide data and information for future analysis of potential remedial alternatives.

To fulfill these objectives, field investigations were conducted June 10 through June 18, 2013. Samples were collected from surface soils, subsurface soil borings, surface water, sediments, and groundwater. Samples were analyzed for presence of COPCs potentially resulting from the construction debris. Target analytes included explosives, metals, hexavalent chromium, semi-volatile organic compounds (SVOCs), polynuclear aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), pesticides, herbicides, polychlorinated biphenyls (PCBs), and asbestos.

The nature and extent of contamination of four media were investigated at CC-IAAP-001: soil, sediment, surface water, and groundwater. Seven metals (arsenic, barium, cadmium, total chromium, hexavalent chromium, lead, and selenium) and one pesticide (endrin aldehyde) exceeded their respective project action limit (PALs) or background concentrations.

- Soil - metals (arsenic, barium, cadmium, total chromium, lead, and selenium) and one pesticide (endrin aldehyde) exceeded their respective PALs or background concentrations.
- Sediment - metals (arsenic, barium, total chromium, and selenium) exceeded their respective PALs.
- Surface Water metals (total and dissolved arsenic; total and dissolved barium; total hexavalent chromium, and total selenium) exceeded their respective PALs.
- Groundwater - metals (total and dissolved arsenic, total chromium, total hexavalent chromium, and total lead) exceeded their respective PALs.

At CC-IAAP-002 seven metals (arsenic, barium, cadmium, total chromium, hexavalent chromium, lead, and selenium) and thirteen SVOCs (acenaphthene, acenaphthylene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene) exceeded their respective PALs or background concentrations.

- Soils, metals (arsenic, barium, total chromium, lead, and selenium) exceeded their respective PALs or background concentrations.
- Sediment - metals (arsenic, barium, total chromium, lead, and selenium) and thirteen SVOCs (acenaphthene, acenaphthylene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene) exceeded their respective PALs or background concentrations.
- Groundwater - metals (total and dissolved arsenic, total chromium, and total hexavalent chromium) exceeded their respective PALs.

The concentrations of metals in surface and subsurface soils at both sites are within the range of the background samples collected across the installation, with the exception of selenium.

Fate and Transport

The primary contaminant migration pathways for contaminants at CC-IAAP-001 and CC-IAAP-002 are:

- Leaching from soils to groundwater,
- Leaching from sediments to surface water, and
- Transport in surface drainage channels.

Visual observations, including brush and trees (four to six inches in diameter) growing through the debris piles and accumulation of soil plant material within the piles indicate the debris has been present for more than 20 years. The age of the debris and the lack of wide-spread source materials for metals contamination in either soils or groundwater suggest that the CC-IAAP-001 and CC-IAAP-002 soils are in likely in a steady-state condition whereby the rate of leaching of metals into the groundwater will not increase over time. Metals are generally most mobile in soil soon after they are released. Immobilization of metals, by mechanisms of adsorption and precipitation, will prevent movement of the metals to groundwater. Based on geotechnical data from soil and sediment samples collected at both sites, the pH of soils ranged from 5.3 to 8.2. The pH buffering capacity near neutral to slightly acidic pH values tends to limit the ability of most metals to migrate rapidly because the metals tend to precipitate as solids or to bind tightly to soil particles through cation exchange. Inorganic compounds are commonly bound to soil particles as a result of electrostatic interactions. The mineral hydrous ferric oxide ($Fe_2H_2O_4$) is a dominant sorbent for many inorganic compounds in natural systems, owing to its common presence on soil particle surfaces, high surface area, and amphoteric character.

Visual observations indicate that the debris was deposited at CC-IAAP-001 and CC-IAAP-002 at least 20 years ago. This means that no new contaminants have been generated and the previously released contaminants have had some time to bind to the mineral matrix. Thus, leaching rates cannot be any greater than at the current time unless geochemical conditions change.

Organic chemicals including VOCs, pesticides, and PAHs were detected in soil, but were not detected in groundwater at concentrations greater than their respective PALs with a few exceptions. This indicates the levels of these chemicals detected in soil do not present enough total mass to yield detectable groundwater concentrations after dilution, dispersion, and other natural mechanisms reduce their concentrations.

Baseline Human Health Risk Assessment

A BHHRA was performed for CC-IAAP-001 and CC-IAAP-002 as part of the RI at IAAAP in Middletown, IA. The objective of the BHHRAs is to quantify the human health risks associated with potential exposures to site-related COPCs under current and reasonably foreseeable future land use conditions, in the absence of any remedial actions. The BHHRAs were performed using the United States Environmental Protection Agency (USEPA) Risk Assessment Guidance for Superfund documents. The BHHRAs use the analytical data collected during the 2013 Remedial Investigation.

CC-IAAP-001 BHHRA

The media evaluated in the BHHRA for CC-IAAP-001 include the following:

- Surface and subsurface soil;
- Surface water and sediment – intermittent streams; and
- Overburden groundwater, as represented by overburden monitoring wells.

Within these media, COPCs were selected in accordance with USEPA guidance. COPCs for surface soil, surface and subsurface soil, and sediment included arsenic only. COPCs for groundwater included dissolved/total arsenic, dissolved/total barium, total hexavalent chromium, total lead, and total uranium.

The BHHRA evaluated health risks to receptor populations that could potentially be exposed to COPCs under current and possible future land use conditions. The following receptor populations were evaluated:

- A current and future hunter scenario evaluated adolescents and adults potentially exposed to COPCs in soil, surface water and sediment.
- A future construction worker scenario evaluated an adult potentially exposed to COPCs in surface and subsurface soil.
- A future commercial/industrial worker scenario evaluated an adult potentially exposed to COPCs in surface and subsurface soil and a hypothetical drinking water scenario.

The potentially complete exposure pathways evaluated in the BHHRA included direct contact (incidental ingestion and dermal contact) with soil, surface water, and sediment, inhalation of COPCs in dust released from soil, and potable use of groundwater (ingestion with groundwater used as tap water in a commercial setting).

Health risks for each of the current and future land use exposure scenarios were quantified using algorithms specified in USEPA guidance. The majority of quantitative exposure parameters used in the exposure scenarios was USEPA reasonable maximum exposure (RME) default values.

The BHHRA characterized cancer and non-cancer risks associated with the COPC, media and potential receptors identified above. The results of the BHHRA indicate, for current and potential future land uses, that potential exposure to soil, surface water, and sediment at the Site would be associated with cancer risks that do not exceed USEPA's cancer risk range of $1x10^{-6}$ to $1x10^{-4}$ (for all receptors except for the Commercial/Industrial Worker, which falls within the acceptable range), and non-cancer hazard index (HI) values that are lower than EPA's threshold value of 1. These conclusions are applicable to the following current and potential future land uses:

- Current and future hunter exposure to soil, surface water and sediment;
- Future construction worker exposure to soil and soil derived dust; and
- Future commercial/industrial worker exposure to soil and groundwater hypothetically used as drinking water.

In addition, the results of the BHHRA indicate that combined exposures to soil, surface water, sediment, and groundwater used as drinking water would not result in risks that exceed the upper bound of the USEPA Remedial Goal range or an HI of 1.

Conclusions

In conclusion, the results of the BHHRA indicate that cancer and non-cancer risks associated with soil, surface water, sediment and groundwater at the site do not exceed USEPA risk management thresholds and, therefore, no response actions to mitigate cancer and non-cancer risks are required for these media.

CC-IAAP-002 BHHRA

The media evaluated in the BHHRA for CC-IAAP-002 include the following:

- Surface and subsurface soil;
- Sediment – associated with intermittent streams; and
- Overburden groundwater, as represented by overburden monitoring wells.

Within these media, COPCs were selected in accordance with USEPA guidance. COPCs for surface soil, surface and subsurface soil, included arsenic only. COPCs for sediment included arsenic and benzo(a)pyrene. COPCs for groundwater included dissolved/total arsenic, total barium, total cadmium, total hexavalent chromium, and bromomethane.

The BHHRA evaluated health risks to receptor populations that could potentially be exposed to COPCs under current and possible future land use conditions. The following receptor populations were evaluated:

- A current and future hunter scenario evaluated adolescents and adults potentially exposed to COPCs in soil and sediment.
- A future construction worker scenario evaluated an adult potentially exposed to COPCs in surface and subsurface soil.
- A future commercial/industrial worker scenario evaluated an adult potentially exposed to COPCs in surface and subsurface soil and a hypothetical drinking water scenario.

The potentially complete exposure pathways evaluated in the BHHRA included direct contact (incidental ingestion and dermal contact) with soil and sediment, inhalation of COPCs in dust released from soil, and potable use of groundwater (ingestion with groundwater used as tap water in a commercial setting).

Health risks for each of the current and future land use exposure scenarios were quantified using algorithms specified in USEPA guidance. The majority of quantitative exposure parameters used in the exposure scenarios was USEPA RME default values.

The BHHRA characterized cancer and non-cancer risks associated with the COPC, media and potential receptors identified above. The results of the BHHRA indicate, for current and potential future land uses, that potential exposure to soil, surface water, and sediment at the Site would be associated with cancer risks that do not exceed USEPA's cancer risk range of $1x10^{-6}$ to $1x10^{-4}$ (for all receptors except for the Commercial/Industrial Worker, which falls within the acceptable range), and non-cancer HI values that are less than or equal to EPA's threshold value of 1. These conclusions are applicable to the following current and potential future land uses:

- Current and future hunter exposure to soil and sediment;
- Future construction worker exposure to soil and soil derived dust;
- Future commercial/industrial worker exposure to soil and groundwater hypothetically used as drinking water.

In addition, the results of the BHHRA indicate that combined exposures to soil sediment, and groundwater used as drinking water would not result in risks that exceed the upper bound of the USEPA Remedial Goal range or an HI of 1.

Conclusions

In conclusion, the results of the BHHRA indicate that cancer and non-cancer risks associated with soil sediment and groundwater at the Site do not exceed USEPA risk management thresholds and, therefore, no response actions to mitigate cancer and non-cancer risks are required for these media.

Screening Level Ecological Risk Assessment

A SLERA was performed for CC-IAAP-001 and CC-IAAP-002 as part of the RI at Iowa Army Ammunition Plant (IAAAP) in Middletown, IA. The objective of the SLERAs is to assess the potential for Site-related chemical of potential ecological concern (COPECs) in environmental media at CC-IAAP-001 and CC-IAAP-002 to adversely affect ecological receptors. The SLERAs were performed using United States Environmental Protection Agency (USEPA) Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (USEPA, 2007).

In accordance with USEPA guidance, the SLERAs identified complete exposure pathways, conducted a conservative assessment of all COPECs, and identified which COPECs can be eliminated from further consideration and which should be evaluated further in a Baseline Ecological Risk Assessment (BERA) (if necessary).

The SLERAs assessed analytical data collected in 2013 that were obtained in support of the Remedial Investigation for the Site. The SLERAs build upon the findings of a site-wide BERA prepared by MWH in 2004 (MWH, 2004). For example, information regarding the environmental setting presented in the BERA was incorporated into the SLERAs (see Section 4.0). Final NOAEL-based Critical Concentrations (CC'S) from the site-wide BERA were used as soil, surface water, and sediment screening values as described below in sections 7.3.22 and 7.4.2.2. Also, the SLERAs were performed following the same regulatory approach (*i.e.* USEPA, 1997) as the site-wide BERA (MWH, 2004).

CC-IAAP-001 SLERA

The SLERA of construction debris site CC-IAAP-001 evaluated the potential for chemical constituents of concern detected in surface soil, surface water and sediment to adversely affect ecological receptors. Based on the screening level risk estimate and considering the conservative nature of screening level ecological risk assessment tools:

- Risks to ecological receptors (including Indiana bat) from constituents in CC-IAAP-001 surface soil are likely negligible.
- Risks to ecological receptors (including Indiana bat) from constituents in CC-IAAP-001 surface water are likely negligible.
- Risks to ecological receptors (including Indiana bat) from constituents in CC-IAAP-001 sediment are likely negligible.

No further evaluation of risk to ecological receptors in CC-IAAP-001 is necessary.

CC-IAAP-002 SLERA

Based on the screening level risk estimate and considering the conservative nature of screening level ecological risk assessment tools:

- Risks to ecological receptors (including Indiana bat) from constituents in CC-IAAP-002 surface water are likely negligible;
- Risks to ecological receptors (including Indiana bat) from constituents in CC-IAAP-002 sediment are likely negligible.
- No further evaluation of risk to ecological receptors in CC-IAAP-002 is necessary.

The exposed pile of construction debris in CC-IAAP-002 is expected to be addressed by excavating the debris and associated soils.

Conclusions

The small reservoir of contamination in soil provides little total contaminant mass for migration to groundwater or other media. Metals associated with the aqueous phase of soils are subject to movement with soil water, and may be transported through the vadose zone to ground water. Metals, unlike the hazardous organics, cannot be degraded. Some metals, such as chromium, arsenic, and selenium can be transformed to other oxidation states in soil, reducing their mobility and toxicity. Immobilization of metals, by mechanisms of adsorption and precipitation, will prevent movement of the metals to groundwater.

Metal-soil interaction is such that when metals are introduced at the soil surface, downward transportation does not occur to any great extent unless the metal retention capacity of the soil is overloaded, or metal interaction with the associated waste matrix enhances mobility. Changes in soil environmental conditions over time, such as the degradation of the organic waste matrix, changes in pH, redox potential, or soil solution composition, due to various remediation schemes or to natural weathering processes, also may enhance metal mobility. The extent of vertical contamination is intimately related to the soil solution and surface chemistry of the soil matrix with reference to the metal and waste matrix in question.

Metals that exceeded their respective PALs and background concentrations at CC-IAAP-001 and CC-IAAP-002 include arsenic, barium, cadmium, total chromium, hexavalent chromium, lead, and selenium. However, the maximum concentrations of the metals detected in soil were within the range of the concentrations of the background samples collected from other areas of the facility, with the exception of selenium and lead. The sample data indicate that the total volume of contaminated soil is small. Since no background data for groundwater are available, it is unclear if the metals detected in groundwater samples are attributable to soil contamination or background concentrations.

The results of the BHHRA indicate that cancer and non-cancer risks associated with soil sediment and groundwater at either site do not exceed USEPA risk management thresholds and, therefore, no response actions to mitigate cancer and non-cancer risks are required for these media. The results of the SLERA indicate that risks to ecological receptors are negligible.

The extent of asbestos-containing material (ACM) is limited to the roofing material within the debris piles located within CC-IAAP-002. However, there are several areas within the debris piles, where the roofing material has disintegrated due to exposure to the elements. The ACM poses a threat of exposure to friable asbestos.

Recommendations

No action for chemical contaminants is recommended at either site. The ACM poses a threat of exposure to friable asbestos. Therefore, it is recommended that the ACM debris pile be removed and disposed off-site.

2.0 INTRODUCTION

This RI Report was prepared by PIKA International, Inc. (PIKA) on behalf of the Iowa Army Ammunition Plant (IAAAP) in Middletown, IA. This RI Report was prepared in accordance with the Army Contracting Command – Rock Island (CCRC-IS) Contract No. W52P1J-12-C-0025, Modification P00001, dated 16 July 2012. The RI was conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the IAAAP Federal Facility Agreement (FFA). This RI Report describes the procedures, findings, and recommendations that resulted from the implementation of the approved *RI Work Plan for Construction Debris Sites CC-IAAP-001 and CC-IAAP-002, Iowa Army Ammunition Plant, Middletown, Iowa* (PIKA, 2013).

The information collected during the RI was used to:

- Determine the horizontal and vertical extent of the debris;
- Characterize the nature of chemicals of potential concern (COPC) at the sites;
- Provide data for a BHHRA and SLERA; and
- Provide data and information for use in the future analysis of potential remedial alternatives.

2.1 Site Background

This section presents the available information for the installation and each of the two construction debris sites including observations regarding topography, physical features, and site drainage. No previous investigations have been conducted at either construction debris site.

2.1.1 Installation Background

The IAAAP is located in the southeastern part of Iowa, near the town of Middletown, Des Moines County, approximately 10 miles west of the Mississippi River. Figure 2-1 shows the location of the IAAAP in southeastern Iowa and Figure 2-2 identifies the location of the two sites with respect to Line 2 and each other within the IAAAP. The IAAAP is a secured facility covering approximately 19,000 acres in a rural setting. Approximately 7,750 acres are currently leased for agricultural use, 7,500 acres are forested land, and the remaining area is used for administrative and industrial operations. The principal mission of IAAAP has been load, assemble, and pack (LAP) operations dealing with a variety of conventional ammunition and fusing systems.

IAAAP was initially developed in 1941 for the production of supplies for World War II and operated from September 1941 until August 1945. Production was resumed in 1949 and has continued to the present. Also, from 1946 to 1950, nitrogen fertilizer was produced at Line 8. From 1947 through mid-1975, the former Atomic Energy Commission (AEC) occupied facilities on the site, which then reverted to Army control in 1975 (Ecology and Environment, Inc., 1987 in JAYCOR, 1996). Currently, IAAAP is a government facility, owned by the United States Army and operated by a private contractor, American Ordnance, LLC (AO).

2.1.2 Construction Debris Site 001 (CC-IAAP-001)

CC-IAAP-001 was discovered in October 2007 at the intersection of roads H and A during work on a water line along Road H (Figure 2-3). The site is bounded by a curving railroad spur that crosses Road H at the south end of the site and Road I at the northeast end of the site. The site slopes from north to south with steep embankments along Road H and the railroad spur. An unnamed drainage way bisects the site and flows from Road I, parallel to Road H, to the railroad spur at the south end of the site. The drainage exits the site through a culvert under the railroad spur approximately 50 feet west of Road H. The discharge from the intermittent drainage ditch eventually discharges into Brush Creek.

The site is moderately vegetated with small trees present in the western portion of the site. The site was used to discard construction and demolition debris. Debris is visible in several eroded areas along the steep embankment adjacent to Road H. Surface debris also exists along the drainage located at the base of the embankment along Road H. Visible debris includes scattered bricks, corrugated metal, metal parts, wire, and metal banding.

2.1.3 Construction Debris Site 002 (CC-IAAP-002)

CC-IAAP-002 was discovered by recreational users in March 2009 along a tributary to Brush Creek in a forested area south of Line 2 (Figure 2-4). The site was used to discard construction and demolition materials including sheets of metal, bricks, corrugated transite roofing/siding, wire, buckets, and wood. The debris appears to have been placed along the banks of an intermittent, unnamed drainage which discharges to Brush Creek. The end of the debris lies approximately 100-200 feet from the confluence with Brush Creek. Similar to CC-IAAP-001, it is possible that the site may contain ordnance related items and/or low-level radiological wastes. Surface water runoff follows the topography of the site and flows from the southwest to the northeast where it joins Brush Creek in the vicinity of a utility right-of-way. There is no vehicle access to the site. The area surrounding the site is heavily wooded with medium to large trees and an understory of moderately thick brush.

2.2 Report Organization

This RI Report includes sections presenting the site background (Section 2); field activities associated with site characterization (Section 3); physical characteristics of the site (Section 4); results of the field investigations (Section 5); contaminant fate and transport (Section 6); baseline risk assessment (Section 7); summary and conclusions (Section 8), and references (Section 9).

Figures – Includes the site maps, sample location figures, PAL and Background Exceedances, and asbestos sample results.

Tables – Provides lists of background concentrations; sample locations, analyses, exceedances, chemical properties, exposure pathways, and risk summaries.

Appendix A – RI Field Documents, provides electronic copies of field documents related to site activities: Daily reports, photographs of site activities, and daily safety and task briefing logs.

Appendix B – RI Field Data, includes soil boring logs, sample collection forms, Geographical Information System (GIS) data, and radiological and unexploded ordnance (UXO) survey logs.

Appendix C – IDW Disposal Documentation (Non-Hazardous Waste Manifest and Disposal Ticket and analytical data)

Appendix D – Laboratory Data and Project Action Limits (PALs) Comparison Tables, provides Detected results summaries detailed data reports for soil and water samples collected as part of this RI. The Project Action Limits (PALs) Comparison Table (previously included in the RI Work Plan [PIKA, 2013]) is also included in this appendix.

Appendix E – Data Validation Reports

Appendix F – Baseline Human Health Risk Assessment Calculations includes the tables and risk calculations used in performing the BHHRA.

Appendix G – Ecological Risk Assessment Data, contain the data used to calculate ecological risk.

3.0 STUDY AREA INVESTIGATIONS

The main objective of the RI was to determine the horizontal and vertical extent of debris at each site and to secure analytical data of sufficient quantity and quality to adequately characterize the nature and extent of COPCs at the two construction debris sites. This section presents the overall approach and details the tasks accomplished during RI. The RI was developed to collect data required to characterize the debris at each site, determine the potential risks to human and environmental receptors resulting from site contamination, and recommend remedial actions to mitigate/eliminate the risks resulting from identified hazards.

The sampling and data collection activities were conducted in accordance with the Final RI Work Plan (PIKA, 2013) with the following exceptions:

Site CC-IAAP-001:

- The steep slopes and dense vegetation along the road and railroad spur created unsafe access and working conditions for personnel and equipment. Therefore, no sampling was conducted on the embankments. However, characterization borings installed along the road and at the base of the railroad spur indicate that no waste material was present in the material used to create the road grade or railroad spur embankments.
- GW3 (total depth of 23.5 feet) was installed near the seasonal drainage at the base of the railroad spur embankment. Although the soil at the bottom of the well was moist during well installation, no groundwater collected in the well. After 24 hours, a water level elevation measurement was taken and no water was present. Therefore, an additional well, GW4 (total depth 33 feet) was installed to the west of SB03 where a pile of isolated debris (tiles/bricks) was discovered while creating pathways for access in to the western and southern areas of the site. The site boundary was expanded to include the debris and GW4.
- Given the limited volume of water in the groundwater wells and extremely slow recharge rates, samples were collected over the course of several days at each well to accumulate sufficient volume for the required analyses. Insufficient water remained in the wells after sampling to collect representative water quality parameters.
- Insufficient water was available in GW4 to collect sufficient volume required for proposed analyses. Water collected from this well was analyzed for metals and SVOCs only.
- Samples for VOCs were collected with 650 mL mini-bailers. All three 40ml volatile organic analysis (VOA) vials were filled with one bailer volume when possible. Given the small volume in some of the wells, two bailer volumes (collected within minutes of each other) were used to fill the vials.
- An additional sediment sample was collected at ST04 near GW4 to determine if any contamination was associated with the isolated brick pile.

Site CC-IAAP-002:

- No surface water was present in the central unnamed wash at the site. Therefore, no surface water samples were collected.
- Unsafe access and working conditions created by terrain and vegetation on site limited data collection at pre-determined soil boring and ground water well locations. These locations were adjusted allowing for the best representation/coverage of the site given the access limitations
- The steep terrain and vegetation created unsafe access and working conditions for mobilizing the Direct Push Technology (DPT) rig to the eastern bank of the dry wash, across from the debris pile. A hand auger was used to collect one soil boring (SB04) and three characterization borings (SC01, SC02, and SC03).

3.1 Project Approach and Field Activities

The following sections provide a summary of the RI activities including steps taken to create safe access and working conditions to allow for data collection.

3.1.1 Site Setup

On June 10, 2013, PIKA and subcontractor personnel completed mandatory AO protocols (background checks, badging, security and environmental rules) for access to IAAAP. Following completion of access protocols, the team met with the AO facility operations department to acquire utility clearance permits and obtain site orientation/ training. Site set up activities started after completion of IAAAP orientation included reconnaissance/orientation of both sites within IAAAP, locating a mobile office, track mounted DPT equipment, a portable toilet at CC-IAAP-001, and miscellaneous sampling instruments and materials (scoops, mini bailers, tubing, sampling containers, shipping coolers).

Before beginning field activities, initial safety and site orientation briefings were provided to all PIKA and subcontractor personnel. Additionally, daily safety and task briefings were conducted for all personnel. Documentation for above activities is included in Appendix A. A reconnaissance of each site was conducted to establish the boundaries and data collection (soil and water) locations (as proposed in the RI Work Plan (WP)) and to locate the general boundaries/extent of the debris piles within each site. A Trimble Nomad 900 GL Global Positioning System (GPS) unit was used to establish site boundaries and data collection locations and a Schonstedt Magnetometer (Model GA-52Cx) was used to conduct munitions avoidance and identify the presence of buried ferrous (iron based) debris at each site.

3.1.2 Brush Clearance

Given the significant vegetative growth, brush removal was conducted as required to create access pathways to the site and to clear vegetation around the soil boring and sample locations. Anomaly avoidance was conducted in all areas before vegetation removal. No large trees (greater than 6 inches in diameter) were removed.

3.1.3 Radiological Screening

Prior to soil boring and sampling activities radiological screening was conducted for each site and all data collections locations. A Ludlum Model 2221 survey meter with a model 44-10 scintillation probe and a Ludlum Model 12 Radiation Detector with a 44-9 probe were used to establish background readings each morning. A ten minute background reading was taken daily during instrument source check at the field operations staging area. The background was verified by a one minute check at each sample location to ensure that the reading was within the accuracy of the instrument. No radiation levels above background were detected at either site. Table 3-1 lists the background radiation recorded for each day of site activities.

3.1.4 Survey for Asbestos Containing Materials

A survey for the presence of potential asbestos containing material (ACM) was conducted by an Iowa licensed inspector before soil boring and sampling activities were conducted. The inspector surveyed all work areas within each site to ensure no ACM were present before mobilizing equipment or beginning investigation and sampling activities. The inspection focused on asbestos containing building materials, primarily asbestos-cement panels (transite), and pieces of thermal insulation resulting from disposal of building demolition debris.

3.1.5 Drilling and Sample Collection

Between June 11 and June 18, 2013, Terracon (Cedar Rapids, Iowa) used DPT to install temporary core borings for rapid sampling /data collection at the sampling locations established in the RI WP. Where uneven/unsafe terrain conditions prevented equipment and personnel access, modified locations were selected supported by magnetometer aided visual observations for metallic and construction debris. The soil borings, site characterization borings, and most of the temporary well borings were drilled with 3.25 inch inner-diameter (ID) rods with 2.1 inch ID acetate sleeves in five foot lengths. The remaining temporary well borings were advanced with 2.25 inch ID rods with 1.375 inch ID acetate sleeves in four foot lengths to facilitate reaching groundwater at depths greater than 25 feet.

Once retrieved, the cores were screened for radiation (compared against background radiation levels) before being characterized, logged, and sampled by the PIKA geologist. An Iowa licensed inspector also conducted a visual screening for potential ACM materials. The acetate sleeve was opened with a two-blade cutting tool to reveal the surface of the soil core. The core was field screened with the photo-ionization detector (PID) for VOCs, sampled for VOCs, photographed, and logged in accordance with the Unified Soil Classification System (USCS). The cores were carefully examined for evidence of anthropogenic activities, such as debris and unnatural materials. Sampling for VOCs was conducted using Encore® samplers immediately after the acetate sleeve was opened to prevent loss of volatile organic compounds. The remaining soil samples were collected in glass jars using disposable scoops. One soil boring and three site characterization borings were collected using a hand-auger at CC-IAAP-002 at locations that could not be accessed by the DPT equipment.

Temporary groundwater wells were constructed using one inch diameter PVC casing with 10 feet of 10-slot PVC screen and #12/20 filter pack sand to approximately two feet above the screened interval, and bentonite chips to near ground surface. Groundwater was sampled using mini-bailers for VOC samples and a peristaltic pump for all other samples.

The temporary groundwater wells were abandoned (following Iowa Administrative Code 7/2/08, Chapter 39, p.1) by removing the PVC stick-up casing, backfilling with soil/sand and sealing the hole with bentonite chips. The standard Iowa abandonment forms were completed, signed, and certified by the site geologist. The boring logs, well completion logs, and the State of Iowa standard abandonment forms are presented in Appendix B.

3.2 CC-IAAP-001

The following subsections describe the site specific investigation at CC-IAAP-001 conducted between June 11 and June 19, 2013.

3.2.1 Surface Water and Sediment Investigations

To determine the impact of the construction debris present on the northwestern edge of the intermittent stream within the site, surface water and stream sediment samples were collected at three locations (upgradient, downgradient, and in the central portion) of the stream.

Sediment and surface water samples were surveyed for VOC using a real time VOC detector (i.e., PID); for metal debris using a magnetometer; and radiation using a multi-spectrum detector (i.e. alpha/beta/gamma). The radiation detector indicated all radiation levels were below background therefore no samples were submitted for radiological analysis. The surface water samples and associated analyses are listed on Table 3-2. The sediment samples collected and associated analyses are listed in Table 3-3. The results of the surface water and sediment sampling are discussed in Section 5.2.

3.2.2 Geological and Analog Geophysical Investigations

Between June 11 and June 16, 2013, five soil borings, seven site characterization borings, and four temporary well borings were installed, three of which yielded groundwater for sampling. Temporary well and boring locations are shown on Figure 2-3. All soil borings from these locations were logged in accordance with the Final RI Work Plan and the USCS. Soil borings were advanced to 10 feet below ground surface (bgs); site characterization borings were advanced to depths ranging from four to 10 feet bgs, and the temporary well borings were advanced to depths ranging from 23.5 to 36 feet bgs. A summary of the soil boring descriptions is provided in Table 3-4. The soil boring results are discussed in Section 5.2.

The analog geophysical Investigation was performed using a Schonstedt magnetometer. The

Schonstedt was scanned along linear tracks in the investigation area and used at each borehole location to scan inside the holes to a depth of approximately three feet bgs. Only positive results (metal vs. no-metal) were documented, as shown in Figure 2-3.

The analog geophysical investigation (magnetometer aided) conducted within the conceptual boundary of the site (per the RI WP) confirmed the construction debris deposited along the northwestern corner of the stream. Additionally three areas of anomalies were identified along the southern edge of the site. The first two were identified along the railroad tracks. One, closest to the southern edge along the rail tracks was attributed to scrap metal originating from the rail tracks. Further investigation on the upper bank of the southern edge (along the railroad) revealed miscellaneous railroad debris (fish plates and anchor spikes) strewn along the entire length of the railroad. The second anomaly along the southern edge was a buried anomaly and a soil characterization sample collected in the vicinity of the buried anomaly did not reveal any buried metallic debris.

While creating a pathway to access the southern and western portion of the site, the third anomaly was identified along another unnamed wash (draining west to east into the main stream draining north to south). A small pile of tile/brick debris was located approximately 150 feet west of SC4 as indicated in Figure 2-3. A soil characterization boring, sediment sample and groundwater sample collected at this location did not indicate any contamination resulting from this pile of debris.

3.2.3 Surface and Subsurface Soil Investigations

The soils beneath the construction debris were characterized through the collection and analysis of soil samples for laboratory analysis.

Soil sample locations are shown on Figure 2-3. The general soil characteristics (e.g., color, texture, etc.) from each boring were described and recorded in the Soil Boring Logs included in Appendix B. The location of each boring/sample collection point was recorded using GPS. GPS coordinates for all borings are included in Appendix B.

Soil samples were collected for analysis to determine if COPCs are present in soil and to determine concentrations needed to complete the human health and ecological screening level risk assessments. Specific sampling methodologies are provided in Section 3 of the Field Sampling Plan (PIKA, 2013). At each construction debris site soil samples were collected from 0 to 0.5 feet below the construction debris/soil interface and from 2 feet below starting depth. Additional samples were collected at the 6 foot interval and at a maximum depth of 10 feet below the starting interval.

Soils were field screened for radiation using a multi-spectrum detector (i.e. alpha/beta/gamma). The radiation detector indicated all radiation levels were below background therefore no samples were submitted for radiological analysis. The soil boring samples collected and analyses performed are listed on Table 3-3. The sampling results are discussed in Section 5.2.

3.2.4 Groundwater Investigation

Using the DPT equipment, three groundwater samples were collected from temporary groundwater wells in CC-IAAP-001. The well locations are depicted on Figure 2-3. No water could be recovered from well GW-3. Therefore, an additional well, GW-4 was installed to the east of the SB03 sampling location. Insufficient water was present in well GW-4 to collect all of the required analyses. Only samples for metals and SVOCs were collected.

Groundwater samples were field screened for radiation using a multi-spectrum detector (i.e. alpha/beta/gamma). The radiation detector indicated all radiation was at background levels, therefore no samples were submitted for radiological analysis. The groundwater samples were collected using a peristaltic pump and low-flow sampling techniques. VOC samples were collected using disposable Teflon mini-bailers. Additionally due to limitations of the peristaltic pump to collect water from depths greater than 30 feet, Teflon mini-bailers were used to collect groundwater samples from GW-4. The groundwater samples collected and analyses performed are summarized on Table 3-2 and discussed in Section 5.2.

3.2.5 Radiological and ACM Surveys

Radiological surveys of all sampling locations did not indicate radiation levels above background levels. No suspect ACM materials were observed during the visual survey conducted at CC-IAAP-001 or inspections conducted at sampling locations. Samples collected from soil and subsurface locations were submitted for asbestos analysis by Method ASTM D7521. The details for groundwater and soil samples collected for asbestos analysis are listed in Table 3-2 and 3-3, respectively, and discussed in Section 5.4.

3.2.6 Ecological Survey

An AMEC Environmental & Infrastructure, Inc. (AMEC) ecologist qualitatively assessed the dominant habitats and natural communities present at CC-IAAP-001 on June 13, 2013. The Ecological assessment at CC-IAAP-001 is described in detail in Section 7.4.1.1.

3.3 CC-IAAP-002

The following subsections describe the site specific investigation conducted at CC-IAAP-002 between June 14 and June 19, 2013.

3.3.1 Surface Features

Site CC-IAAP-002 was used to discard construction and demolition materials including sheets of metal, bricks, corrugated transite roofing/siding, wire, buckets, and wood. The debris appears to have been placed along the banks of an intermittent, unnamed wash which discharges to Brush Creek. The end of the debris lies approximately 100-200 feet from the confluence with Brush Creek. No ordnance or radiological wastes were identified during the RI.

Surface water runoff follows the topography of the site and flows from the southwest to the northeast where it joins Brush Creek in the vicinity of a utility right-of-way. There is no vehicle access to the site. The area surrounding the site is heavily wooded with medium to large trees and an understory of moderately thick brush.

3.3.2 Surface Water and Sediment Investigations

To determine the impact of the construction debris present on the northwestern edge of the intermittent wash within the site, surface water and stream sediment samples were collected at three locations (upgradient, downgradient, and in the central portion) of the wash. Since no surface water was present at Site CC-IAAP-002, only sediment samples were collected at the designated locations.

Sediment samples were surveyed for VOC using a real time VOC detector (i.e., PID), munitions debris utilizing a magnetometer, and for radiation using a multi-spectrum detector (i.e. alpha/beta/gamma). The radiation detector indicated all radiation was at background levels, therefore no samples were submitted for radiological analysis. The sediment samples and associated analyses are included in Table 3-6. The sediment sampling results are discussed in Section 5.3.

3.3.3 Geological and Analog Geophysical Investigations

Between June 14 and June 18, 2013, four sampling soil borings, six site characterization borings, and three temporary well borings were advanced which all yielded groundwater for sampling. The well and boring locations are shown in Figure 2-4. All soil borings from these locations were logged by the attending site geologist in accordance with the Final RI Work Plan and the USCS. Soil sampling borings were advanced to 10 feet bgs; site characterization borings were advanced to five feet bgs, and the temporary well borings were advanced to depths ranging from 22.5 feet to 28 feet bgs. A summary of the boring descriptions is provided in Table 3-7. The soil boring results are discussed in Section 5.3.

The analog geophysical investigation was performed using the Schonstedt magnetometer in the same manner as in Construction Debris Site 1 (Section 3.2.3) at the borehole locations.

The analog geophysical investigation (magnetometer aided) conducted within the conceptual boundary of the site (per the RI WP) revealed miscellaneous metallic debris scattered along the western banks of the unnamed wash. Several intermittent areas along the wash were also identified where metallic debris washed down from previous run-off events had accumulated over the years. Additionally miscellaneous intermittent areas along the eastern bank were also noted to contain anomalies (likely barbed wire from fences) and pieces of metallic debris (lids for 5-gallon bucket/pail).

3.3.4 Surface and Subsurface Soil Investigations

The soils beneath the construction debris were characterized through the collection and analysis of soil samples for laboratory analysis.

Soil sample locations are illustrated in Figure 2-4. The general soil characteristics (e.g., color, texture, etc.) from each boring were described and recorded in the Soil Boring Logs included in Appendix B. The location of each boring/sample collection point was recorded using a Trimble GPS.

Soil samples were collected for analysis to determine if COPCs are present in soil and to determine concentrations needed to complete the human health and ecological screening level risk assessments. Specific sampling methodologies are provided in Section 3 of the Field Sampling Plan (PIKA, 2013). At each construction debris site soil samples were collected from 0 to 0.5 feet below the construction debris/soil interface and from 2 feet below starting depth. Additional samples were collected at the 6 foot interval and at a maximum depth of 10 feet below the starting interval.

Soils were field screened for radiation using a multi-spectrum detector (i.e. alpha/beta/gamma). The radiation detector indicated all radiation was at background levels, therefore no samples were submitted for radiological analysis. The soil boring samples collected and analyses performed are listed on Table 3-6. The sampling results are discussed in Section 5.3.

3.3.5 Groundwater Investigation

Three groundwater samples were collected from temporary groundwater wells in CC-IAAP-002. The temporary well locations are depicted on Figure 2-4. Groundwater samples were field screened for radiation using a multi-spectrum detector (i.e. alpha/beta/gamma). The radiation detector indicated all radiation was at background levels, therefore no samples were submitted for radiological analysis. The groundwater samples were collected using a peristaltic pump and low-flow sampling techniques. VOC samples were collected using disposable Teflon mini-bailers. The groundwater samples collected and analyses performed are listed on Table 3-5 and the results are discussed in Section 5.3.

3.3.6 Radiological and ACM Surveys

Radiological surveys of all sampling locations did not indicate radiation levels above background levels. The visual inspection/ survey conducted at CC-IAAP-002 identified a large area within the central portion of the site along the western bank and edges of the unnamed wash wherein suspect asbestos containing materials were observed to have been disposed with miscellaneous metal and construction debris. The general area where these ACM piles were observed is identified on Figure 2-4. Three such piles were documented containing significant quantities of several layers of asbestos containing cement panels. Due to the uneven terrain and the potential threat of disturbing the piles and releasing friable asbestos fibers further investigations to determine approximate volume of the pile(s) were not undertaken. Non-intrusive visual observations indicated that the piles ranged from 2-5 feet in depth. Four samples were collected at random locations from each pile, three of which were of material representing the cement panels and one representing a tar like substance (likely a roofing adhesive or sealant). The sample locations are identified on Figure 2-4 (ACM1, ACM2, ACM3, and ACM4). No suspect material was visually identified in the soil in any of the soil boring cores. Soil samples collected at specified depths from the soil cores were submitted for asbestos analysis. The details for groundwater, soil, and ACM samples collected for asbestos analysis by Method ASTM D7521 are listed in Table 3-5 and 3-6, respectively. The sampling results are discussed in Section 5.4.

3.3.7 Ecological Survey

An AMEC ecologist qualitatively assessed the dominant habitats and natural communities present at CC-IAAP-001 on June 13, 2013. The Ecological assessment at CC-IAAP-001 is described in detail in Section 7.5.1.1.

3.4 Investigation Derived Waste (IDW)

The DPT sampling equipment used for the RI was decontaminated between each data collection location following procedures in the Final RI Work Plan (PIKA, 2013). The water generated as a result of the equipment decontamination procedures was collected in one 55-gallon drum. Soil generated from bore holes was reused for filling the holes prior to abandoning them in accordance with Iowa Administrative Code 7/2/08, Chapter 39, p.1. The wells were abandoned by removing the PVC stick-up casing, backfilling with soil/sand and sealing the hole with bentonite chips. Excess soil resulting from cores was containerized in a 55-gallon drum. The drums used were steel drums (with removable lid and fitted 12-gauge bolted ring) and were appropriately labeled and staged on a pallet near CC-IAAP-001 (by the southern entrance gate to Line 2).

After completion of the RI activities, one representative grab sample was collected for each matrix and analyzed to characterize the waste stream prior to off-site disposal. The details for the representative samples collected for investigation derived waste (IDW) analyses are listed in Tables 3-5 and 3-6 and the results are discussed in Section 5.5. All personal protective equipment (PPE) used for sampling activities are considered non-hazardous. These were placed in a plastic bag and disposed of as regular trash. Copies of the analytical data and disposal documents are included in Appendix C.

4.0 PHYSICAL CHARACTERISTICS

The following sections present a summary of the general physical characteristics of the IAAAP and the two study areas. Additional information regarding the environmental setting at IAAAP is provided in the Baseline Ecological Risk Assessment (BERA) (MWH, 2004).

4.1 Climate

Des Moines County has a typical Midwestern climate of hot, humid summers and cold, wet winters (USATHAMA, 1980). According to the National Weather Service, between 1981 and 2010, the average annual temperature in this area was 50.9 degrees Fahrenheit (°F) with typical variations of 14.3°F (January) to 85.7°F (July). The average annual precipitation in this area is 36.2 inches, with monthly averages ranging from 1.06 inches in January to 4.97 inches in June. During the winter, precipitation frequently occurs as snow, and during the rest of the year it is chiefly rain, often heavy. Approximately 25 percent of precipitation occurs as snow in the winter months, amounting to approximately 6.2 inches of precipitation. The highest rainfall amounts tend to occur between May and July.

4.2 Ecology

Des Moines County is a loess-covered glacial till plain. The soils formed under prairie and forest vegetation. The nearly level and gently sloping soils formed in loess. The native vegetation in these areas consists of grass. The soils in the steeper areas formed from glacial till. The nearly level and gently sloping soils on bottom land along the Mississippi and Skunk rivers formed in alluvium. The native vegetation found in this area consists of oak, hickory, ash, elm and maple trees. The main types of prairie grasses found in the bottomlands are big bluestem and little bluestem prairie grasses (JAYCOR, 1996).

Wildlife found at the IAAAP site includes a large white-tail deer population, foxes, gray squirrels, raccoons, woodchucks, coyotes, eastern cottontail rabbits, mice, moles, pocket gophers, beavers, muskrats, badgers, opossum, and mink. In an attempt to effectively manage the overpopulation of deer, limited hunting seasons have been allowed on the site. Trapping of fur-bearing mammals is also allowed during limited times of the year (JAYCOR, 1996).

Numerous bird species inhabit or migrate through the IAAAP site. Some of the most common species include the American robin, northern cardinal, blue jay, red-headed woodpecker, common crow, common grackle, mourning dove, red-winged blackbird, chipping sparrow, eastern meadowlark, American goldfinch, and turkey. Red-tailed hawks are the most common raptor species present, but bald eagles have been observed flying over the IAAAP or feeding on the fish they catch in Mathes Lake. Because of its close proximity to the Mississippi River flyway, a large variety of migrating bird species may also use the IAAAP environs. Water fowl commonly seen include mallards, blue-winged teals, goldeneyes, buffleheads, wood ducks, hood mergansers, green-winged teals, northern shovelers, and Canadian geese. Nest boxes have been set up on the site for wood ducks, which are common near the on-site ponds and lakes (JAYCOR, 1996).

According to the U.S. Department of the Interior's Fish and Wildlife Service, no known endangered species reside at IAAAP. However, one federally-listed endangered species (Indiana bat, *Myotis sodalis*) has been sighted in adjacent Louisa and Van Buren counties, but has not been observed at IAAAP and is considered transient with respect to site occurrence. An endangered species management plan (Tetra Tech EM, Inc. 2001) has been prepared for the Indiana bat at the Site.

The bald eagle is protected under the Bald and Golden Eagle Protection Act. The bald eagle winters along large rivers such as the Mississippi and Skunk. Additionally, the U.S. Fish and Wildlife Service has recently petitioned to list three grassland species, the plains spotted skunk, the prairie gray fox, and Mearn’s eastern cottontail rabbit as threatened or endangered. The ranges of these species may include IAAAP. The Iowa Department of Natural Resources (IDNR) has identified two state-listed threatened species that may be found at IAAAP. These species are the orangethroat darter and the yellow trout lily. The orangethroat darter is known to inhabit small headwater streams and was present in Brush and Spring Creeks during a 1987 sampling event. Although no yellow trout lilies have been observed at IAAAP, they are generally found in low woodlands along streams or on low wooded slopes and bluffs (JAYCOR, 1996).

4.3 Topography and Surface Water

Overall, topography at IAAAP is generally flat in the uplands and dissected by several major drainages, with overall topography sloping gently toward the south. Ground surface elevations range from approximately 728.3 feet in the uplands in the north to approximately 531.5 feet near the southern property boundary at Long Creek. The IAAAP property is drained by, from west to east, the Skunk River, Long Creek, Brush Creek, and Spring Creek.

Little Flint Creek drains a small area in the north of the site. The rest of the plant is drained by, from west to east, the Skunk River, Long Creek, Brush Creek, and Spring Creek. Long and Brush Creeks are tributaries of the Skunk River, which flows to the Mississippi River. Spring Creek is a tributary of the Mississippi River.

4.4 Geology

The IAAAP is located in the Dissected Till Plain section of the Central Lowland Province of the Southern Iowa Drift Plain Region. The IAAAP is reported to be underlain by a sequence of unconsolidated glacial deposits of Pleistocene age overlying sedimentary bedrock units.

The glacial tills consist primarily of silty clay and clayey silt with thin sand seams and lenses and are assigned to the Kellersville Till Member (Illinoian Age) of the Glasford Formation of southeastern Iowa.

The tills extend to depths in excess of 100 feet in portions of the north half of the IAAAP, but are thin or absent locally in deeper stream valleys in the south around Mathes Lake, and in the northeast.

The bedrock underlying IAAAP consists of a sequence of limestones interbedded with varying thicknesses of shales and sandstones ranging in age from Cambrian to Mississippian. There are two basic formations of importance at the facility, which are the uppermost rock units within the area—the Keokuk Limestone and Burlington Limestone of the Osaga Series (Mississippian) (JAYCOR, 1996).

The field observations, by the site geologist during this Remedial Investigation, confirm that the CC-IAAP-001 is underlain by poorly drained, native soil built on glacial till. The soils were primarily clayey silts and silty clays with a few thin lenses of gravels and sand. The plasticity characteristics of these fine-grained soils tended to increase with depth. The silty clays contained trace amounts of moderately sorted and well rounded to angular gravel and sand. Little organic material was observed except in the poorly developed thin A horizon, and, in general, no discernible B horizon. The exception was the boring from the dry well GW3, which was dark colored nearly its whole profile length with a distinctive organic decay odor. CC-IAAP-001 appears to be a cut and fill area in native soil as the result of construction activities from building the adjacent roads and railroad berms, with some of this activity associated with open dumping and subsequent shallow covering of debris with available native soil.

The field observations, by the site geologist during this Remedial Investigation, confirm that the CC-IAAP-002 is underlain by poorly to moderately drained, native soil built on glacial till. Soils were better drained in the more sloped areas of the site with better developed A horizons, but in general had similar characteristics as soils in CC-IAAP-001. There was no indication of anthropogenic activities evidenced by the soil borings, with the exception of CC-IAAP-02-SB03-GW, which has dark colored bedding at 5.5 feet, suggesting a former A horizon, but this could be the natural result of deposition due to changes in drainage, since there are no other indications. CC-IAAP-002 appears to be an open dump area with little subsurface material, except what was likely covered by erosion and deposition.

4.5 Hydrogeology

In Des Moines County, Iowa, there are four principal aquifers: the surficial soils aquifer and the bedrock aquifers of Mississippian, Devonian, and Cambro-Ordovician units. The shallow surficial soil aquifer at IAAAP occupies the upland till plain and is predominantly clay-rich glacial tills that exhibit low hydraulic conductivities and yield only small quantities of groundwater to wells. Surficial soils aquifers are described using the following terminology: shallow till (typically containing the water table surface), intermediate till, and basal till. Depth to the water table in the shallow till is generally less than 10 to 15 feet. Shallow groundwater flow typically mimics surface topography (JAYCOR, 1996).

Information on hydrogeologic conditions in the bedrock aquifers underlying the deeper till is sparse. Facility-wide groundwater levels suggest that overall flow direction in the bedrock is to the south and east toward the Skunk and Mississippi Rivers, when not intercepted by incised surface drainages

(JAYCOR, 1996).During this Remedial Investigation, four temporary groundwater wells were installed at CC-IAAP-001. The static depth to water at each location was: GW1 – 13.61 feet, GW2 – 16.31 feet, GW3 – dry, and GW4 – 32.19 feet. The data indicate a groundwater gradient from northeast to southwest at CC-IAAP-001. Groundwater well locations are shown on Figure 2-3.

During this Remedial Investigation, three temporary groundwater wells were installed at CC-IAAP-002. The static depth to water at each location was: GW1 – 12.63 feet, GW2 – 12.77 feet, and GW3 – 12.70 feet. The data indicate a groundwater gradient from northeast to southwest at CC-IAAP-002. Groundwater well locations are shown on Figure 2-4.

5.0 NATURE AND EXTENT OF CONTAMINATION

The scope of the Construction Debris Sites RI is to identify the horizontal and vertical extent of the debris, collect samples to evaluate whether contaminants have impacted the soil or groundwater beneath the sites, and determine whether runoff from the debris has negatively affected adjacent streams. The sample data were compared to the risk-based PALs and background concentrations. The PALs Comparison Table that was presented in the RI Work Plan (PIKA, 2013) is included on CD in Appendix D for quick reference.

This section discusses only the detected sample concentrations that exceeded their respective PALs or background concentrations. The analytical data reports and searchable summary tables of all detected sample concentrations at CC-IAAP-001 and CC-IAAP-002 are included on the CD in Appendix D.

5.1 Background

The concentrations of detected metals in surface and subsurface soils were compared to the risk-based PALs included in the Final RI Work Plan (PIKA, 2013). However, some metals (e.g., arsenic and selenium) commonly have background concentrations that are greater than the PALs. To determine whether detected metals concentrations could be attributed to the presence of naturally occurring metals in soils at the facility, the sample concentrations of metals were compared to the background concentrations developed in the *Line 1 and Firing Site Supplemental Remedial Investigation Report, Iowa Army Ammunition Plant* (T&N Associates, 2001). The background data only were used to evaluate the nature and extent of metals contamination at the two sites, not to eliminate risk.

The data used to establish the facility background concentrations were developed from 84 soil samples (collected from 28 locations at depths of 0 - 0.5 feet; 1.5 - 2.0 feet; and 3.0 - 3.5 feet). The background soil samples were collected between 1991 and 1993 from locations in the northern portion of the installation, upgradient (with respect to overland surface drainage and groundwater flow) from all site features, production activities, and waste handling and disposal operations. The data statistically analyzed and reported in the *Revised Draft Final Remedial Investigation Report, Iowa Army Ammunition Plant* (JAYCOR, 1996), and background concentrations were developed in the *Line 1 and Firing Site Supplemental Remedial Investigation Report, Iowa Army Ammunition Plant* (T&N Associates, 2001). Background levels were derived as average concentrations and are listed in Table 5-1.

5.2 CC-IAAP-001 Site Characterization Results

An instrument aided visual survey was conducted at Site CC-IAAP-001 to identify and adjust (as needed) the sample and soil characterization locations proposed in the RI WP. A total of seven surface soil samples, four sediment samples, 15 subsurface samples, three surface water samples, and three ground water samples were collected. Additionally, seven soil characterization boreholes were completed to identify and delineate the site boundary of extent of fill material (if present). Table 5-2 provides a summary of the characterization boreholes and environmental samples collected at CC-IAAP-001.

5.2.1 CC-IAAP-001 Surface Soil and Sediment Sample Results

A total of seven surface soil samples and four sediment samples were collected at Site CC-IAAP-001. The detected sample concentrations of four metals (arsenic, barium, total chromium, and selenium) and one pesticide (endrin aldehyde) that exceeded their respective PALs at CC-IAAP-001 are shown on Figure 5-1, listed in Table 5-3, and summarized below.

- Selenium concentrations exceeded the PAL at all seven surface sample locations;
- Lead and arsenic concentrations exceeded their respective PALs at six of the seven sample locations;
- Total chromium concentrations exceeded the PAL at four of the seven sample locations; and
- Endrin aldehyde concentrations exceeded PAL at two of the seven sample locations.

The average concentration of selenium in surface soil and sediment samples is 2.6 milligrams per kilogram (mg/kg). The average concentration of arsenic is 7.9 mg/kg (the background level for arsenic is 7.33 mg/kg).

5.2.2 CC-IAAP-001 Geological and Analog Geophysical Characterization Results

Visual surveys were conducted at each site to identify areas of surface contamination and locations for soil characterization boreholes installed to investigate the presence or absence of non-native or fill materials and effectively delineate the boundary of each site. The surveys and boreholes also assisted in identifying the location for collection of environmental samples. The locations were adjusted as needed to ensure safe access to personnel and equipment for conduct RI operations to ensure the sampling captured specific site conditions.

In general, the results of the soil boring logs and field observations by the site geologist confirm that the CC-IAAP-001 is underlain by poorly drained, native soil built on glacial till, as indicated by the geologic summary of the area from Section 4.4. The soils were primarily clayey silts and silty clays with a few thin lenses of gravels and sand. The plasticity characteristics of these fine-grained soils tended to increase with depth. The silty clays contained trace amounts of moderately sorted and well rounded to angular gravel and sand. Little organic material was observed except in the poorly developed thin A horizon, and, in general, no discernible B horizon. The exception was the boring from the dry well GW3, which was dark colored nearly its whole profile length with a distinctive organic decay odor. This could have been the result of ponded water for an extended duration.

There was some indication of anthropogenic activity as summarized below.

- The poorly developed A horizon is consistent with the area being adjacent to a paved road built on a berm, likely the result of cut and fill during the road construction, and largely not related to the disposal operation. The A horizon was in general more developed to the west of the cleared area adjacent to the road, near the creek (Figure 2-3).
- The evidence for buried metal was spotty, confined largely to the debris area adjacent to the creek, as defined by visual inspections, and linear sweeps of the Schonstedt Magnetic Locator as indicated in Figure 2-3. One exception was in soil boring SC01, taken at the base of the road berm. At this location, there was an indication of subsurface metal at a depth of three feet bgs, but subsequent borings showed no buried metal near this area.
- There was some evidence of disturbed soil, interpreted to suggest cut and fill activity. It appears that native soil was pushed with heavy equipment to cover up material from construction activities when the road and railroad berms were built. The soil cores found small pieces of terra cotta near the surface, former A horizons (organic rich layer) below the surface, and unusual mottling patterns that showed a mix of native soil types. These findings are listed in Table 5-4.

In summary, CC-IAAP-001 appears to be a cut and fill area in native soil as the result of construction activities from building the adjacent roads and railroad berms, with some of this activity associated with open dumping and subsequent shallow covering of debris with available native soil.

5.2.3 CC-IAAP-001 Soil Sampling Results

Subsurface soil samples were collected at five locations and at three depths (2-feet, 6-feet, and 10-feet bgs) at each location for a total of 15 samples within site CC-IAAP-001. The detected subsurface sample concentrations of arsenic, barium, total chromium, lead, and selenium that exceeded their respective PALs or background levels at CC-IAAP-001 are shown on Figure 5-2, listed in Table 5-5, and summarized below.

- 2-feet bgs
  - Selenium concentrations exceeded the PAL at all five sample locations;
  - Total chromium concentrations exceeded the PAL at four of the five sample locations;
  - Arsenic concentrations exceeded the PAL at three sample locations; and
  - Lead, barium, and cadmium concentrations exceeded their respective PALs at one of the five sample locations.
- 6-feet bgs
  - Arsenic and selenium concentrations exceeded their respective PALs at all five sample locations;
  - Total chromium concentrations exceeded the PAL at three of the five sample locations; and

  - Lead concentrations exceeded the PAL at one of the five sample locations.
- 10-feet bgs
  - Selenium concentrations exceeded the PAL at all five sample locations;
  - Arsenic concentrations exceeded the PAL at four of the five sample locations; and
  - Cadmium concentrations exceeded the PAL at one of the five sample locations.

The average concentration of selenium over the entire soil profile is 2.5 milligrams per kilogram (mg/kg). The sample with the highest detected concentration (4.3 mg/kg) was collected at SB-5 at 2 feet bgs. Similarly, the average concentration of arsenic was 10.9 mg/kg and the sample with the highest detected concentration (21 mg/kg) was collected at SB-1 at 2 feet bgs.

5.2.4 CC-IAAP-001 Surface and Groundwater Sampling Results

A total of three surface water samples and three ground water samples were collected at Site CC-IAAP-001. The detected concentrations of five metals (arsenic, barium, hexavalent chromium, lead and selenium) that exceeded their respective PALs at CC-IAAP-001 are shown on Figure 5-3, listed in Table 5-6, and summarized below.

- Surface Water Samples
  - Arsenic and barium sample concentrations exceeded their respective PALs at all three locations; and
  - Arsenic (dissolved), barium (dissolved), selenium, and hexavalent chromium sample concentrations exceeded their respective PALs at one of the three locations.
- Ground Water Samples
  - Arsenic and chromium sample concentrations exceeded their respective PALs in all three wells;
  - Arsenic (dissolved) sample concentrations exceeded the PALs at two of the three wells; and
  - Lead and hexavalent chromium sample concentrations exceeded their respective PALs at one of the three wells.

The detected concentration of barium (total and dissolved) in surface water is 130 micrograms per liter (µg/l). The PAL for barium is 110 µg/l. The average concentration of total arsenic in surface water is 1.53 µg/l. The detected dissolved concentration is 1.5 µg/l. The average total concentration of arsenic in groundwater is 8 µg/l. The average dissolved concentration is 2.8 µg/l.

5.3 CC-IAAP-002 Site Characterization Results

An instrument aided visual survey was conducted at Site CC-IAAP-002 to identify and adjust (as needed) the sample and soil characterization locations proposed in the RI WP. A total of 6 surface soil samples, 3 sediment samples, 12 subsurface samples, 3 ground water samples, and 4 ACM samples were collected. The unnamed wash within the site was dry and no surface water samples were collected. Additionally, 6 soil characterization boreholes were completed to identify and delineate the site boundary of extent of fill material (if present). Table 5-2 provides a summary of the characterization boreholes and environmental samples collected at CC-IAAP-002.

5.3.1 CC-IAAP-002 Surface Soil and Sediment Sampling Results

A total of six surface soil samples and three sediment samples were collected at Site CC-IAAP-002. The detected sample concentrations and exceedances are shown on Figure 5-4, listed in Table 5-7, and summarized below. The detected concentrations of four metals (arsenic, barium, and chromium, and selenium) exceeded their respective PALs at all four sediment sampling locations. At one location, ST-01 (downstream location), the detected concentrations of acenapthene, acenapthylene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)flouranthene, benzo(g,h,i)perylene, benzo(k)flouranthene, chrysene, dibenzo(a,h)anthracene, flouranthene, indeno(1,2,3-CD)pyrene, phenanthrene, and pyrene were greater than their respective PALs. However, PAHs were not detected at concentrations greater than their respective PALs at any other sampling location at CC-IAAP-002. In addition, all of the detected sample concentrations were qualified as estimated because they were not detected in the duplicate sample with the exception of acenapthylene and pyrene.

Selenium was detected at all six surface sampling locations at an average concentration of 2.6 mg/kg (the background level for selenium is 0.335 mg/kg). Lead was detected at four surface sampling locations at an average concentration of 27 mg/kg (the background level for lead is 17.7 mg/kg). Arsenic was detected at three surface sampling locations at an average concentration of 7.73 mg/kg (the background level for arsenic is 7.33 mg/kg).

5.3.2 CC-IAAP-002 Geological and Analog Geophysical Characterization Results

In general, the results of the soil boring logs and field observations by the site geologist confirm that the CC-IAAP-002 is underlain by poorly to moderately drained, native soil built on glacial till, as indicated by the geologic summary of the area from Section 4.4. Soils were better drained in the more sloped areas of the site with better developed A horizons, but in general had similar characteristics as soils in CC-IAAP-001.

There was no indication of anthropogenic activities evidenced by the soil borings, with the exception of CC-IAAP-02-SB03-GW, which has dark colored bedding at 5.5 feet, suggesting a former A horizon, but this could be the natural result of deposition due to changes in drainage, since there are no other indications. There was no indication of subsurface metal by the Schonstedt Magnetic Locator in any of the soil borings. In conclusion, all indications are that CC-IAAP-002 is an open dump area with little subsurface material, except what was likely covered by erosion and deposition. These findings are listed in Table 5-8.

5.3.3 CC-IAAP-002 Soil Sampling Results

Subsurface soil samples were collected at four locations and at three depths (2-feet, 6-feet, and 10-feet bgs) at each location for a total of 12 samples within site CC-IAAP-002. The detected subsurface concentrations of arsenic, barium, total chromium, lead, and selenium that exceeded their respective PALs or background levels at CC-IAAP-002 are shown on Figure 5-5, listed in Table 5-9, and summarized below.

- 2-feet bgs
  - Total chromium and selenium sample concentrations exceeded their respective PALs at all four locations; and
  - Arsenic sample concentrations exceeded the PAL at three of the four locations.
- 6-feet bgs
  - Arsenic sample concentrations exceeded the PAL at all four locations;
  - Selenium sample concentrations exceeded the PAL at three of the four locations; and
  - Selenium and lead sample concentrations exceeded their respective PALs at two of the four locations.
- 10-feet bgs
  - Arsenic sample concentrations exceeded the PAL at all four locations;
  - Selenium sample concentrations exceeded the PAL at three of the four locations; and
  - Barium exceeded the PAL at one of the four locations.

The average concentration of selenium over the entire soil profile is 2.7 mg/kg. The sample with the highest detected concentration (4.5 mg/kg) was collected at SB-3 at six feet bgs. The average concentration of arsenic was 10.8 mg/kg and the sample with the highest detected concentration (21 mg/kg) was collected at SB-3 at 6 feet bgs.

5.3.4 CC-IAAP-001 Groundwater Sampling Results

A total of three ground water samples were collected at Site CC-IAAP-002. The detected concentrations of five metals (arsenic, total chromium and hexavalent chromium) that exceeded their respective PALs at CC-IAAP-001 are shown on Figure 5-6, listed in Table 5-10, and summarized below.

- Arsenic sample concentrations exceeded the PAL at all three locations;
- Arsenic sample concentrations (dissolved) exceeded the PAL at one of the three locations;
- Total chromium sample concentrations exceeded the PAL at two of the three locations; and
- Hexavalent chromium exceeded the PAL at one of the three locations.

The average total arsenic concentration was 6.85 µg/l. The one dissolved arsenic concentration that exceeded the PAL was 1.2 µg/l

5.4 Asbestos Sampling Results

All soil and water samples collected from CC-IAAP-001 and CC-IAAP-002 were analyzed for asbestos. Asbestos was not detected in any of the samples from either site. In addition, a visual inspection of both sites was conducted by an Iowa licensed Asbestos Inspector. The inspection was performed by physically walking the work areas and performing a visual inspection of the surface. The inspection focused on ACM, primarily asbestos-cement panels (transite), and pieces of thermal insulation possibly remaining after building demolitions or disposal. The visual inspection of CC-IAAP-001 identified no suspect ACM in the surface soil or in any of the soil boring cores. The visual inspection of CC-IAAP-002 identified three distinct areas of suspect ACM. Three areas along the creek contained significant quantities of asbestos containing cement panels. Samples were collected of the cement panels and of a very small quantity of a tar like substance (likely a roofing adhesive or sealant). Asbestos (chrysotile) was detected in all four samples. The asbestos sample locations at CC-IAAP-002 are shown in Figure 5-7 and the presented in Table 5-11. No suspect material was visually identified in the soil in any of the soil boring cores at CC-IAAP-002. The asbestos inspection report is included in Appendix B.

The extent of ACM is limited to the roofing material within the debris piles located within CC-IAAP-002. Based on observations made during the RI, there are several areas within the debris piles, where the roofing material has disintegrated due to exposure to the elements.

5.5 Investigation Derived Waste - Sampling Results and Disposition

One representative grab sample was collected for each matrix (soil and water) from the two drums of investigation derived waste collected during the RI activities. The samples were extracted using the Toxicity Characteristic Leaching Procedure (TCLP) and analyzed for metals, PCBs, VOCs, and SVOCs. The detected sample concentrations are listed in Table 5-12. Concentrations of barium, cadmium, lead, and selenium were detected in the sample from the soil drum. Concentrations of metals (arsenic, barium, cadmium, calcium, total chromium, lead, magnesium, sodium, uranium, and selenium), and VOCs (2- butanone, acetone, bromomethane, and chloromethane) were detected in the water sample.

The sample concentrations were compared to the corresponding values listed in 40 Code of Federal Regulations (CFR) §261.24. The comparison concluded that the theoretical maximum concentration in the leachate would not exceed the toxicity value, and hence it was determined that the decontamination soil and water could be disposed as non Resource Conservation and Recovery Act (RCRA) waste. A non-hazardous manifest was prepared and the drums were disposed at the Hazardous Chemicals Center associated with the Des Moines County Landfill on August 23, 2013. The disposal documentation is included in Appendix C.

5.6 Data Validation

The data validation and data quality review was performed by AMEC Environment & Infrastructure, Inc. (AMEC) according to the following guidance documents:

- *Final Work Plan. Remedial Investigation of Construction Debris Sites CC-IAAP-001 and CC-IAAP-002,* Quality Assurance Project Plan (QAPP) (PIKA, 2013),
- *Department of Defense (DoD) Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.0* (DoD, 2013)
- *National Functional Guidelines for Inorganic Superfund Data Review* (EPA, 2010),
- *National Functional Guidelines for Superfund Organic Data Review* (EPA, 2008), and
- The analytical methods referenced by the laboratory. The EPA guidelines were written specifically for the Contract Laboratory Program, and have been modified for the purposes of this data validation where they differ from QAPP and EPA SW-846 quality control (QC) requirements.

All samples (with the exception of the waste profile samples) were validated. The full validation reports are included in Appendix E and summarized below.

CC-IAAP-001

Three SVOC results and one herbicide result were rejected due to matrix spike exceedances. The remainder of the data generated during this sampling event is usable and of acceptable quality, with the addition of the qualifiers presented in Table C1 (Appendix C). A total of 6,335 data records were evaluated during the data validation and review of the sample results. Of the total data records, 723 records (11 %) were J or UJ qualified as estimated concentrations, 20 records (0.3%) were U qualified as not detected, 8 records (0.1%) were N qualified as tentatively identified, and 4 records (0.1%) were R qualified and rejected. 99.9% of the data is considered valid, meeting the Quality Assurance Project Plan (QAPP)-specified minimum completeness goal of 98%.

CC-IAAP-002

Two herbicide results and one SVOC result were rejected due to failed matrix spike recoveries. The remainder of the data generated during this sampling event is usable and of acceptable quality, with the addition of the qualifiers presented in Table C2 (Appendix C). A total of 5,052 data records were evaluated during the data validation and review of the sample results. Of the total data records, 385 records (7.6 %) were J or UJ qualified as estimated concentrations, one record (0.02%) was NJ qualified as tentatively identified, 29 records (0.57%) were U qualified as being not detected, 176 records (3.5%) were X qualified as being not reportable, and 3 records (0.06%) were R qualified and rejected.

Based on the data validation, 99.9% of the data is considered valid, meeting the QAPP-specified minimum completeness goal of 98%.

6.0 CONTAMINANT FATE AND TRANSPORT

This section discusses fate and transport of contaminants detected during the remedial investigations at CC-IAAP-001 and CC-IAAP-002. The detected results are listed in Tables D-1 and D-2 in Appendix D and discussed in Section 5.0. Knowledge about a contaminant's potential to migrate and persist in an environmental medium is important when evaluating the potential for a chemical to elicit an adverse human health or ecological effect. This section contains information on chemical properties and degradation potential of the chemicals detected at CC-IAAP-001 and CC-IAAP-002.

The environmental conditions of the site and hydrological considerations that are likely to affect contaminant fate and transport at each site are also discussed. It is expected that the fate and transport of other contaminants with similar physical and chemical properties would be comparable to the fate and transport processes for the chemicals discussed in the following sections.

Section 6.1 discusses the various chemical and physical properties of these chemicals. Section 6.2 describes the potential for chemical compounds to biodegrade or experience other transformations. Section 6.3 describes transport pathways where migration and attenuation might be occurring and explains how spatial and temporal variations in hydrologic conditions might affect transport. Section 6.4 summarizes contaminant migration in and around CC-IAAP-001 and CC-IAAP-002.

6.1 Chemical and Physical Properties Affecting Mobility

The physical and chemical properties of representative organic chemicals detected at CC-IAAP-001 and CC-IAAP-002 are listed in Table 6-1. Because organic chemicals are considered not to be present in background, this table includes properties for all organic chemicals that exceeded their respective PALs. The solubility of inorganic chemicals is typically a function of the tendency of the chemical to form mineral phases and the relative abundance of the chemical ingredients required to form the mineral phase. Table 6-2 is a simple representation of the gross mobility of metal ions expected under various combinations of oxidation-reduction (redox) potential and pH. These properties can be used to estimate qualitatively the environmental mobility and fate of site contaminants. The following properties are discussed:

- Vapor pressure.
- Water solubility−Henry's Law constant,
- Octanol/water partition coefficient (K_{ow}),
- Organic carbon partition coefficient (K_{oc}),
- Soil-water distribution coefficient (K_d),
- Bioconcentration factor (BCF), and
- Mobility index (MI).

The environmental significance of each of these parameters is discussed in the following subsections. The physical properties and comparison criteria were derived using U.S. Environmental Protection Agency EPI SuiteTM v4.11© (USEPA, 2012a).

6.1.1 Vapor Pressure

Vapor pressure indicates the tendency for chemical volatilization from both solid and aqueous matrices Vapor pressures for volatile organics are generally many times greater than vapor pressures for PAHs, and pesticides. Chemicals with greater vapor pressures are expected to enter the atmosphere much more readily than chemicals with lower vapor pressures.

- Vapor Pressure > 10^{-4} exists mostly in the vapor (gas) phase
- Vapor Pressure = 10^{-5} - 10^{-7} exists in the vapor and particulate phase
- Vapor Pressure < 10^{-8} exists mostly in the solid phase

As shown in Table 6-1, all of the VOCs and some of the pesticides (gamma and beta-BHC) and some SVOCs (acenaphthene, acenaphthylene, and naphthalene) may exist in the gas phase. Pesticides (with the exception of Endrin Aldehyde) were detected at concentrations less than their respective PALs in surface soil at CC-IAAP-001 and CC-IAAP-002. Acenaphthene, acenaphthylene, and naphthalene were detected in sediment at CC-IAAP-002. Volatilization from stream sediments can be significant under low-flow conditions (i.e., during summer months and drought conditions) when the sediments are exposed to the atmosphere in a dry creek bed. However, volatilization of these chemicals is not significant for compounds existing in the particulate and solid phase (i.e., pesticides, PAHs) or for inorganic compounds (i.e., metals).

6.1.2 Water Solubility

Many chemicals of environmental interest are often considered to be insoluble in reference books (i.e., the "Handbook of Chemistry and Physics") because they are insoluble for most practical situations. However, most chemicals are soluble to some extent in water; and even those that are classified as insoluble may be soluble in the parts-per-billion (µg/L) or parts-per-million (mg/L) concentration ranges. General classifications based on water solubility are listed below in parts-per-million (mg/L):

> 10,000 - Very soluble

> 1,000 - 10,000 Soluble

> 100 - 1,000 Moderate solubility

> 0.1 - 100 Slightly soluble

< 0.1 - Negligible solubility

The tendency for a chemical to be leached from soil by infiltrating precipitation is governed by its water solubility. More soluble chemicals are more readily leached than less soluble chemicals. The VOCs listed in Table 6-1 fall into the soluble category. Nine of the 17 PAHs listed in Table 6-1 are slightly soluble and the rest are negligible soluble. Five of the seven pesticides listed in Table 6-1 are slightly soluble and the rest are negligible soluble. Pesticides (with the exception of Endrin Aldehyde) were detected at concentrations less than PALs at CC-IAAP-001 and CC-IAAP-002. PAHs were detected at concentrations greater than their respective PALs at CC-IAAP-001 and CC-IAAP-002. The PAHs are considered slightly soluble and may be susceptible to leaching from sediment. However, no surface water was present during sampling and PAHs were not detected at concentrations greater than their respective PALs at CC-IAAP-002.

6.1.3 Henry's Law Constant

Both vapor pressure and water solubility are useful for determining volatilization rates from surface water bodies and groundwater. The measured ratio of these two parameters (the Henry's Law constant) under equilibrium conditions is used to calculate the equilibrium chemical concentrations in the vapor (air) phase versus the liquid (water) phase for the dilute solutions commonly encountered in environmental settings. In general, chemicals having a Henry's Law constant less than 1 $x10^{-5}$ atmosphere per cubic meter per mole (atm–m^3/mol), such as the PAHs detected at CC-IAAP-002 are expected to volatilize very little and to be present only in minute amounts in the atmosphere or soil vapor. Two chemicals (bromomethane and chloromethane) with Henry's Law constants greater than $1x10^{-3}$ atm–m^3/mol, were detected at CC-IAAP-002. Volatilization and diffusion in soil vapor for these chemicals could be significant. However, these chemicals were not detected at concentrations greater than their respective PALs so volatilization from groundwater to ambient air or soil vapor is not considered likely.

6.1.4 Octanol/Water Partition Coefficient ($_{Kow}$)

K_{ow} is a measure of the equilibrium partitioning of chemicals between octanol and water as determined under laboratory conditions. A linear relationship between the K_{ow} and the uptake of chemicals by fatty tissues of animal and human receptors, or the BCF, has been established (Lyman et al., 1990).

Log K_{ow} indicates how likely a chemical will be absorbed through biological membranes. General trends are given below:

- Liquids with a log K_{ow} of 24 tend to absorb well through the skin.
- Chemicals with a log K_{ow} > 4 tend to not absorb well.
- Chemicals with a log K_{ow} of 5-6 tend to bioconcentrate in the lipid portion of the membrane

The K_{ow} is also useful in characterizing the sorption of compounds by organic soils where experimental values for soil are not available. Pesticides and aromatic compounds found at CC-IAAP-001 and CC-

IAAP-002 including acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, crysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, 4,4-DDE, 4,4-DDE and methoxychlor are likely to partition into fatty tissues than the more water-soluble VOCs. However, only acenaphthene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene were detected at concentrations exceeding their respective PALs at one sediment location at CC-IAAP-002. In addition, all of the detected concentrations were qualified as estimated because they were not detected in the duplicate sample with the exception of acenapthylene and pyrene.

6.1.5 Soil Adsorption Coefficient (K_{oc})

The K_{oc} provides a measure of the ability of a chemical to sorb (adhere) to the organic portion of soil, sediment and sludge under laboratory conditions. Like K_{ow}, K_{oc} is often expressed as a log due to the wide range of measured K_{oc} values. K_{oc} indicates the potential for the chemical to leach through soil and be introduced into ground water and partition between water and the suspended solids and sediment in the water column. Strong adsorption to soil will impact other fate properties.

Several factors affect the measured value of K_{oc}. Values of K_{oc} usually decrease with increasing pH. The fine silt and clay fraction of soil and sediments may have a greater tendency to absorb chemicals because they often have a higher concentration of organic matter and more adsorption sites per unit volume. Some chemicals may form strong chemicals bonds with the humic acid present, decreasing the potential for leaching with ground water.

Low K_{oc} (not tightly bound to soil)

- Leaches into the soil
- Reduces surface level concentration
- Potential contamination of groundwater
- Contamination of surface water with storm runoff

High Koc (tightly bound to soil)

- Removal from water column via sorption to sediment and particulate matter
- May reduce rate of degradation because the chemical is less available to microorganisms

Log K_{oc} Adsorption Classifications

> 4.5 Very strong sorption to soil / sediment, negligible migration to ground water

3.5 - 4.4 Strong sorption to soil / sediment, negligible to slow migration to ground water

2.5 - 3.4 Moderate sorption to soil / sediment, slow migration to ground water

1.5 - 2.4 Low sorption to soil / sediment, moderate migration to ground water

< 1.5 Negligible sorption to soil / sediment, rapid migration to ground water

The VOCs listed in Table 6-1 have relatively low K_{oc} values, and they tend to be fairly mobile in the environment as a result of groundwater or surface water movement. However, VOCs were only sporadically detected at concentrations less than their respective PALs in groundwater and soil samples collected from CC-IAAP-001 and CC-IAAP-002. Chemicals such as PAHs (CC-IAAP-001 and CC-IAAP-002) and pesticides (CC-IAAP-001) are relatively immobile in the soil and are preferentially bound to the soil. However, these immobile chemicals can be transported by erosional processes when they occur in surface soils or sediment.

6.1.6 Soil-Water Distribution Coefficient (K_d)

Soil-water distribution coefficient (K_d) is a measure of the equilibrium distribution of a chemical in soil/water systems. The K_d of organic chemicals is a function of both K_{oc} and the fraction of organic carbon in the soil (f_{oc}):

$K_d = K_{oc} * f_{oc}$

The degree to which organic chemicals sorb to soils is very important when assessing migration potential. If a chemical tends to sorb strongly to soil, there is much less probability that the chemical will reach groundwater and affect the groundwater quality. In sediments, a high degree of sorption similarly indicates that the chemical is more likely to be transported in entrained sediments than as a dissolved species in surface water.

Chemicals, such as PAHs, that migrate slowly through soil and the upper unsaturated rock units are subjected to biodegradation processes for a relatively long time before they reach the first water-bearing rock unit. As a consequence of low migration potential, there is a very low probability that chemicals with very high K_d values (i.e., PAHs) will reach surface water bodies via groundwater flow. However, if PAHs are present at the ground surface, eroded, and transported in surface runoff with soil particles (as a sorbed phase), then there is potential for these compounds to reach adjacent stream channels as in the PAHs detected in sediment at CC-IAAP-002.

6.1.7 Chemical Complex Formation

Metals may form chemical complexes or combinations that alter their mobility. Some of the most important environmental chemicals that form metal complexes are humic substances. These complex mixtures of organic acids and other organic matter are formed naturally in shallow surface soils, pond and, lake bottoms, through the decay of vegetable matter. These substances, after binding with a metal, can increase its mobility by dissolving into an aqueous phase. If the humic substances are adsorbed to a solid substrate, such as soil, sediment, or vegetation, they will tend to remove metal ions from solution by binding to the metals and fixing them to the solid substrate. The binding equilibria are affected by pH. At low pH, the bound metals are released; and at high pH, the metals are preferentially bound. Fulvic acid is a component of humic substances. The pH at which fulvic acid complexes begin to release relatively large proportions of bound metals has been shown to be less than 5 (Dragun, 1988). The soil pH at CC-IAAP-001 and CC-IAAP-002 ranged from 5.1 to 8.8. Thus, most metals are expected to be preferentially bound to the humic substances at these sites.

6.1.8 Bioconcentration Factor

The BCF provides an indication of the potential for a chemical to bioconcentrate in lipids (fatty tissue) of organisms and is used as a surrogate for bioaccumulation in higher trophic levels of the food web. Many PAHs will bioconcentrate at levels three to five orders of magnitude greater than those concentrations found in the water, but VOCs are not as readily bioconcentrated. Chemicals with a high BCF are less water soluble and are expected to bioconcentrate in aquatic organisms. Conversely, low BCF indicates higher water solubility.

BCF	**Log BCF**	**Classifications**
> 5000	≥ 3.7	High bioconcentration potential
1000 - 5000	3	Moderate bioconcentration potential
< 1000	< 3	Low bioconcentration potential

Chemicals with high bioconcentration potential (Table 6-1) include the SVOCs found at CC-IAAP 001 and CC-IAAP-002 (benzo(a)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene); and the pesticides detected at CC-IAAP-002 (4,4-DDE, and 4,4-DDT). Any bioconcentration that occurs generally requires that the chemical of interest be in the dissolved state; otherwise, the chemical is inaccessible to the organism. For plants, this means that the chemical must be dissolved in the surrounding soil. For other organisms that can inhale, aspirate, or ingest solid particles, the chemical may be bound to the particles and released after ingestion.

6.1.9 Mobility Index

The MI is a quantitative assessment of mobility that uses water solubility (S), vapor pressure (VP), and the K_{oc} (McCall, Swann, and Laskowski, 1983). It is defined as:

$$MI = \log((S*VP)/K_{oc})$$

A scale to evaluate MI, as presented by Ford and Gurba (1984), is:

Relative MI	**Mobility Description**
> 5	extremely mobile

0 to 5	very mobile
-5 to 0	slightly mobile
-10 to -5	immobile
< -10	very immobile

The VOCs have MIs greater than 5 and are considered extremely mobile such as the bromomethane and chloromethane detected at CC-IAAP-002. Lighter molecular weight PAHs, such as naphthalene (CC-IAAP-002), have MIs ranging from -5 to 0 and are considered slightly mobile. Heavier molecular weight PAHs [i.e., benzo(a)pyrene] detected at both sites are classified as very immobile, having MIs less than -10.

6.2 Chemical Persistence and Degradation Processes

Degradation and other transformation processes that affect site contaminants are discussed in this section. Degradation leads to the following possibilities, depending on the contaminant of interest and the contaminant's environment:

- Transfer of the chemically unaltered contaminant from one environmental medium to another (physical changes may occur, i.e., transfer of dissolved contaminant to vapor);
- Transformation of the original contaminant into a less toxic chemical;
- Transformation of the original contaminant into a more toxic or otherwise problematic chemical; and
- Transfer of a chemically or biochemically transformed contaminant from one environmental medium to another.

All of these transformations may occur individually or together, and more than one of these processes may occur for any single chemical. Consequently, the number and complexity of possibilities is partly a function of the number of contaminants and partly a function of which contaminants are present.

Degradative processes are unlikely to substantially influence the concentrations of the majority of the contaminants identified in soils at the Sites. The pesticides, VOCs, and SVOCs have some potential to degrade in response to abiotic and/or biotic processes; however, the effects of degradation on the fate of these compounds are unlikely to be significant over the near-term. None of the metals at either site will be influenced by degradation processes.

The fate and transport of contaminants detected at concentrations greater than their respective PALs and background concentrations are described in the following subsections. The chemicals are discussed in groups that are indicated by their analytical fractions (i.e., VOCs, pesticides, PAHs, and metals) because these fractions generally represent chemicals with similar properties. Only those processes that are most applicable to the indicated fractions are described. No attempt was made to model the fate and transport of the chemicals mathematically because the levels of contaminants are generally low and migration will tend to reduce the concentrations further through dispersion, dilution, and other transport mechanisms.

6.2.1 Volatile Organic Chemicals

One VOC (2-butanone) was detected in groundwater at CC-IAAP-001 and three VOCs (bromomethane, chloromethane, and 2-hexanone) were detected in groundwater at CC-IAAP-002. These VOCs are very soluble and mobile; However, the total mass of these VOCs is low (all concentrations were less than or equal to 1.5 µg/L) and all concentrations were less than their respective PALs. Therefore, VOCs are not a significant site-related contaminant.

6.2.2 Semi-volatile Organic Chemicals

SVOCs, most of which are PAHs, were detected in soil, sediment, and ground water at CC-IAAP-001 and CC-IAAP-002. The detected SVOCs are listed in Appendix D, Tables D1 and D2. With the exception of downstream sediment sample at CC-IAAP-002, all detected concentrations of SVOCs were less than their respective PALs.

PAHs, as a group, are much more likely to bind to soil and be transported via erosion and surface water runoff than to be solubilized. PAHs are subject to slow degradation via aerobic bacterial metabolism, but may be relatively persistent in the absence of microbial populations or macronutrients such as phosphorus and nitrogen.

Land spreading applications have indicated that PAHs are highly amenable to microbial degradation in soil. This would presumably apply to sediments as well. The rates of degradation in these media are influenced by temperature, pH, oxygen concentrations, initial chemical concentrations, and moisture. Photolysis, hydrolysis, and oxidation are not important fate processes for the degradation of PAHs in soil (Agency for Toxic Substances and Disease Registry [ATSDR], 1997).

6.2.3 Metals

Metals that exceeded their respective PALs and background concentrations at CC-IAAP-001 and CC-IAAP-002 include arsenic, barium, cadmium, total chromium, hexavalent chromium, lead, and selenium. Metals are highly persistent environmental contaminants because they do not biodegrade. However, their valence states can readily change based on pH and Eh conditions, biotic uptake and assimilation into living organisms, and decay and decomposition of dead plant matter. The major fate mechanisms for metals are adsorption to the soil matrix or precipitation as a mineral coating, uptake and bioaccumulation in plants, or transport through the hydrologic system. Table 6-2 presents a qualitative characterization of select metal mobility in the environment as a function of ambient conditions.

Metals commonly form carbonates, silicates, oxides, and hydroxides after they have been released to the environment and interact with carbon dioxide, oxygen, and water in their surroundings. The carbonate, oxide, and hydroxide equilibria, which dictate whether one species predominates over another, are sensitive to the surrounding pH and oxidation-reduction (redox) potentials. At high pH values, oxides and hydroxides form readily. At pH values less than about 4, these species are essentially non-existent, except under highly oxidizing conditions. The soil pH at CC-IAAP-001 and CC-IAAP-002 ranged from 5.1 to 8.8. Thus, most metals are not expected to readily form oxides and hydroxides.

The important environmental chemistry characteristics and information concerning metals detected at CC-IAAP-001 and CC-IAAP-002 are described briefly below. These factors affect the mobility and, hence, the fate of metals in the environment.

Arsenic is naturally occurring, commonly classified as a metalloid because it has properties that are transitional between metallic and non-metallic chemical elements. In water, inorganic arsenic occurs primarily in the (+5) valence state when conditions are oxidizing, such as in surface water. Under reducing conditions, such as may be found in groundwater, the inorganic form of arsenic is predominantly in the (+3) valence state. In acidic or neutral waters, arsenic (+5) is extensively adsorbed, but arsenic (+3) is not. The mobility of arsenic is low to moderate in clay (as identified at both CC-IAAP-001 and CC-IAAP-002). Arsenic (+5) is adsorbed most strongly at pH 5 in clay minerals. As pH increases, more arsenic (+3) is adsorbed. Arsenic adsorbs strongly to sediments. If conditions change sufficiently from oxidizing to reducing, arsenic may be released from sediments.

Barium is commonly found in nature as sulfate (Emsley, 2001). It forms hydroxides, carbonates, and sulfates in soils. Barium carbonates and sulfates are relatively insoluble. By contrast, barium hydroxides, and especially nitrates and chlorides of barium, are quite soluble (Lang, 1985). Thus, over time, barium is expected to precipitate out of solution as it migrates to areas containing high carbonate or sulfate concentrations and high concentrations of other anions that form barium precipitates. In the absence of these anions, barium is likely to be moderately mobile. Barium is generally classified as a metal of low mobility (see Table 6-2).

Cadmium is expected to be moderately mobile in soil because it is present under most naturally occurring redox and pH conditions as the (+2) ion. If it is combined with anions such as sulfide, it can be very immobile. At pH values greater than about 8, cadmium tends to form insoluble hydroxides. These conditions are not expected at either site. Therefore, the cadmium mobility is expected to be moderate.

Chromium exists primarily as two oxidation states – chromium (+3) and chromium (+6). Chromium (+6) is very mobile in the environment under oxidizing conditions, but chromium (+3) is less mobile except at pH values less than about 4. The trivalent metal predominates under most conditions, except those that are low pH (i.e., less than 4) and high oxidation potential (i.e., greater than 0.4). This element forms insoluble hydroxides under low to moderately reducing conditions. Under highly oxidizing conditions, it forms the soluble chromate ion at pH values greater than about 6 and the bichromate ion at lower pH values (Dragun, 1988). Chromium is mobile in ground and surface water under oxidizing conditions and can move in sediments when adsorbed to sediment grains.

Lead is a very immobile element in the environment. This metal has a relatively high soil-water distribution coefficient, ranging from 4.5 to 7,640 ml/g (Dragun, 1988). This indicates that it preferentially binds to soils rather than dissolving in water. When adsorbed to sediments this metal will be transported with the sediment as a bound species. This metal appears in the divalent (+2) state under most pH and redox conditions. At high pH values (i.e., greater than 8), it readily forms hydroxides and oxides. The concentrations of this metal were less than human health screening levels in soil, sediment and groundwater.

The chemistry of selenium is similar to arsenic. This bioaccumulative essential nutrient is a metalloid, thus exhibiting properties similar to both metals and non-metals. Methyl and dimethyl selenide gases have been determined to be produced by anaerobic soils and sediments. Selenium is also taken up and concentrated by some plants that, in turn, may be ingested with ill effect by herbivorous or omnivorous animal species (Emsley, 2001). Selenium, however, is essential for life and participates in an endless cycle of transfer from soil and water to the atmosphere and back to soil and water.

In summary Metals the metals that exceeded their respective PALs and background concentrations at CC-IAAP-001 and CC-IAAP-002 are highly persistent environmental contaminants because they do not biodegrade. The soil pH at CC-IAAP-001 and CC-IAAP-002 ranged from 5.1 to 8.8. Thus, highly reducing and highly oxidizing conditions are not present. The mobility of the metals found in soil at CC-IAAP-001 and CC-IAAP-002 is considered low to moderate.

6.3 Contaminant Transport Pathways

A contaminant transport pathway represents the physical path or the mechanism by which a contaminant moves or may move from one location (i.e., the source area) to another. A transport pathway may also involve a phase change for the contaminant (i.e., a contaminant is absorbed to soil, volatilizes to soil gas in the vadose zone, and then migrates into a basement as a gas). In addition, contaminant transport pathways provide mechanisms and conduits for contaminants to migrate to a new location where they may contribute to a human health or ecological risk. The determination of whether a pathway is currently causing a risk or could potentially cause a future risk depends on the combination of chemical characteristics, the existence of a potential pathway, the physical site conditions, and the potential for exposure to occur now or in the future.

This section presents a brief summary of contaminant fate and transport pathways that exist at both sites. Based on the evaluation of existing conditions, the following potential contaminant transport pathways may exist:

- Leaching of soil contaminants to groundwater;
- Migration of groundwater contaminants within the soil and bedrock strata;
- Erosion and runoff of contaminated particles from soil and deposition in surface water bodies;
- Leaching of contaminants from creek sediment to surface water;
- Migration of contaminants in surface water as dissolved or sorbed phases during storm events; and
- Volatilization from soil, groundwater, or surface water.

6.3.1 Leaching of Soil Contaminants to Groundwater

Contaminants that adhere to soil particles or have accumulated in soil pore spaces at both sites can leach and migrate vertically to the groundwater as a result of infiltration of precipitation. The rate and extent of this leaching is influenced by the amount of precipitation, rate of infiltration, the physical and chemical properties of the soil, the physical and chemical properties of the contaminant, and the depth of the water table.

Concentration of arsenic in soil and sediment at the two Sites ranged from 2.8 mg/kg to 21 mg/kg and the average sample concentration was 9.49 mg/kg. These concentrations are within the range of concentrations reported in the background study (0.5 to 30 mg/kg) and the calculated background concentration is 7.33 mg/kg. This may indicate that the arsenic is not a site contaminant or, if it is, that the total mass of arsenic contamination is not much greater than what is present naturally. However, arsenic is retained and considered a site-related contaminant until these uncertainties are evaluated in Section 7.0. Concentrations of other metals also were within the range of concentrations reported in the background study.

- Sample concentrations of barium ranged from 45 mg/kg to 390 mg/kg. The average sample concentration of barium was 149 mg/kg. The minimum and maximum concentrations reported in the background study were 39 to 649 mg/kg. The calculated background concentration is 201 mg/kg.
- Sample concentrations of cadmium ranged from 0.078 mg/kg to 1.36 mg/kg. The average sample concentration is 0.32 mg/kg. The minimum and maximum concentrations reported in the background study were 0.7 to 1.49 mg/kg. The calculated background concentration is 0.73 mg/kg.
- Sample concentrations of total chromium ranged from 12 mg/kg to 39 mg/kg. The average sample concentration is 14.2 mg/kg. The minimum and maximum concentrations reported in the

background study were 7.71 to 74.2 mg/kg. The calculated background concentration is 19.3 mg/kg.

- Sample concentrations of lead ranged from 6.2 mg/kg to 150 mg/kg. The average sample concentration is 20.8 mg/kg. The minimum and maximum concentrations reported in the background study were 6.8 to 53 mg/kg. The calculated background concentration is 17.7 mg/kg.
- The lead concentrations in the sediment sample (91 mg/kg) and duplicate (150 mg/kg) collected at CC-IAAP-002 ST01 exceeded the maximum concentration of 53 mg/kg reported in the background sample.
- Concentrations of selenium ranged from 1.7 mg/kg to 4.3 mg/kg, exceeding the maximum concentration reported in the background study (1.65 mg/kg). Selenium is considered a site-related contaminant and evaluated in Section 7.0.

The rates of metal leaching from soils to groundwater will not increase unless geochemical conditions, such as pH or oxidation-reduction potentials, are changed. This is an unlikely event because it involves changes to soils and bedrock that would require massive influxes of chemical before a meaningful change would occur. If it were to occur, the reservoir of metals in the native minerals would vastly outweigh the amount of site-related contamination.

Aside from geochemical conditions such as pH and oxidation-reduction potentials, a major factor affecting metal leaching rates is the length of time that the source material is present. Metals are generally most mobile in soil soon after they are released. Immobilization of metals, by mechanisms of adsorption and precipitation, will prevent movement of the metals to groundwater. Based on geotechnical data from soil and sediment samples collected at both sites, the pH of soils ranged from 5.3 to 8.2. The pH buffering capacity near neutral to slightly acidic pH values tends to limit the ability of most metals to migrate rapidly because the metals tend to precipitate as solids or to bind tightly to soil particles through cation exchange. Inorganic compounds are commonly bound to soil particles as a result of electrostatic interactions. The mineral hydrous ferric oxide ($Fe_2H_2O_4$) is a dominant sorbent for many inorganic compounds in natural systems, owing to its common presence on soil particle surfaces, high surface area, and amphoteric character.

The dates the debris was deposited at CC-IAAP-001 and CC-IAAP-002 are not known. However, visual observations including brush and trees (four to six inches in diameter and larger) growing through the middle of the debris piles and the lack of any visible access roads, indicate the debris has been present for more than 10 years. This means meaning that no new contaminants have been generated and the previously released contaminants have had some time to bind to the mineral matrix. Thus, leaching rates cannot be any greater than at the current time unless geochemical conditions change.

A second factor affecting the soil-to-groundwater migration is the relatively low concentrations of metal contaminants in soil compared to installation background concentrations. Using arsenic as the example, the range of site concentrations are only slightly less than the range of installation background concentrations for arsenic. The maximum arsenic concentration in any site soil sample was 21 mg/kg. This is less than the maximum installation background concentration 30 mg/kg.

A third factor affecting the soil-to-groundwater migration is the arsenic spatial distribution. Because the boundaries of CC-IAAP-001 and CC-IAAP-002 are very small in size (1.34 and 0.625 acres, respectively), and the possible source material is scattered metal debris, the reservoir of contamination that could be transferred to groundwater is limited. In addition, when the vertical profile of arsenic concentrations in soil is considered, arsenic concentrations appear to be randomly distributed with depth over the entire observed concentration range.

The fourth factor affecting the soil-to-groundwater migration is the observed groundwater metal concentrations in comparison to soil concentrations and other well concentrations. The well with the greatest arsenic concentration at CC-IAAP-001 (21 µg/L) was GW-1. This well is located upgradient of the debris field, and several hundred feet away from, the most contaminated soil sampling location, SB-1.

Visual observations, including brush and trees (four to six inches in diameter) growing through the debris piles; and the accumulation of soil plant material within the piles indicate the debris has been present for more than 20 years. The age of the debris and the lack of wide-spread source materials for metals contamination in either soils or groundwater suggest that the CC-IAAP-001 and CC-IAAP-002 soils are in likely in steady-state condition whereby the rate of leaching of metals into the groundwater will not increase over time. Although the factors discussed above affecting the soil-to-groundwater migration are focused on arsenic, similar arguments can be made for other metals whose concentrations that exceeded soil screening levels.

As indicated in Section 6.2.3, many metals detected in site soils were not selected as COPCs in groundwater. This is additional evidence that the soil-to-groundwater leaching pathway is of limited concern. Furthermore, immobilization of metals, by mechanisms of adsorption and precipitation, will prevent movement of the metals to groundwater. Because the metal COPC concentrations are not currently much greater than the range of installation background concentrations, it would be difficult or impossible to measure any such rates of decrease.

All analyzed metals were detected in at least one groundwater sample. Essential human nutrients (magnesium, potassium, calcium, and sodium) are considered toxic only at very high doses and do not have screening levels referenced in this report. These nutrients were eliminated from consideration as COPCs.

Organic chemicals including VOCs, pesticides, and PAHs were detected in soil at both sites, but were not detected in groundwater with the following exceptions. Concentrations of 2-butanone, 2-hexanone, bromomethane, fluoranthene, fluorene, phenanthrene, and pyrene were detected in groundwater samples. However, none of these chemicals were detected at concentrations greater than their respective PALs. This indicates the levels of these chemicals detected in soil do not present enough total mass to yield detectable groundwater concentrations after dilution, dispersion, and other natural mechanisms reduce their concentrations.

6.3.2 Migration of Groundwater Contaminants

Organic groundwater contaminants will alternately adsorb to and desorb from organic matter in the soil and bedrock at the molecular level as they migrate with groundwater toward the south of CC-IAAP-001 and the northeast of CC-IAAP-002 towards Brush Creek. The relative migration rates will depend on individual contaminant adsorption characteristics and rates of degradation that may occur, as described in Sections 6.1 and 6.2.

The reservoir of organic contamination in soil that could feed groundwater is small, based on soil concentrations reported in Appendix D, Tables D-1 and D-2. Therefore, the level of importance of groundwater migration is expected to be minor. This is borne out by the low frequencies of organic contaminant detections for groundwater.

Volatilization of VOCs, or precipitation of metals as a mineral phase, may physically transform contaminants. Contaminants may be chemically transformed through hydrolysis, oxidation/reduction, or biodegradation. Besides biodegradation, dilution from surface recharge is also a factor that causes the concentrations of contaminants to decrease in the downgradient directions.

Metals in groundwater will follow groundwater flow patterns just as the organic contaminants do. The metals may migrate in soluble form or as ions or non-ionized organometallic complexes bound to colloidal particles. Migration of soluble metals would be retarded by ion exchange with bedrock, and the rate of colloidal flow through the bedrock would depend on particle size with smaller particles moving more quickly than larger particles. In general, highly charged (+3 or greater) metals and complexes will be retarded to the greatest degree and weakly charged species (+1) will be the most mobile. Lead, (Pb), is a notable exception. This metal binds tightly to soil as the Pb+2 ion and is essentially immobile despite its moderate charge of “+2”. This ion also binds tightly to sediments but is mobile when the sediments, themselves, migrate.

As explained in Section 6.3.1, the amount of metals leaching into groundwater is limited, hence, the migration of metals in groundwater will remain steady or decrease over time relative to the current concentrations.

6.3.3 Migration of Contaminants from Surface Soil to Surface Water

Rainfall, snowmelt, and surface water runoff that come into direct contact with surface soils can leach contaminants from the soils and transport them to drainage channels via runoff during storm events. Soil particles containing sorbed contaminants can also be dislodged from the soil surface and physically transported to the creek via overland runoff.

Few organic chemicals (anthracene, fluoranthene, fluorene, and phenanthrene) were detected in surface water at CC-IAAP-001 and all detections were less than their respective PALs. No surface water was present at CC-IAAP-002. These few detections at low concentrations indicate that surface runoff is not a significant migration pathway.

6.3.4 Leaching of Contaminants from Creek Sediment to Surface Water

Precipitation is the source of water in the CC-IAAP-001 and CC-IAAP-002 drainage channels. PAHs, pesticides, and metals were detected in sediment samples from both sites. Thirteen SVOCs (acenaphthene, acenaphthylene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene) and five metals (arsenic, barium, total chromium, lead, and selenium) were detected at concentrations greater than their respective PALs and or background concentrations in sediment. However, the opportunity for transfer from drainage channel sediments to surface water is limited by the frequency of precipitation.

As discussed in the previous sections, PAHs, as a group, are much more likely to bind to soil and be transported via erosion and surface water runoff than to be solubilized. This may be a significant transport pathway. However, given, the small size of each site and the limited amount of actual sediment present, the amount of contaminants available for transport is limited.

6.3.5 Migration of Contaminants as Dissolved or Sorbed Phases in Surface Water Run-off

Once contaminants are dislodged from surface soil particles, some of which then become dissolved, they may flow with surface water and entrained sediments to downgradient areas. The masses and concentrations of organic and inorganic contamination available in surface soils and sediments are limited. Therefore, while the drainage channels represent potential migration pathways, it does not appear that these migration pathways are significant.

6.3.6 Volatilization from Soil, Groundwater, or Surface Water

The only VOCs detected in soil were 2-butanone, acetone, and methylene chloride. None of the detected concentrations of these VOCs exceeded their respective PALs. Other detected compounds in soil were metals, pesticides and SVOCs or other relatively non-volatile chemicals as discussed in Section 6.1.2; therefore, volatilization from soil is an insignificant transport pathway. A similar situation exists for the other media; therefore, volatilization from any of these media is considered to be insignificant. This is further supported by the small reservoir of contamination present in any of the investigated media. When small masses of contaminants are coupled with slow rates of release, the migration pathway of interest is insignificant.

6.4 Conceptual Site Model

The conceptual site model (CSM) is a description of known site conditions. It explains how contaminants were or could have been deposited, how these contaminants can or do move in the environment, and the impact they may have on receptors. The focus of this section is on the physical model. Effects and potential effects on environmental organisms, including humans, are discussed in the risk assessment sections.

CC-IAAP-001 was used to discard construction and demolition debris. Debris is visible in several eroded areas along the steep embankment adjacent to Road H. Surface debris also exists along the drainage located at the base of the embankment along Road H. Visible debris includes scattered bricks, corrugated metal, metal parts, wire, and metal banding.

CC-IAAP-002 was used to discard construction and demolition materials including sheets of metal, bricks, corrugated transite roofing/siding, wire, buckets, and wood. The debris appears to have been placed along the banks of an intermittent, unnamed drainage which discharges to Brush Creek. The end of the debris lies approximately 100-200 feet from the confluence with Brush Creek.

There were analytical detections of metals, VOCs, SVOCs, pesticides, and one explosive compound at CC-IAAP-001. However, only seven metals (arsenic, barium, cadmium, total chromium, hexavalent chromium, lead, and selenium) and one pesticide (endrin aldehyde) exceeded their respective PALs or background concentrations.

- o In soils, metals, VOCs, pesticides, SVOCs, and one explosive compound 1,3,5-Trinitroperhydro-1,3,5-triazine (RDX) were detected. The metals and SVOCs were detected throughout the site including the periphery areas. Pesticide detections were associated with surface soils and the VOCs are randomly distributed and likely due to external contamination. Only metals (arsenic, barium, cadmium, total chromium, lead, and selenium) and one pesticide (endrin aldehyde) exceeded their respective PALs or background concentrations.
- o Metals, and SVOCs were detected all three sediment samples and one pesticide (endosulfan sulfate) was detected in the sample from location ST-01. The distribution is similar to the distribution in soil: metals and SVOCs were spread throughout the site and

the pesticide detection was surficial. Only metals (arsenic, barium, total chromium, and selenium) exceeded their respective PALs or background concentrations.

- o In surface water sampling locations metals and SVOCs were detected at all three locations. Only metals (arsenic, barium, hexavalent chromium, and selenium) exceeded their respective PALs or background concentrations.

  In groundwater, metals were detected in all three wells. SVOCs (fluorene and fluoranthene) and one VOC (2-butanone) were detected in GW-1. Only metals (arsenic, total chromium, hexavalent chromium, and lead) exceeded their respective PALs.

- There were analytical detections of metals, SVOCs, and VOCs at CC-IAAP-002. Seven metals (arsenic, barium, cadmium, total chromium, hexavalent chromium, lead, and selenium) and thirteen SVOCs (acenaphthene, acenaphthylene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene) exceeded their respective PALs or background concentrations.
  - o In soils, metals, VOCs, and SVOCs were detected. The metals and SVOCs were detected throughout the site including the periphery areas. One VOC (acetone) was detected at SB-04 and is likely due to external contamination. Only metals (arsenic, barium, total chromium, lead, and selenium) exceeded their respective PALs or background concentrations.
  - o Metals, and SVOCs were detected all three sediment samples and two pesticides (beta-BHC and endosulfan sulfate) was detected in the samples from locations ST-01 and ST-03, respectively. Five metals (arsenic, barium, total chromium, lead, and selenium) and thirteen SVOCs (acenaphthene, acenaphthylene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene) exceeded their respective PALs exceeded their respective or background concentrations.
  - o In groundwater, metals were detected in all three wells. Phenanthrene was detected in GW-1 and GW-2 and pyrene was detected in GW-3. VOCs (2-hexanone and bromomethane) were detected in GW-1. Only metals (arsenic, total chromium, and hexavalent chromium) exceeded their respective PALs or background concentrations.

The concentrations of metals in surface and subsurface soils at both sites are within the range of the background samples collected across the installation, with the exception of selenium discussed in Section 6.3.1. The average concentration of selenium detected in soils at CC-IAAP-001 and CC-IAAP-002 is 2.75 mg/kg. The lowest detected concentration is 1.5 mg/kg and the highest detected concentration was 4.5 mg/kg. These numbers show that there was very little variation in selenium concentrations across the site.

Metals do not degrade in the environment, but they can be assimilated into minerals. Their oxidation states can change over time as they migrate from one location to another. Metals in general, however, are relatively immobile, except for those with predominantly single positive charges such as sodium and potassium. A few other metals, such as calcium and magnesium, are also relatively mobile. These four metals, however, generally pose little to no environmental risks to receptors. Receptor exposure and risk are treated more completely in Section 7.0.

The primary contaminant migration pathways for contaminants at CC-IAAP-001 and CC-IAAP-002 are:

- Leaching from soils to groundwater,
- Leaching from sediments to surface water, and
- Transport in surface drainage channels.

As described in Section 6.3.1, the age of the debris and the lack of wide-spread source materials for metals contamination in either soils or groundwater suggest that the CC-IAAP-001 and CC-IAAP-002 soils are in likely in steady-state condition whereby the rate of leaching of metals into the groundwater will not increase over time. Organic chemicals including VOCs, pesticides, and PAHs were detected in soil, but were not detected in groundwater with a few exceptions. This indicates the levels of these chemicals detected in soil do not present enough total mass to yield detectable groundwater concentrations after dilution, dispersion, and other natural mechanisms reduce their concentrations.

PAHs, and metals were detected in sediment samples from both sites at concentrations greater than their respective PALs and or background concentrations. As discussed in the previous sections, PAHs, as a group, are much more likely to bind to soil and be transported via erosion and surface water runoff than to be solubilized to surface water. This may be a significant transport pathway. Given, the small size of each site and the limited amount of actual sediment present, the amount of contaminants available for transport is limited. Therefore, while the drainage channels represent potential migration pathways, it does not appear that these migration pathways are significant.

In summary, the small reservoir of contamination in soil provides little total contaminant mass for migration to groundwater or other media. The metals will persist and the organics will degrade over time, albeit some of them (i.e., PAHs) will do so slowly. Given the low concentrations observed at this site, modeling to estimate the degradation rates was not conducted. The concentrations of the metals listed above were generally within the range of the concentrations of the background samples collected from other areas of the facility, and the total volume of any contaminated soil is so small that impacts on groundwater may not be measurable, either through a modeling exercise or through actual groundwater monitoring.

7.0 RISK ASSESSMENTS

This section of the RI Report presents the Baseline Human Health Risk Assessments (BHHRAs) and Screening Level Ecological Risk Assessments (SLERAs) prepared for the two Sites (CC-IAAP-001 and CC-IAAP-002). These BHHRAs and SLERAs were prepared in accordance with the Final RI Work Plan (PIKA, 2013).

The objective of the BHHRAs is to quantify the human health risks associated with potential exposures to site-related constituents under current and reasonably foreseeable future land use conditions, in the absence of any remedial actions.

The BHHRAs are completed using a four-step process, consistent with the framework for risk assessment described in Risk Assessment Guidance for Superfund (*RAGS)* (USEPA, 1989). The four steps include Data Evaluation, Exposure Assessment, Toxicity Assessment, and Risk Characterization. Also included is an uncertainty analysis which provides an evaluation of the variables and assumptions used in the BHHRAs that could have a substantial bearing on the results of the risk assessment. Supporting documentation of the risk assessment methods, inputs, and results are provided in tables, figures, and appendices to this document.

These BHHRAs for CC-IAAP-001 and CC-IAAP-002 have been completed in accordance with the Final RI Work Plan (PIKA, 2013), and the USEPA CERCLA guidance for risk assessment. In accordance with the Final RI Work Plan (PIKA, 2013), Iowa-specific screening and/or toxicity values were incorporated into the BHHRA when they were more conservative than USEPA values.

The objective of the SLERAs is to assess the potential for Site-related chemicals of potential ecological concern (COPECs) in environmental media to adversely affect ecological receptors.

The Superfund Guidance "*Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments"* (USEPA, 1997), herein referred to as the Process Document, provides the framework for these SLERAs. The Process Document outlines an iterative eight-step approach to ecological risk assessment. The eight-step approach consists of two tiers. The first tier is a SLERA which includes Step 1 (the Screening Level Problem Formulation) and Step 2 (the Screening Level Exposure Estimate and Risk Calculation). The second tier is a BERA that, if needed, evaluates COPECs in greater detail and in the context of site-specific factors.

In accordance with the Process Document, these SLERAs:

- Characterize site conditions;
- Summarize site data;
- Present the ecological conceptual site model;
- Identify complete exposure pathways;
- Select COPECs by comparing conservative exposure estimates to ecological screening

benchmarks; and
- Characterize risk to ecological receptors from COPECs in environmental media.

Potential conclusions of these SLERAs fall into three broad categories:

- Risk to ecological receptors is negligible therefore no further study is required;
- The information is not adequate to make a decision, but the ecological risk assessment process will continue (*i.e*. additional information will be collected and evaluated); or
- The risk of adverse ecological effects could not be ruled out and further action is warranted, either in the form of additional ecological risk assessment (*i.e.* a BERA) or remediation.

The following four sections present the BHHRAs and SLERAs for Construction Debris Sites CC-IAAP-001 and CC-IAAP-002.

7.1 CC-IAAP-001 BHHRA

A CSM for CC-IAAP-001 has been developed to form the basis of the assumptions used in this BHHRA. The physical CSM for the Site (sources, migration pathways, receiving media) is described in detail in Section 6.4 of this RI Report. Based on this CSM, current and future land use, applicable receptors, exposure pathways, exposure media and relevant exposure points were identified. These are described in Section 7.1.3 Exposure Assessment.

7.1.2 Data Collection and Evaluation

This section identifies the data available for use in BHHRA and documents the selection or exclusion of particular data for use in the risk assessment, provides the rationale for the way data will be grouped for evaluation in the risk assessment, and documents the methods used to summarize data using statistical descriptors. The data evaluation section also provides the methods used to select COPCs and documents the COPC selection results.

Section 7.1.2.1 is a summary of data collected and identification of sampling locations for the CC-IAAP-001. Section 7.1.2.2 is a general discussion of data evaluation methods. Section 7.1.2.3 documents the CC-IAAP-001 data evaluation and selection of COPCs. **Appendix F-1** presents the list of samples included in the BHHRA by media. Laboratory analytical data used in the BHHRA are presented in Tables D-1 and D-2.

7.1.2.1 Data Collection Summary

The analytical data that were considered for use in the BHHRA were collected by PIKA in June 2013 and include the following:

- Seven surface soil samples (soil samples collected from between 0 and 1 foot below ground surface (ft bgs)).

- Fifteen subsurface soil samples (soil samples collected from between 1 and 10 ft bgs).
- Three groundwater samples collected from on-Site locations.
- Four sediment samples collected from between 0 and 0.5 ft bgs.
- Three surface water samples.

All samples for all media were submitted for the following analyses: metals, pesticides, PCBs, herbicides, VOCs, SVOCs, PAHs, explosives, and asbestos. Additionally soil and sediment were submitted for analysis of pH and total organic carbon (TOC) (sediment only). Groundwater and surface water were submitted for analysis for sulfate, chloride, alkalinity, sulfide, dissolved organic carbon (DOC), and TOC. Figure 2-3 shows the 2013 sampling locations. **Appendix F-1** presents the list of samples included in the BHHRA by media. Laboratory analytical data used in the BHHRA are presented in Tables D-1 and D-2.

7.1.2.2 Data Evaluation

The laboratory analytical data were validated as described in Section 5.4. All validated results were considered representative of Site conditions and appropriate for use in the BHHRA.

7.1.2.3 Selection of COPCs

The BHHRA dataset derived through the data evaluation process described above was utilized to select COPCs for each medium (surface soil (soils 0 to 1 ft bgs), surface and subsurface soil (soils 0 to 10 ft bgs), groundwater, sediment, and surface water). **Appendix F-2 Risk Tables 2.1** through **2.5** are 'RAGS Part D Table 2's' (USEPA, 1989) that provide summaries of the laboratory analytical data for the Site media and document the selection of COPCs.

Appendix F-2 Risk Tables 2.1 through **2.5** utilize the following descriptors to summarize the data sets:

- Range of detected concentrations (maximum and minimum)
- Data qualifier associated with each minimum and maximum detected concentration
- Sample location associated with each maximum detected concentration
- Detection frequency (number of positively detected results/total number of results)
- Range of reporting limits (RLs) for non-detects

Figure 2-3 shows the locations of samples used in the BHHRA.

COPCs are chemicals that may pose more than a de minimis health risk. A concentration-toxicity screening is used to reduce the number of chemicals evaluated in the risk assessment to only those that would potentially pose more than a de minimis health risk (USEPA, 1989). The procedure used to select COPCs for the BHHRA is summarized as follows, and is consistent with USEPA methodology:

- An analyte was selected as a COPC in surface soil, surface and subsurface soil, and sediment if the maximum detected concentration is greater than the lower of the USEPA Regional Screening Levels (RSL) (adjusted to a Hazard Quotient (HQ) of 0.1) for Industrial Use soils (USEPA, 2013a) and the Iowa Statewide Standards for Soil (IDNR, 2013a).

- An analyte was selected as a COPC in groundwater and surface water if the maximum detected concentration is greater than the lower of the USEPA Tapwater RSLs (adjusted to an HQ of 0.1), the Federal Maximum Contaminant Levels (MCLs), or the Iowa Statewide Standards for a Protected Groundwater Source (IDNR, 2013a). Both total and dissolved metals concentrations were considered in the selection of COPCs and both are presented in the Part D Table 2's.
- Essential nutrients were evaluated using the USDA Tolerable Upper Intake Levels (USDA, 2012). It was assumed that the USDA Tolerable Upper Intake Levels represent acceptable intakes of calcium, magnesium, and sodium for the age groups cited. Acceptable doses were calculated using the acceptable intakes and average body weights for the age groups cited (see Appendix X for these calculations). These acceptable doses were used as reference doses in the USEPA RSL calculator (found here: http://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search). These calculated RSLs (presented in Appendix X) were used to screen essential nutrients.
- Chemicals for which no screening value or appropriate surrogate is available are retained as COPCs.

The RSLs for soil address direct contact (ingestion and dermal contact) exposures, as well as inhalation of constituents that may be released to air. The published RSLs have been derived as the lower of the concentration associated with a cancer risk of 1 in 1 million ($1x10^{-6}$) and the concentration associated with a non-cancer HQ of 1 or 0.1. The published RSLs based on the lower of the concentration associated with a cancer risk $1x10^{-6}$ and the concentration associated with a non-cancer HQ of 0.1 were used for the purposes of this BHHRA. As per Iowa Administrative Code (IAC) 567-137.5, the statewide soil standards are concentrations of contaminants in soil at which normal exposure via ingestion and dermal contact is considered unlikely to pose a threat to human health. Refer to IAC 567-137.5 for the basis of the Iowa statewide soil standards.

The use of the tap water RSLs, Federal MCLs, and the Iowa statewide standards for a protected groundwater source to identify COPCs in groundwater and surface water for CC-IAAP-001 whereby these water bodies are not currently used for drinking water purposes is conservative. Therefore, analytes present at concentrations that could exceed an Applicable or Relevant and Appropriate Requirements (ARAR) or potentially pose more than a *de minimis* risk for potable use are identified, regardless of whether or not the groundwater or surface water is presently or may be in the future used as a potable water source.

The results of the COPC selection for each data set are provided in **Appendix F-2 Risk Tables 2.1** through **2.5** and identified below, by medium**.**

- Surface Soil: COPCs in surface soil (0-1 ft bgs) include arsenic (**Appendix F-2: Table 2.1**).
- Surface and subsurface Soil: COPCs in surface and subsurface soil (0-10 ft bgs) include arsenic

(**Appendix F-2: Table 2.2**).

- Groundwater: COPCs in groundwater include dissolved arsenic, dissolved barium, dissolved manganese, total arsenic, total barium, total hexavalent chromium, total lead, and total uranium (**Appendix F-2: Table 2.3**).
- Surface Water: COPCs in surface water include dissolved arsenic, total arsenic and total hexavalent chromium (**Appendix F-2: Table 2.4**).
- Sediment: COPCs in sediment include arsenic (**Appendix F-2: Table 2.5**).

All chemicals for which maximum detected concentrations exceeded the applicable screening criteria were retained as COPCs. When both a dissolved and total metal concentration was selected as a COPC, the higher of the two was carried through the risk assessment. This provides a very conservative estimate of the potential risk posed by metals in groundwater and surface water.

7.1.3 Exposure Assessment

The exposure assessment is conducted to evaluate the populations of humans that may potentially use or access the Site under the current and possible future land use conditions, the mechanisms or exposure pathways by which those humans may be potentially exposed to COPCs at the Site, and the magnitude of exposure that may occur through the potential exposure pathways. This process involves three steps:

1. Characterization of the exposure setting in terms of physical characteristics, current and future uses of the Site, and the populations that may be potentially exposed to COPCs under the current and possible future land uses;

2. Identification of potential exposure pathways and exposure points to which the populations may be exposed; and developing exposure point concentrations (EPCs).

3. Quantification of exposure (intakes) for each population from all exposure pathways.

These components are discussed in Sections 7.1.3.1 through 7.1.3.3.

7.1.3.1 Exposure Setting and Exposure Pathways

The current land use at the property has been described in detail in Section 2.1.1. The exposure setting and exposure pathways (including exposure media, receptors, exposure areas, and exposure routes) have previously been identified and discussed in the CSM (Section 3.1) and in **Table 7-1**.

The IAAAP is a secured facility covering approximately 19,000 acres in a rural setting. Approximately 7,750 acres are currently leased for agricultural use, 7,500 acres are forested land, and the remaining area is used for administrative and industrial operations. The principal mission of IAAAP has been LAP operations dealing with a variety of conventional ammunition and fusing systems.

CC-IAAP-001 is a portion of the IAAAP at the intersection of roads H and A. It consists of land situated between Road H, Road A and a railroad spur. The site is moderately vegetated with small trees present in the western portion of the site. It is currently not used. The site was used to discard construction and demolition debris.

Under the current Site use, the only identified potential for human exposure to media at CC-IAAP-001 is a hunter utilizing the IAAAP. Trespassing is unlikely because the property is secured, therefore a trespasser scenario was not considered likely and not evaluated. There are no plans to develop CC-IAAP-001 or use it for other purposes. Future use of the IAAAP is anticipated to remain the same as current use (i.e., commercial/industrial). However, this BHHRA conservatively assumes that a portion of the IAAAP located at or in the proximity to CC-IAAP-001 could be developed such that subsurface soils become more accessible during excavation activities and that the site possibly be used more consistently for commercial/industrial activities. For this exposure scenario, a future hunter, construction worker, and a future commercial/industrial worker were evaluated. In order to provide a conservative risk assessment, the future commercial/industrial worker was assumed to be an outdoor worker in lieu of an indoor worker, as described per USEPA guidance. The outdoor worker is considered to have more intense exposure to COPCs in soil compared to the indoor worker. This scenario provides an upper bound estimate of the potential risk posed by CC-IAAP-001 to future receptors. The receptors described above would be expected to contact the following media via the following pathways:

- Current hunters would be expected to be exposed to surface soil as a result of their hunting activities. Two age groups may be expected to hunt at CC-IAAP-001: an adolescent from 12 to 18 years of age and an adult. It is assumed the hunter may wade through shallow surface water during hunting activities; therefore, they may contact surface water and sediment as well. Sediment was considered to have similar exposure potential as surface soil and because concentrations of COPCs (i.e., arsenic) were similar; sediment and surface soil data were combined and evaluated as one exposure point. The hunters' exposure to soil/sediment was evaluated for incidental ingestion, dermal contact, and inhalation of particulates. Hunters may also contact surface water via incidental ingestion and dermal contact. Exposure to groundwater was not evaluated because hunter's activities are limited to the ground surface and therefore they would not come into contact with groundwater. Inhalation of volatiles in ambient air was not evaluated as volatile compounds have not been detected in soil, sediment, or surface water. Once again, a number of the assumptions that went into the development of this exposure scenario are quite conservative. It is unlikely that a hunter would spend an entire day at CC-IAAP-001 due to its limited size (i.e., approximately 1 acre). It is also unlikely that a hunter would return to the same location every time that they hunt on IAAAP. Additionally, incidental ingestion of surface water by a hunter is highly unlikely. These pathways and assumptions were considered in the BHHRA to provide a very conservative estimate of risk to a hunter. It is likely that the actual risk to a hunter at IAAAP would be much lower.

- Future hunters (both adolescent and adults) would be expected to have the same exposure as a current hunter, with the following exception. It is assumed that future construction activity at CC-IAAP-001 could bring what is currently subsurface soil to the ground surface. Therefore, it is assumed the future hunter could also contact subsurface soil (soils currently located between 1 to 10 ft bgs) and, the overall exposure point evaluated for the future hunter is sediment and soils from 0-10 ft bgs. A similar caveat as described above should be made for the future hunter. The scenario is unlikely and the risk posed to an actual hunter at IAAAP would be much lower. It should also be noted that a future hunting scenario is unlikely as construction activities would likely disturb CC-IAAP-001 and make the location less attractive to wildlife.
- Future construction workers would be expected to contact both surface and subsurface soil (i.e., soils from 0 to 10 ft bgs). Construction workers are not anticipated to perform work in the streams, so contact with surface water and sediment is not evaluated. Construction work is not anticipated to be deeper than 10 ft bgs; and the depth to groundwater was recorded between 14 ft bgs to 33 ft bgs. Therefore direct contact with groundwater was not evaluated.
- Future commercial/industrial workers would be expected to come into contact with surface soil at CC-IAAP-001. However, future construction activity at CC-IAAP-001 could bring what is currently subsurface soil to the ground surface. Therefore, the commercial/industrial worker was assumed to be exposed to both surface soil and subsurface soil via ingestion, dermal contact, and inhalation of particulates. As previously stated, an outdoor worker scenario was evaluated, which is more conservative than an indoor worker scenario, per USEPA guidance. This is a conservative evaluation as there are no plans to develop CC-IAAP-001 to be used for commercial/industrial purposes with outdoor employees. Future commercial/industrial workers are not anticipated to contact surface water and/or sediment as they would be performing work activities at CC-IAAP-001 and not participating in recreational activities. As per the dispute resolution document (USEPA, 2013c) the commercial/industrial worker was evaluated for exposure to groundwater as a potable source as well.

Table 7-1 provides a summary of the receptors and exposure scenarios evaluated in the BHHRA for the Site.

Vapor migration/intrusion and inhalation of volatiles in both ambient and indoor air was eliminated as a pathway of concern at CC-IAAP-001. There are currently no buildings at CC-IAAP-001; therefore, vapor intrusion is not a current pathway. It is possible that a building may be constructed in the future, and/or volatiles could be found in ambient air, however, due to the low and infrequent detections of VOCs these pathways have been eliminated as a pathway of concern. A more detailed discussion is presented below:

- One volatile (2-Butanone) out of the list of VOCs reported via USEPA 8260B was detected in one of three groundwater samples at a concentration below the laboratory reporting limit. The detected concentration of 1.3 J µg/L is many orders of magnitude below the USEPA Vapor Intrusion screening criteria of 2,000,000 µg/L for groundwater. Due to the infrequent detection and low concentration of 2-butanone, volatilization from groundwater to ambient air, and/or future indoor air is not a pathway of concern for the CC-IAAP-001.

- Acetone, methylene chloride and 2-butanone were detected sporadically in surface and subsurface soil at CC-IAAP-001. The majority of the detections were detected at concentrations below the laboratory reporting limit (i.e., they are estimated concentrations), and at very low concentrations (i.e., below 1 mg/kg). Additionally, acetone and methylene chloride are common laboratory contaminants. A source of volatiles was not identified at CC-IAAP-001; therefore, it is possible that these detections are laboratory artifacts and not representative of volatile concentrations in soils at CC-IAAP-001. Due to the infrequent and low concentrations of volatiles detected at CC-IAAP-001, volatilization from soil to ambient and and/or future indoor air is not a pathway of concern for CC-IAAP-001.

7.1.3.2 Exposure Point Concentrations

The USEPA defines the exposure point concentration (EPC) as the representative medium-specific chemical concentration a receptor may contact at an exposure point over the exposure period (USEPA, 1989). Separate EPCs are calculated for each exposure medium at each exposure point. The typical concept of human exposure within a defined exposure area is that an individual contacts the contaminated medium on a periodic and random basis. Because of the repeated nature of such contact, the human exposure does not really occur at a fixed point but rather at a variety of points with equal likelihood that any given point within the exposure area will be the contact location on any given day. Thus, exposure areas were identified considering the likelihood of a receptor contacting all areas within the exposure area with equal probability, as reflected in EPCs based on arithmetic averages of the chemical concentrations within the exposure area. However, to account for uncertainty in estimating the arithmetic mean concentration, the USEPA recommends that an upper confidence limit (UCL) on the mean be used to represent the EPC. It is notable that the data set must be adequately robust (i.e., typically 10 samples) for a UCL on the mean to be derived. For small data sets often a maximum concentration is used as the EPC. For the exposure scenarios described above, EPCs were selected as follows:

- Surface soil/sediment: due to the limited number of sediment samples (i.e., a total of four) and the similar exposure potential to both surface soil and sediment, the datasets for these two media were combined. The EPC consists of the lower of the 95 percent UCL on the arithmetic mean concentration (95% UCL value) and the maximum detected concentration in the data set (USEPA, 1989).
- Surface soil/subsurface soil: as described above, the only potential exposure to subsurface soil (i.e., soils deeper than 1 ft bgs) would be in a future site development scenario whereby subsurface soil is brought to the ground surface during excavation. Therefore, this EPC represents surface and subsurface soil collected from depths between 0 to 10 ft bgs. A total of 22 samples were included in this dataset. The EPCs are based on the lower of the 95% UCL value or the maximum detected concentration in the data set (USEPA, 1989).

- Surface soil/subsurface soil/sediment: Similar to the EPC above, this EPC assumes subsurface soil is brought to the ground surface during excavation, but it also includes sediment samples. This EPC is used for the future hunter receptor only. Therefore, this EPC represents surface soil subsurface soil, and sediment collected from depths between 0 to 10 ft bgs. A total of 26 samples were included in this dataset. The EPCs are based on the lower of the 95% UCL value or the maximum detected concentration in the data set (USEPA, 1989).
- Groundwater: There was insufficient data to calculate 95% UCLs (i.e., a total of three samples) for the groundwater dataset. Therefore, the maximum detected concentrations were used as the EPCs for this dataset.
- Surface water: There was insufficient data to calculate 95% UCLs for the surface water dataset (i.e., a total of three samples). Therefore, the maximum detected concentrations were used as the EPCs for this dataset.

The 95% UCL values are calculated using the ProUCL software (Version 4.1.00, USEPA, 2010a). The ProUCL software performs a goodness-of-fit test for data sets with or without non-detects to identify the distribution type for the data set (e.g., normal, lognormal, gamma, or non-discernible), and then calculates a conservative and stable 95 percent UCL value in accordance with the framework described in “Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites” (USEPA, 2002a). The software includes numerous algorithms for calculating 95% UCL values, and provides a recommended UCL value based on the algorithm that is most applicable to the statistical nature of the data set.

EPCs are identified in ‘RAGS Part D Table 3’, which are presented in **Appendix F-2 Risk Tables 3.1** (soil and sediment), **3.2** (groundwater), and **3.3** (surface water). ProUCL output sheets are provided in **Appendix F-3**.

Inhalation exposure to soil-derived dust was evaluated for outdoor workers and construction workers. The source media for dust is soil, and the soil EPCs are used as the ‘source’ concentrations multiplied by a particulate emission factor for estimating dust-associated COPC concentrations in air.

7.1.3.3 Exposure Quantification

The process for calculating health risks requires the quantification of exposure [as a dose (or intake) or as a representative concentration] of a COPC and then combining the quantified intake with a toxicity value that relates the intake to a measure of health risk.

Exposures to COPCs are quantified by calculating intakes for representative receptor populations that may use or access the Site under the various current and possible future land use conditions. This section describes the process that is used to quantify COPC exposure in each of the media evaluated in the BHHRA.

The process for calculating intakes involves two principal components:

1. Identifying the representative concentration of COPCs in each medium that a receptor population is exposed to. This term is called the EPC. EPCs are derived for each exposure area and exposure route for which potentially complete exposure pathways may exist, as described in Section 7.1.3.1. The methods used to derive EPCs are identified in Section 7.1.3.2.

2. Quantifying the amount of each medium that a receptor population is exposed to. This is derived by considering the types of activities that a receptor population would be engaged in (e.g., excavation work vs. playing outdoors) and the ages of the receptor population (e.g., children vs. adults). From this information, receptor exposure scenarios are developed that relate the activities that could result in exposure to values that can be used to quantify exposure. The quantitative values are called exposure parameters. The types of exposure parameters and descriptions of the exposure scenarios used to quantify exposure are provided in Section 7.1.3.1.

Fundamentally, intake is thus a function of EPC and exposure parameters:

Intake = (EPC) x (Exposure Parameters)

Appendix F-4 presents the specific equations used to calculate average daily intake per media.

The exposure parameters selected to evaluate health risks associated with the potentially complete exposure pathways under current and possible future land use in this BHHRA are generally based on the upper-end distributions from USEPA guidance that are referred to as the RME. The selected exposure parameters and their sources are presented as **Appendix F-2 Risk Tables 4.1** through **4.3** and described below:

Current Land Use:

- Hunter: It is assumed that adolescents and adults may utilize the IAAAP for hunting purposes and may come into contact with surface soil/sediment, and surface water at CC-IAAP-001 while hunting. The length of Iowa's deer season (including blow, rifle, antlerless, etc.) changes each year. An exposure frequency of 26 days a year at CC-IAAP-001 was selected as an upper bound estimate of a 30 year exposure period. The incidental ingestion rate and dermal contact parameters used are USEPA recommended default parameters for the outdoor worker receptor and equivalent values (based on the appropriate age range for the adolescent) (USEPA, 2002b).

Future Land Use:

- Hunter: The future hunter is assumed to have the same exposure parameters as the current hunter.
- Outdoor worker: The future outdoor commercial/industrial worker scenario (e.g. landscaper, maintenance worker, etc.) is a long-term receptor that spends the majority of each work day outdoors (8 hours per day, 250 days per year, for 25 years per USEPA, 2002b) where incidental

ingestion of soil, dermal contact with soil and inhalation of wind-borne dust occur. The incidental ingestion rate and dermal contact parameters used are the USEPA recommended default parameters for the outdoor worker receptor (USEPA, 2002b). This receptor is also evaluated for consumption of groundwater. In accordance with the dispute resolution document (USEPA, 2013c), it is assumed that the receptor drinks 1 liter of water per day, 250 days per year, for 25 years. This scenario is very conservative as it assumes a drinking water well is installed within the limits of the site.

- Construction worker: The construction worker scenario provides an estimate of potential risks associated with a short-term, high-intensity contact with surface and subsurface soil. The construction worker scenario assumes that a worker spends each work-day over a one year period at the Site (resulting in a frequency of 8 hours per day, 5 days per week, or 250 days per year). Incidental soil ingestion and dermal contact exposures have been evaluated using UESPA recommended default parameters for this scenario assuming dermal exposure is limited to the head, hands, and forearms of the construction worker (USEPA, 2002b). Also inhalation of fugitive dusts or particulates generated was evaluated using USEPA recommended default parameters (USEPA, 2002b).

7.1.4 Toxicity Assessment

The objective of the toxicity assessment is to quantify the relationship between the intake, or dose, of COPCs and the likelihood that adverse health effects may result from exposure to the COPCs.

There are two major types of adverse health effects evaluated in the BHHRA: non-carcinogenic, and carcinogenic. Non-carcinogenic health effects refer to toxicological effects other than cancer which may result from exposure to a substance, such as toxicity to the liver, skin, or central nervous system. Carcinogenic health effects refer to the development of cancer which may result from exposure to a substance. Following USEPA guidance (USEPA, 1989), these two types of effects (non-carcinogenic and carcinogenic) are evaluated separately.

There are two types of toxicity values, or dose-response values, for evaluating health risks: cancer slope factors (CSFs) and unit risk (UR) values for carcinogens; and reference doses (RfDs) and reference concentrations (RfCs) for non-carcinogens. For potentially carcinogenic COPCs, both types of values have been developed by USEPA because these COPCs may elicit both carcinogenic and non-carcinogenic (systemic) effects. In addition, because toxicity and/or carcinogenicity can depend on the route of exposure (i.e., oral or inhalation), unique dose-response values have been developed for the oral, dermal, and inhalation exposure routes.

Section 7.1.4.1 describes the types of toxicity values that are used for evaluation of carcinogenic risks, and **Section 7.1.4.2** describes the types of toxicity values that are used for evaluation of non-cancer hazards.

7.1.4.1 Toxicity Assessment for Carcinogenic Effects

The toxicity assessment followed the USEPA two-part evaluation to characterize the carcinogenicity of a chemical. The first part involves assigning a weight-of-evidence classification to a chemical, which describes the strength of available information with respect to the association of chemical exposure and human cancer. The second part involves calculation of a cancer slope factor (CSF) or UR to reflect the carcinogenic potency.

Historically, USEPA has used an alphanumeric system to describe the weight-of-evidence:

Group A - Human Carcinogen. This category indicates there is sufficient evidence from epidemiological studies to support a causal association between an agent and human cancer.

Group B - Probable Human Carcinogen. This category generally indicates there is at least limited evidence from epidemiologic studies of carcinogenicity to humans (Group B1) or that, in the absence of data on humans, there is sufficient evidence of carcinogenicity in animals (Group B2).

Group C - Possible Human Carcinogen. This category indicates that there is limited evidence of carcinogenicity in animals in the absence of data on humans.

Group D - Not Classified. This category indicates that the evidence for carcinogenicity in animals is inadequate.

Group E - No Evidence of Carcinogenicity to Humans. This category indicates that there is evidence of noncarcinogenicity in at least two adequate animal tests in different species or in both epidemiologic and animal studies.

This assessment also followed the revised Guidelines for Carcinogenic Risk Assessment (USEPA, 2005), wherein USEPA revised the approach to describing the carcinogenic potential of an agent from an alphanumeric system to a weight-of-evidence-based descriptive narrative. Descriptors are as follows:

Carcinogenic to Humans. This descriptor indicates strong evidence of human carcinogenicity, and is appropriate A) when there is convincing epidemiologic evidence of a causal association between human exposure and cancer; or B) when all of the following conditions are met: (a) there is strong evidence of an association between human exposure and either cancer or the key precursor events of the agent's mode of action but not enough for a causal association, and (b) there is extensive evidence of carcinogenicity in animals, and (c) the mode(s) of carcinogenic action and associated key precursor events have been identified in animals, and (d) there is strong evidence that the key precursor events that precede the cancer response in animals are anticipated to occur in humans and progress to tumors, based on available biological information.

Likely to be Carcinogenic to Humans. This descriptor is appropriate when the weight of the evidence is adequate to demonstrate carcinogenic potential to humans but does not reach the weight of evidence for the descriptor “Carcinogenic to Humans”. The use of the term “likely” as a weight of evidence descriptor does not correspond to a quantifiable probability. Supporting data for this descriptor may include: an agent demonstrating a plausible (but not definitively causal) association between human exposure and cancer, in most cases with some supporting biological, experimental evidence, though not necessarily carcinogenicity data from animal experiments; an agent that has tested positive in animal experiments in more than one species, sex, strain, site, or exposure route, with or without evidence of carcinogenicity in humans; a positive tumor study that raises additional biological concerns beyond that of a statistically significant result, for example, a high degree of malignancy, or an early age at onset; a rare animal tumor response in a single experiment that is assumed to be relevant to humans; or a positive tumor study that is strengthened by other lines of evidence, for example, either plausible (but not definitively causal) association between human exposure and cancer or evidence that the agent or an important metabolite causes events generally known to be associated with tumor formation (such as DNA reactivity or effects on cell growth control) likely to be related to the tumor response in this case.

Suggestive Evidence of Carcinogenic Potential. This descriptor is appropriate when the weight of evidence is suggestive of carcinogenicity; a concern for potential carcinogenic effects in humans is raised, but the data are judged not sufficient for a stronger conclusion. This descriptor covers a spectrum of evidence associated with varying levels of concern for carcinogenicity, ranging from a positive cancer result in the only study on an agent to a single positive cancer result in an extensive database that includes negative studies in other species.

Data Inadequate for an Assessment of Human Carcinogenic Potential. This descriptor is appropriate when available data are judged inadequate for applying one of the other descriptors.

Not Likely to be Carcinogenic in Humans. This descriptor is appropriate when the available data are considered robust for deciding that there is no basis for human hazard concern. In some instances, there can be positive results in experimental animals when there is strong, consistent evidence that each mode of action in experimental animals does not operate in humans. In other cases, there can be convincing evidence in both humans and animals that the agent is not carcinogenic.

The weight of evidence classification in Integrated Risk Information System (IRIS) for a given chemical may reflect either of the two classification schemes identified above, depending on when USEPA most recently reviewed and revised the carcinogenicity assessment for any given chemical.

It has been generally assumed historically that carcinogenic effects are non-threshold effects. This means that any dose, no matter how small, has been assumed to pose a finite probability of generating a response. Thus, no dose of a carcinogen has been thought to be risk-free. More contemporary evaluations that focus on the mechanisms of action by which a chemical may cause cancer have, for some chemicals, identified threshold doses below which carcinogenesis does not occur. In consideration of the nature of the toxicological data that are available for a given chemical, USEPA uses one or more of several different models to identify the relationship between the dose of the chemical and a carcinogenic response.

The common measures of cancer potency assessment are the CSF (ingestion and dermal exposure) or a UR (commonly applied to inhalation). The CSF is the estimated upper-bound excess lifetime cancer risk (ELCR) associated with a lifetime average daily dose of a chemical agent of 1 mg/kg/day and the inhalation UR is the upper-bound ELCR associated with a lifetime average daily exposure of 1 $\mu g/m^3$ in air. CSF values are expressed as risk per mg/kg/day [$(mg/kg/day)^{-1}$] and UR values are expressed as risk per ($\mu g/m^3$) [$(\mu g/m^3)^{-1}$]. USEPA and other regulatory and scientific organizations have typically calculated CSFs and URs for chemicals in weight of evidence Groups A, B1, B2, and “Carcinogenic to humans” and “Likely to be carcinogenic to humans”. For some, but not all chemicals with Group C weight of evidence classification, USEPA and other organizations have also calculated cancer dose-response values.

In this BHHRA, CSFs are used to estimate the incremental risks associated with ingestion and dermal exposures, and URs are used to estimate the cancer risks associated with inhalation of COPCs in air (airborne dust). The CSF and UR values and supporting documentation are provided in **Appendix F-2 Risk Tables 6.1** and **6.2**.

7.1.4.2 Toxicity Assessment for Non-Carcinogenic Effects

Unlike carcinogenic effects, non-carcinogenic effects are threshold effects and were evaluated accordingly. This means that at some level of exposure there is a threshold below which adverse effects would not be expected, and above which adverse effects could potentially occur. Examples of non-carcinogenic (i.e., threshold) effects include liver toxicity, kidney toxicity, reproductive effects, neurotoxicity, and teratogenicity. The same process that is used to identify toxicity data to support carcinogenic potency assessment is also used to identify toxicity data to support the identification of dose-response relationships for non-carcinogenic effects.

Non-cancer toxicity values include RfDs and RfCs. The RfD expressed in units of mg/kg/day, is defined as an estimate (with uncertainty spanning perhaps an order of magnitude or greater) of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime (USEPA, 1989). Unlike a CSF or UR, which represents a probability of incurring a carcinogenic effect following exposure to a substance, the RfD represents a threshold dose below which adverse health effects are unlikely to occur, and above which the potential for adverse health effects exists. The RfD is derived from the following equation:

$$RfD\ (mg/kg/day) = \frac{NOAEL\ or\ LOAEL}{UF\ and/or\ MF}$$

The No Observed Adverse Effect Level (NOAEL) represents the dose of a chemical at which there are no statistically or biologically significant differences in the frequency of an adverse effect between the exposed population and its appropriate control. The Lowest Observed Adverse Effect Level (LOAEL) represents the lowest dose at which a statistically significant difference in the frequency of an effect is noted. Both the NOAEL and the LOAEL are reported in terms of mg/kg/day. An uncertainty factor (UF) is used to account for inter-species and intra-species differences, whether the dose was an NOAEL or an LOAEL, and the adequacy of the data. The magnitude of the UF will therefore vary from chemical to chemical, ranging from 3 to 3,000. A modifying factor (MF), ranging from 1 to 10 may also be included to reflect qualitative uncertainties not explicitly addressed in the UFs. The toxicity endpoint upon which the RfD is derived and the UF and/or MF used in the calculation are presented in the dose-response tables provided in **Appendix F-2 Risk Tables 5.1** and **5.2.**

The RfC, in units of mg/m^3, is analogous to the RfD and is developed through a similar process. However, unlike RfDs, which represent a dose (in mg/kg/day) at which adverse or deleterious effects are unlikely, RfCs represent air concentrations (in mg/m^3) at which adverse or deleterious effects are unlikely (i.e., an air concentration corresponding to a HI = 1.0). In this BHHRA, inhalation RfCs are used to estimate the non-cancer risks associated with inhaling COPCs.

The use of chronic RfDs and RfCs to evaluate the potential for adverse health effects resulting from substantially less-than-lifetime exposures may be overly protective. Subchronic Reference Doses and Subchronic Reference Concentrations (RfD_ss/RfC_ss) have been developed for some chemicals to evaluate the potential non-carcinogenic effects of limited duration exposures. Subchronic RfD_ss/RfC_ss are similar to chronic RfDs/RfCs; the distinction is the length of exposure duration. The construction worker scenario is the only scenario evaluated in this risk assessment that is associated with subchronic exposures. Therefore, when available subchronic RfDs and RfCs are used to evaluate potential non-cancer risks for the construction worker. Chronic RfDs and RfCs are used for all other receptor scenarios.

The RfDs and RfCs and supporting documentation for the chemicals selected as COPCs are provided in **Appendix F-2 Risk Tables 5.1** and **5.2**.

7.1.4.3 Adjustment for Dermal Exposure

Oral Cancer CSFs and non-cancer RfDs were developed to evaluate risk associated with the ingestion exposure route (typically based on the applied dose). In accordance with USEPA guidance (USEPA, 2004), dermal dose-response values are calculated from oral dose-response values using an oral absorption factor. The dermal dose-response values are appropriate for evaluating the calculated absorbed dose associated with dermal exposures. The oral absorption factor represents the fraction of ingested amount that is absorbed from the gastrointestinal tract following oral administration of a substance. The absorbed dose represents the amount of substance that is potentially available for biological interaction. The calculated dermal dose-response value is appropriate for evaluating the absorbed dermal doses.

Thus, for potentially carcinogenic substances, the dermal dose-response value is calculated as follows:

$$CSF_d = CSF_o / Oral\ ABS$$

The dermal dose-response value for evaluating non-carcinogenic effects is calculated as follows:

$$RfD_d = RfD_o \times Oral\ ABS$$

Chemical-specific oral ABS values are published by USEPA (USEPA, 2004). In accordance with USEPA guidance (USEPA, 2004), oral dose-response values are only adjusted using an oral ABS value if the COPC has an oral ABS value less than 50 percent. Otherwise, the oral dose-response value is used as the dermal dose-response value.

Dermal CSFs and RfDs are presented in **Appendix F-2 Tables 6.1** and **5.1,** respectively.

7.1.4.4 Sources of Dose Response Values

USEPA guidance (USEPA, 2003a) was followed when selecting dose-response values.

The main source of dose-response values is the Tier 1 source, IRIS, which is a database established by USEPA containing all validated data on many toxic substances found at hazardous waste sites. This database (USEPA, 2013b), current as of August 2013, was used to identify the CSFs, URs, RfDs, and RfCs applied in this risk assessment. The Health Effects Assessment Summary Tables (HEAST, 2011), dated December 2011 was used to obtain a subchronic arsenic RfD. The CSF for hexavalent chromium was obtained from the New Jersey Department of Environmental Protection (NJDEP) in accordance with the USEPA Region 7 Memorandum regarding Recommended Chromium (VI) Toxicity Values (USEPA, 2010b). In addition, per the Memorandum, hexavalent chromium was considered a mutagen and age-dependent adjustment factors (ADAFs) were applied consistent with USEPA guidance. A weighted ADAF of 2.3 was applied to the hexavalent chromium CSF for the adolescent receptor. The weighted ADAF was calculated by assuming an ADAF of 3 between the ages of 12 to 16 years, and an ADAF of 1 between the ages of 16 to 18 years.

7.1.4.5 Chemical-Specific Considerations

Lead: In accordance with CERCLA risk assessment procedures, risks associated with potential exposures to lead in soil are characterized using lead biokinetic uptake models (USEPA, 2012b). USEPA publishes two biokinetic uptake models: one is used to evaluate lead uptake in children, and one is used to evaluate lead uptake in adults. The child lead model (integrated exposure uptake biokinetic model (IEUBK)) is used to characterize lead risks associated with residential land use and allows for an evaluation of risk posed by lead in groundwater that is ingested. Because children are more susceptible to lead toxicity than adults; lead concentrations that are protective for children are also protective for adults. The adult lead model does not allow for the evaluation of an adult's exposure to lead in groundwater. Therefore, although quite conservative, the IEUBK model was used in this BHHRA to characterize potential lead exposures and risks for a child ingesting groundwater at CC-IAAP-001. The assumption being that if the lead concentrations in groundwater do not pose a risk to children, the concentrations would also be safe for adults.

Appendix F-7 presents the lead modeling results.

Arsenic: Arsenic was evaluated using the USEPA 2012 guidance, Recommendations for Default Value for Relative Bioavailability of Arsenic in Soil, OSWER 9200.1-113 (USEPA, 2012c). This guidance recommends that in the absence of site-specific bioavailability testing, for soil ingestion exposures, a default Relative Bioavailability (RBA) of 60% be included in the dose calculations. This reflects that arsenic is soil is less bioavailable than from drinking water (the exposure medium upon which the toxicity values were based). The drinking water-based toxicity values are relevant for the water soluble arsenic species, but would overestimate biovailability of arsenic in soils and other solid media where the arsenic is not in a highly water soluble form. This 60% RBA is incorporated in the risk calculations for arsenic in soils.

7.1.5 Risk Characterization

Risk characterization, including uncertainty analysis, is the final step in the risk assessment process. The risk characterization integrates the exposure and toxicity information generated in previous sections to quantitatively evaluate the potential health risks associated with exposure to chemicals at the Site. Risk estimates are then evaluated through a comparison to CERCLA risk management criteria. Section 7.1.5.1 describes the methodology used to calculate risks for each COPC and to sum risk estimates among COPCs, exposure pathways, and exposure media to derive cumulative receptor risks. Section 7.1.5.2 provides the risk assessment results for each of the scenarios evaluated in the BHHRA. Section 7.1.5.3 identifies and discusses uncertainties in the BHHRA and their potential impact on the results and conclusions of the risk assessment.

7.1.5.1 Risk Characterization Methods

Quantitative estimates of both carcinogenic and non-carcinogenic risks are calculated for each exposure scenario selected for evaluation in the exposure assessment, in accordance with USEPA (1989) guidance.

An estimate of the ELCR associated with exposure to each COPC in a given medium is calculated by multiplying the exposure route pathway-specific lifetime average daily dose (e.g., dermal exposure to surface soil) or lifetime average exposure concentration (e.g., inhalation of dust) by its exposure route-specific CSF (e.g., oral CSF) or UR.

$$ELCR = \text{Lifetime Average Daily Dose or Exposure } (mg/kg/day \text{ or } \mu g/m^3) \times CSF\ (mg/kg/day)^{-1} \text{ or } UR\ (\mu g/m^3)^{-1}$$

The ELCR represents an upper bound of the probability of an individual developing cancer over a lifetime as the result of exposure to a COPC. The ELCR is calculated for each carcinogenic COPC for each medium and exposure route combination for each receptor at each exposure area. The ELCR for all COPCs in a given medium are summed to identify a route-specific total ELCR (e.g., soil ingestion) and the ELCR for all exposure routes for a given receptor/medium combination (e.g., soil ingestion and dermal contact) are summed to yield a total ELCR (e.g., for surface soil).

The non-cancer HQ associated with exposure to each COPC is calculated by dividing the exposure route pathway-specific average daily dose or exposure concentration by its exposure route-specific RfD or RfC.

$$HQ = \text{Average Daily Dose or Exposure (mg/kg/day or } \mu g/m^3\text{) / RfD (mg/kg/day) or RfC (} \mu g/m^3\text{)}$$

The HQ is calculated for each COPC for each medium and exposure route combination for each receptor at each exposure area. For a given medium/receptor/age group combination (e.g., surface soil and adult outdoor worker), HQs for all COPCs are summed by route (e.g., dermal contact) to identify a medium/route HI, and the HIs for multiple exposure routes (e.g., incidental ingestion and dermal contact) are summed to identify a medium-specific total HI (e.g., for surface soil ingestion and dermal contact). An HI less than 1 indicates that non-carcinogenic toxic effects are unlikely to occur as a result of COPC exposure. HIs greater than 1 may be indicative of a possible non-carcinogenic toxic effect. As the HI increases, so does the likelihood that adverse effects might be associated with exposure.

Risk calculations are documented in **Appendix F-5** (RAGS Part D Table 7s) and **Appendix F-6** (RAGS Part D Table 9s). **Tables 7.1** through **7.6** (called RAGS Part D tables 7s) in **Appendix F-5**, present, for a given receptor/age group and exposure point, COPC-specific cancer risk and HQs for each medium/exposure route combination (e.g., surface soil ingestion) and presents cumulative or total cancer risk and screening HI for each medium/exposure route combination (e.g., surface soil ingestion), the cumulative or total cancer risk and screening HI for each medium (e.g., surface soil), and the cumulative or total cancer risk and screening HI for the receptor/age group.

Tables 9.1 through **9.6** (called RAGS Part D table 9s) in **Appendix F-6** present the same calculated risk information in a slightly different structure, but also provides information beyond the simple, screening HI (it is assumed that non-cancer hazards of all COPCs are additive).

7.1.5.2 Risk Characterization Results

The calculated cancer and non-cancer risks are evaluated in the context of risk management criteria established in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and discussed in the preamble to the NCP (USEPA, 1990). The results of the baseline risk assessment are evaluated by comparing them to the USEPA's remedial goals. With respect to cancer risk, USEPA sets remediation goals for total cancer risk "that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} to 10^{-6} lifetime excess cancer risk." USEPA sets remediation goals for noncancer risk "such that exposures present no appreciable risk of significant adverse effects to individuals, based on comparison of exposures to the concentration associated with reliable toxicity information such as USEPA's reference doses." For cumulative risks due to noncarcinogens, "EPA will set the remediation goals at levels for individual chemicals such that cumulative effects of multiple chemicals will not result in adverse effects." USEPA has stated that "acceptable exposure for noncarcinogens is one to which human populations, including sensitive subgroups such as pregnant women and children may be exposed without adverse effects during a lifetime or part of a lifetime, incorporating an adequate margin of safety." Given the stated remediation goals, the results of the baseline risk assessment are evaluated in accordance with the NCP - cancer risk estimates for a site are compared to an ELCR range of 10^{-6} (one in a million) to 10^{-4} (one in ten-thousand). Total risks at or below 10^{-4} do not generally warrant a response action. Risks greater than 10^{-4} generally warrant development and evaluation of remedial alternatives. Non-cancer risks are compared to a HI value of 1, which corresponds to levels of exposure that people (including sensitive individuals) could experience without expected adverse effects.

Table 7-2 presents summaries of risks calculated for the current and future land use exposure scenarios. As indicated on **Table 7-2** all of the total receptor ELCRs are lower than the USEPAs acceptable risk range of 10^{-4} to 10^{-6} lifetime excess cancer risk (with the exception of the Commercial/Industrial Worker, which fell within the acceptable risk range). ELCRs range from $2x10^{-7}$ (for the current and future adolescent hunters) to $9x10^{-5}$ (for the future commercial/industrial worker). As indicated on Table 7-2, HIs range from 0.005 (for the current and future adult hunter) to 0.6 (for the future commercial/industrial worker). All cumulative HIs for a receptor are below the USEPA acceptable risk level of 1.

Despite the very conservative assumptions built into this BHHRA, total ELCR to all receptors, with the exception of the commercial/industrial worker, yield risks less than the lower (10^{-6}) end of the USEPAs acceptable risk range of 10^{-4} to 10^{-6}. The risk estimate for the commercial/industrial worker is $9x10^{-5}$, which does not exceed USEPAs acceptable risk range of 10^{-4} to 10^{-6}. Arsenic contributes most to the carcinogenic risk estimates, primarily through dermal contact with soil and ingestion (hypothetical drinking water) of groundwater.

The risk estimates presented herein provide an upper estimate of risk posed to receptors at CC-IAAP-001 and are likely overly conservative for the following reasons:

- An outdoor worker, per USEPA guidance, was evaluated for the commercial/industrial worker scenario. This evaluation included dermal exposure to soil, performing work outdoors 225 days per year. However, it is much more likely that a future commercial/industrial worker would perform indoor work with occasional work outdoors. The standard USEPA commercial/industrial scenario for an indoor worker does not evaluate the dermal pathway and includes a lower ingestion rate (50 mg_{soil}/day in lieu of 100 mg_{soil}/day).
- The commercial/industrial worker was evaluated for consumption of groundwater from the site. This scenario is purely hypothetical as State regulations preclude the use of groundwater at the IAAAP from being used as a water supply. Further, maximum detected metals concentrations

(which were all total metal results) were used as the EPCs in the consumption of groundwater scenario. Generally, water from a water supply well would be filtered prior to reaching the tap and dissolved metals concentrations would be representative of exposure rather than total metals. In addition, the maximum detected concentration is unlikely representative of the EPC, rather an average would be more representative as the well would likely capture water from a larger area than is represented by one monitoring well.

7.1.5.3 Lead Risk Calculation

In accordance with CERCLA risk assessment procedures, risks associated with potential exposures to lead are characterized using lead biokinetic uptake models (USEPA, 2012b). The child lead model (integrated exposure uptake biokinetic model (IEUBK); Version 1.0, Build 11) was developed to characterize lead risks associated with residential land use exposures to multiple media. Because children are more susceptible to lead toxicity than adults, lead concentrations that are protective for children are also protective for adults. The IEUBK provides estimates of blood lead levels that may result from chronic exposures to lead in various exposure media. To evaluate the significance of the estimated blood lead concentrations, the blood lead concentrations are compared to a threshold blood lead level of 10 micrograms per deciliter (µg/dL). This threshold blood lead level is a multi-Agency goal that has been designated by the US Centers for Disease Control (CDC) and the Agency for Toxic Substances and Disease Registry (ATSDR) as a level of concern to protect sensitive populations, including neonates, infants, and children. The protection of sensitive populations is assumed to also provide protection for adults. USEPA indicates that 95% of the exposed population should have a geometric mean blood lead level that does not exceed 10 µg/dl.

The IEUBK Model output provides an estimate of the probability of the exposed population that would have blood levels that exceed USEPA's "safe" level of 10 µg/dL. Model results indicate that the estimated probability that approximately 1.535% of the exposed population of children that will have blood lead levels above the USPA threshold of 10 ug/dL is well below the USEPA "acceptable" probability of 5%. In other words, the model results indicate that the estimated geometric mean blood lead concentration (3.622 ug/dl) for any given child exposed to lead at the site is anticipated to be below the threshold value of 10 ug/dl. **Appendix F-7** provides a summary of the lead modeling results and the IEUBK modeling input parameters.

7.1.5.4 Uncertainty Analysis

This subsection identifies and discusses uncertainties in the risk assessment. These uncertainties are identified to provide perspective on the quantitative risk estimates. Unlike some other assessments, risk assessments rely not just on measured or certain facts, but also on assumptions and estimates, and also policy decisions, in the face of limited or nonexistent data. Historically, many risk assessments have used highly conservative assumptions in the place of unavailable data, with the net result often being a substantial overestimation of potential risks. It is important, however, to evaluate the assumptions and choices made in any risk assessment to evaluate their impact on the results and conclusions.

The following types of uncertainties should be considered in any BHHRA:

- uncertainties in the nature and extent of release of COPC;
- uncertainties associated with the identification of future land uses and potential receptors;
- uncertainties in estimating the frequency, duration, and magnitude of possible exposures (including the identification of representative EPCs in environmental media);
- uncertainties associated with assigning exposure parameters to a heterogeneous population that includes both men and women and young and old (e.g., BW and ingestion rates);
- uncertainties in estimating CSFs and URs and/or non-carcinogenic measures of toxicity (e.g., RfDs or RfCs); and

Uncertainties in the nature and extent of release of COPCs: There is some uncertainty associated with the delineation of the nature and extent of contamination. This is typical for most investigations, and is true for this investigation in particular due to lack of information regarding site history. However, every effort was made to collect sufficient data to characterize the nature and extent of contamination and adequately characterize risk. Sample collection was focused in locations where contamination was considered more likely to be present (i.e., in the immediate vicinity of the construction debris). Therefore, the data that have been collected for the site are likely a conservative representation of nature and extent, and are also more likely to result in overestimates rather than underestimates of the potential risk to human health posed by the site.

Magnesium was identified as a COPC in dissolved groundwater. Magnesium was not evaluated quantitatively in the HHRA, as toxicity values are not available for magnesium. Magnesium is, however, considered an essential nutrient. COPC screening was performed using maximum detected concentrations and a conservative estimate of a risk-based screening level derived using tolerable upper intake levels. It is likely that the actual magnesium EPC would be much lower than is represented by the maximum detected concentration. Additionally, groundwater at CC-IAAP-001 is not a current drinking water source. Due to State regulations and the fact that the Army has near total control over land use at the IAAAP; it is highly unlikely that groundwater will become a drinking water source, therefore, magnesium concentrations in groundwater are unlikely to pose a risk to receptors at the CC-IAAP-001.

Incremental risk comparing risk from site COPCs to background was not calculated, as the conservative risk estimates presented in this BHHRA did not calculate risk above USEPA's acceptable risk criteria. However, it should be noted that background concentrations of arsenic are similar to the concentrations detected at the site (minimum 0.5 mg/kg, maximum 30 mg/kg, average 7.327 mg/kg) and it is likely that background may contribute to the risk posed by arsenic at CC-IAAP-001.

Uncertainties associated with the identification of future land uses and potential receptors: There is little uncertainty associated with future land use and receptors. The Army is the current property owner and has indicated that they do not foresee developing the Site in the future. Additionally, other receptors that may access the Site (e.g., trespassers) would have similar exposures as the hunter.

Uncertainties in estimating the frequency, duration, and magnitude of possible exposures (including the identification of representative EPCs in environmental media): A number of conservative assumptions were used when estimating the frequency duration, and magnitude of potential exposures. It is likely that these assumptions overestimate rather than underestimate risk associated with the receptors at the CC-IAAP-001. These conservative assumptions are described below.

The assumption that hunters will be present at CC-IAAP-001 one day a week for 26 weeks a year is very conservative; CC-IAAP-001 is a very small area of land (approximately 1-acre) with steep embankments. The likelihood that a hunter would do more than pass through CC-IAAP-001 is minimal. Additionally the likelihood that a hunter would have any exposure to surface water is minimal. Surface water at CC-IAAP-001 is ephemeral and unlikely to be present in sufficient quantities such that a hunter would ingest or have dermal contact with the water.

The assumption that a commercial/industrial worker will be working outdoors 250 days per year is highly conservative as well. If CC-IAAP-001 is developed for commercial/industrial use, it is more likely that an indoor worker would be exposed to CC-IAAP-001 on a frequent basis (i.e., 250 days per year) and an outdoor worker (e.g., landscaper or maintenance worker) would be exposed on an infrequent basis. Additionally, the consumption of groundwater was evaluated based on an agreement in the dispute resolution document (USEPA, 2013c). However, groundwater at CC-IAAP-001 is not a current drinking water source. Additionally, due to State regulations and the fact that the Army has near total control over land use at the IAAAP; it is highly unlikely that groundwater will become a drinking water source. Lastly, the groundwater evaluation was performed using total metals concentrations. If groundwater were to be developed for future use it is most likely that it would be filtered prior to consumption.

Uncertainties associated with assigning exposure parameters to a heterogeneous population that includes both men and women and young and old (e.g., BW and ingestion rates): Again, conservative assumptions were used when developing the exposure scenarios. These assumptions are designed to address the most sensitive populations, so it likely overestimates rather than underestimates risk.

7.1.4.5 Risk Assessment Conclusions

Consistent with the current and foreseeable future land use, the BHHRA has evaluated potential exposures to surface soil, subsurface soil, groundwater, and surface water for current and future hunters, future outdoor workers, and future construction workers. This evaluation was performed using conservative exposure assumptions, which represent very conservative estimates of potential site exposure. The conclusions of the BHHRA can be summarized as follows:

- The cancer risk estimates for the current adolescent hunter, current adult hunter, future adolescent hunter, future adult hunter, future commercial industrial worker, and future construction worker are within or below the Superfund acceptable risk range.
- The non-cancer HI estimates for the current adolescent hunter, current adult hunter, future adolescent hunter, future adult hunter, future commercial industrial worker, and future

construction worker are below a value of 1.

- Predicted blood lead level concentrations for the future commercial/industrial worker are below USEPA criteria.

Based on this evaluation, response actions are not recommended for CC-IAAP-001.

7.2 CC-IAAP-002 BHHRA

A CSM for CC-IAAP-002 has been developed to form the basis of the assumptions used in this BHHRA. The physical CSM for the Site (sources, migration pathways, receiving media) is described in detail in Section 6.4 of this RI Report. Based on this CSM current and future land use, applicable receptors, exposure pathways, exposure media and relevant exposure points were identified. These are described in Section 7.2.3 Exposure Assessment

7.2.2 Data Collection and Evaluation

This section identifies the data available for use in BHHRA and documents the selection or exclusion of particular data for use in the risk assessment, provides the rationale for the way data will be grouped for evaluation in the risk assessment, and documents the methods used to summarize data using statistical descriptors. The data evaluation section also provides the methods used to select COPCs and documents the COPC selection results.

Section 7.2.2.1 is a summary of data collected and identification of sampling locations for CC-IAAP-002. Section 7.2.2.2 is a general discussion of data evaluation methods. Section 7.2.2.3 documents the CC-IAAP-002 data evaluation and selection of COPCs. **Appendix F-8** presents the list of samples included in the BHHRA by media. Laboratory analytical data used in the BHHRA are presented in Tables D-1 and D-2.

7.2.2.1 Data Collection Summary

The analytical data that were considered for use in the BHHRA were collected by PIKA in June 2013 and include the following:

- Six surface soil samples (soil samples collected from between 0 and 1 foot below ground surface (ft bgs)).
- Thirteen subsurface soil samples (soil samples collected from between 1 and 10 ft bgs).
- Three groundwater samples collected from on-Site locations.
- Three sediment samples collected from between 0 and 0.5 ft bgs.

Surface water samples could not be collected from CC-IAAP-002, as surface water was not present when the sampling event took place. All samples for all media were submitted for the following analyses: metals, pesticides, PCBs, herbicides, VOCs, SVOCs, PAHs, explosives, and asbestos. Additionally soil and sediment was submitted for analysis of pH and TOC (sediment only). Groundwater was submitted for analysis for sulfate, chloride, alkalinity, sulfide, DOC, and TOC. Figure 2-4 shows the 2013 sampling locations. **Appendix F-8** presents the list of samples included in the BHHRA by media. Laboratory analytical data used in the BHHRA are presented in Tables D-1 through D-2.

7.2.2.2 Data Evaluation

The laboratory analytical data was validated as described in Section 5.4. All validated results were considered representative of Site conditions and appropriate for use in the BHHRA.

7.2.2.3 Selection of COPCs

The BHHRA dataset derived through the data evaluation process described above was utilized to select COPCs for each medium (surface soil, surface and subsurface soil, groundwater, and sediment). **Appendix F-9 Risk Tables 2.1** through **2.4** are 'RAGS Part D Table 2's' (USEPA, 1989) that provide summaries of the laboratory analytical data for the Site media and document the selection of COPCs.

Appendix F-9 Risk Tables 2.1 through **2.4** utilize the following descriptors to summarize the data sets:

- Range of detected concentrations (maximum and minimum)
- Data qualifier associated with each minimum and maximum detected concentration
- Sample location associated with each maximum detected concentration
- Detection frequency (number of positively detected results/total number of results)
- Range of reporting limits (RLs) for non-detects

Figure 2-4 shows the locations of samples used in the BHHRA.

COPCs are chemicals that may pose more than a de minimis health risk. A concentration-toxicity screening is used to reduce the number of chemicals evaluated in the risk assessment to only those that would potentially pose more than a de minimis health risk (USEPA, 1989). The procedure used to select COPCs for the BHHRA is summarized as follows, and is consistent with USEPA methodology.

- An analyte was selected as a COPC in surface soil, surface and subsurface soil, and sediment if the maximum detected concentration is greater than the lower of the USEPA RSL (adjusted to a Hazard Quotient (HQ) of 0.1) for Industrial Use soils (USEPA, 2013) and the Iowa Statewide Standards for Soil (IDNR, 2013a).
- An analyte was selected as a COPC in groundwater if the maximum detected concentration is greater than the lower of the USEPA Tapwater RSLs (adjusted to an HQ of 0.1), the Federal Maximum Contaminant Levels (MCLs), or the Iowa Statewide Standards for a Protected Groundwater Source (IDNR, 2013a). Both total and dissolved metals concentrations were considered in the selection of COPCs and both are presented in the Part D Table 2's.
- Essential nutrients were evaluated using the USDA Tolerable Upper Intake Levels (USDA, 2012). It was assumed that the USDA Tolerable Upper Intake Levels represent acceptable intakes of

calcium, magnesium, and sodium for the age groups cited. Acceptable doses were calculated using the acceptable intakes and average body weights for the age groups cited (see Appendix X for these calculations). These acceptable doses were used as reference doses in the USEPA RSL calculator (found here: http://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search). These calculated RSLs (presented in Appendix X) were used to screen essential nutrients.

- Chemicals for which no screening value or appropriate surrogate is available are retained as COPCs.

The RSLs for soil address direct contact (ingestion and dermal contact) exposures, as well as inhalation of constituents that may be released to air. The published RSLs have been derived as the lower of the concentration associated with a cancer risk of 1 in 1 million ($1x10^{-6}$) and the concentration associated with a non-cancer HQ of 1 or 0.1. The published RSLs based on the lower of the concentration associated with a cancer risk $1x10^{-6}$ and the concentration associated with a non-cancer HQ of 0.1 were used for the purposes of this BHHRA. As per IAC 567-137.5, the statewide soil standards are concentrations of contaminants in soil at which normal exposure via ingestion and dermal contact is considered unlikely to pose a threat to human health. Refer to IAC 567-137.5 for the basis of the Iowa statewide soil standards.

The use of the tap water RSLs, Federal MCLs, and the Iowa statewide standards for a protected groundwater source to identify COPCs in groundwater for CC-IAAP-002 whereby these water bodies are not currently used for drinking water purposes is conservative. Therefore, analytes present at concentrations that could exceed an ARAR or potentially pose more than a *de minimis* risk for potable use are identified, regardless of whether or not the groundwater or surface water is presently or may be in the future used as a potable water source.

The results of the COPC selection for each data set are provided in **Appendix F-9 Risk Tables 2.1** through **2.4** and identified below, by medium**.**

- Surface Soil: COPCs in surface soil (0-1 ft bgs) include arsenic and dimethyl phthalate (**Appendix F-9: Table 2.1**).
- Surface and subsurface Soil: COPCs in surface and subsurface soil (0-10 ft bgs) include arsenic and dimethyl phthalate (**Appendix F-9: Table 2.2**).
- Groundwater: COPCs in groundwater include dissolved arsenic, total arsenic, total barium, total cadmium, total hexavalent chromium, and bromomethane. (**Appendix F-9: Table 2.3**).
- Sediment: COPCs in sediment include arsenic, benzo(a)pyrene, and dimethyl phthalate (**Appendix F-9: Table 2.4**).

All chemicals that were retained as COPCs were detected at maximum concentrations in excess of the appropriate screening values, if screening values were available. When both a dissolved and total metal concentration was selected as a COPC, the higher of the two was carried through the risk assessment. This provides a very conservative estimate of the potential risk posed by metals in groundwater.

7.2.3 Exposure Assessment

The exposure assessment is conducted to evaluate the populations of humans that may potentially use or access the Site under the current and possible future land use conditions, the mechanisms or exposure pathways by which those humans may be potentially exposed to COPCs at the Site, and the magnitude of exposure that may occur through the potential exposure pathways. This process involves three steps:

1. Characterization of the exposure setting in terms of physical characteristics, current and future uses of the Site, and the populations that may be potentially exposed to COPCs under the current and possible future land uses;
2. Identification of potential exposure pathways and exposure points to which the populations may be exposed; and EPCs.
3. Quantification of exposure (intakes) for each population from all exposure pathways.

These components are discussed in Sections 7.2.3.1 through 7.2.3.3.

7.2.3.1 Exposure Setting and Exposure Pathways

The current land use at the property has been described in detail in Section 2.1.1. The exposure setting and exposure pathways (including exposure media, receptors, exposure areas, and exposure routes) have previously been identified and discussed in the CSM (Section 6.4) and in **Table 7-3**.

The IAAAP is a secured facility covering approximately 19,000 acres in a rural setting. Approximately 7,750 acres are currently leased for agricultural use, 7,500 acres are forested land, and the remaining area is used for administrative and industrial operations. The principal mission of IAAAP has been LAP operations dealing with a variety of conventional ammunition and fusing systems.

CC-IAAP-002 is located within an undeveloped forested area of the IAAAP and currently consists of undeveloped land used to discard construction and demolition materials. Under its current use, the only potential for human exposure to media at CC-IAAP-002 is a hunter utilizing the IAAAP. Trespassing is unlikely because the property is secured, therefore a trespasser scenario was not considered likely and not evaluated. There are no plans to use the IAAAP for other purposes and future use of the IAAAP is anticipated to remain the same as current use (i.e., commercial/industrial). However, a portion of the IAAAP located at or in the proximity to CC-IAAP-002 could be developed and used more consistently for commercial/industrial activities. In order to evaluate this exposure scenario, a future construction worker and a future commercial/industrial worker were evaluated. In order to provide a highly conservative risk assessment, the future commercial/industrial worker was assumed to work outdoors. It should be noted that this scenario is unlikely, and instead provides an upper estimate of the potential risk posed by CC-IAAP-002 to future receptors. The receptors described above would be expected to contact the following media via the following pathways:

- Current hunters would be expected to be exposed to surface soil as a result of their hunting activities. Two age groups may be expected to hunt at CC-IAAP-002: an adolescent from 12 to 18 years of age and an adult. Surface water was not present at CC-IAAP-002 during the site investigation activities; therefore exposure to surface water was not evaluated in this BHHRA and sediment was considered to have the same exposure potential as surface soil. Concentrations of COPCs (i.e., arsenic) were similar in surface soil and sediment; therefore these data were combined and evaluated as one exposure point. The hunters' exposure to soil/sediment was evaluated for incidental ingestion, dermal contact, and inhalation of particulates. Inhalation of volatiles in ambient air was not evaluated as volatile compounds have not been detected in soil, or sediment. Once again, a number of the assumptions that went into the development of this exposure scenario are quite conservative. It is unlikely that a hunter would spend an entire day at CC-IAAP-002 due to its limited size (i.e., approximately 0.62 acres). It is also unlikely that a hunter would return to the same location every time that they hunt on IAAAP. These pathways and assumptions were considered in the BHHRA to provide a very conservative estimate of risk to a hunter. It is likely that the actual risk to a hunter at IAAAP would be much lower.
- Future hunters (both adolescent and adults) would be expected to have the same exposure as a current hunter, with the following exception. Future construction activity at CC-IAAP-002 could bring what is currently subsurface soil to the ground surface. Therefore, it is assumed the future hunter could also contact subsurface soil (soils currently located between 1 to 10 ft bgs) and, the overall exposure point evaluated for the future hunter is soils from 0-10 ft bgs. A similar caveat as described above should be made for the future hunter. The scenario is unlikely and the risk posed to an actual hunter at IAAAP would be much lower. It should also be noted that a future hunting scenario is unlikely as construction activities would likely disturb CC-IAAP-002 and make the location less attractive to wildlife.
- Future construction workers would be expected to contact both surface and subsurface soil (i.e., soils from 0 to 10 ft bgs). Construction workers are not anticipated to perform work in the intermittent streams, so contact with sediment is not evaluated. Construction work is not anticipated to be deeper than 10 ft bgs; and the depth to groundwater was recorded between 11 ft bgs to 14 ft bgs. Therefore direct contact with groundwater was not evaluated either.
- Future commercial/industrial workers would be expected to come into contact with surface soil at the CC-IAAP-002. However, future construction activity at CC-IAAP-002 could bring what is currently subsurface soil to the ground surface. Therefore, the commercial/industrial worker was assumed to be exposed to both surface soil and subsurface soil. For this evaluation an outdoor worker scenario was evaluated and therefore exposure was evaluated via ingestion, dermal contact, and inhalation of particulates. As previously stated, an outdoor worker scenario was evaluated, which is more conservative than an indoor worker scenario, per USEPA guidance. This is a conservative evaluation as there are no plans to develop CC-IAAP-001 to be used for commercial/industrial purposes with outdoor employees. As per the dispute resolution document (USEPA, 2013) the commercial/industrial worker was evaluated for exposure to groundwater as

a potable source as well.

Table 7-2 provides a summary of the receptors and exposure scenarios evaluated in the BHHRA for the Site.

Vapor migration/intrusion and inhalation of volatiles in both ambient and indoor air was eliminated as a pathway of concern at CC-IAAP-002. There are currently no buildings at CC-IAAP-002; therefore, vapor intrusion is not a current pathway. It is possible that a building may be constructed in the future, and/or volatiles could be found in ambient air, however, due to the low and infrequent detections of VOCs these pathways have been eliminated as a pathway of concern. A more detailed discussion is presented below:

- Two volatiles (bromomethane and 2-hexanone) out of the list of VOCs reported via USEPA 8260B were detected in groundwater. Bromomethane and 2-hexanone were detected in one groundwater sample at a concentration below the laboratory reporting limit. The detected concentrations are at least one order of magnitude less than the USEPA Vapor Intrusion screening criteria (of 17 µg/L and 8,200 µg/L, respectively) for groundwater. Due to the infrequent detection of and low concentrations of bromomethane and 2-hexanone, volatilization from groundwater to ambient air, and/or future indoor air is not a pathway of concern for the CC-IAAP-002.

Acetone was detected in one soil sample in surface soil at CC-IAAP-002. The detected concentration is just above the laboratory reporting limit at a very low concentration (i.e., below 1 mg/kg). Additionally, acetone is a common lab contaminant. A source of volatiles was not identified at CC-IAAP-002; therefore, it is likely that this detection is a lab artifact and not representative of volatile concentrations in soils at CC-IAAP-002. Due to the infrequent and low concentrations of volatiles detected at CC-IAAP-002, volatilization from soil to ambient and and/or future indoor air is not a pathway of concern for CC-IAAP-002.

7.2.3.2 Exposure Point Concentrations

The USEPA defines the EPC as the representative medium-specific chemical concentration a receptor may contact at an exposure point over the exposure period (USEPA, 1989). Separate EPCs are calculated for each exposure medium at each exposure point. The typical concept of human exposure within a defined exposure area is that an individual contacts the contaminated medium on a periodic and random basis. Because of the repeated nature of such contact, the human exposure does not really occur at a fixed point but rather at a variety of points with equal likelihood that any given point within the exposure area will be the contact location on any given day. Thus, exposure areas were identified considering the likelihood of a receptor contacting all areas within the exposure area with equal probability, as reflected in EPCs based on arithmetic averages of the chemical concentrations within the exposure area. However, to account for uncertainty in estimating the arithmetic mean concentration, the USEPA recommends that an upper confidence limit (UCL) on the mean be used to represent the EPC. It is notable that the data set must be adequately robust (i.e., typically 8 to 10 samples) for a UCL on the mean to be derived. For small data sets often a maximum concentration is used as the EPC. For the exposure scenarios described above, EPCs were selected as follows:

- Surface soil/sediment: due to the limited number of sediment samples (i.e., a total of 3) and the similar exposure potential to both surface soil and sediment, the datasets for these two media were combined. However, even with the combined datasets, there were insufficient data to calculate a 95% UCL (a total of 8 samples). Instead, the EPC was selected as the maximum detected concentration in the data set (USEPA, 1989).
- Surface soil/subsurface soil: as described above, the only potential exposure to subsurface soil (i.e., soils deeper than 1 ft bgs) would be in a future site development scenario whereby subsurface soil is brought to the ground surface during excavation. Therefore, this EPC represents surface and subsurface soil collected from depths between 0 to 10 ft bgs. A total of 23 samples were included in this dataset. The EPCs are based on the lower of the 95% UCL value or the maximum detected concentration in the data set (USEPA, 1989).
- Surface soil/sediment/subsurface soil: as described above, the only potential exposure to subsurface soil (i.e., soils deeper than 1 ft bgs) would be in a future scenario where construction work brought deeper soil to the surface. This EPC is used for the future hunter receptor only. Therefore, this EPC represents surface soil, sediment, and subsurface soil collected from depths between 0 to 10 ft bgs. A total of 26 samples were included in this dataset. The EPCs are based on the lower of the 95% UCL value or the maximum detected concentration in the data set (USEPA, 1989).
- Groundwater: There was insufficient data (i.e., 3 samples) to calculate 95% UCLs for the groundwater dataset. Therefore, the maximum detected concentrations were used as the EPCs for this dataset.

The 95% UCL values are calculated using the ProUCL software (Version 4.1.00, USEPA, 2010a). The ProUCL software performs a goodness-of-fit test for data sets with or without non-detects to identify the distribution type for the data set (e.g., normal, lognormal, gamma, or non-discernible), and then calculates a conservative and stable 95 percent UCL value in accordance with the framework described in “Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites” (USEPA, 2002a). The software includes numerous algorithms for calculating 95% UCL values, and provides a recommended UCL value based on the algorithm that is most applicable to the statistical nature of the data set.

EPCs are identified in ‘RAGS Part D Table 3s’, which are presented in **Appendix F-9 Risk Tables 3.1** (soil and sediment), and **3.2** (groundwater). ProUCL output sheets are provided in **Appendix F-10**.

Inhalation exposure to soil-derived dust was evaluated for outdoor workers and construction workers. The source media for dust is soil, and the soil EPCs are used as the ‘source’ concentrations multiplied by a particulate emission factor for estimating dust-associated COPC concentrations in air.

7.2.3.3 Exposure Quantification

The process for calculating health risks requires the quantification of exposure (as a dose (or intake) or as a representative concentration) of a COPC and then combining the quantified intake with a toxicity value that relates the intake to a measure of health risk.

Exposures to COPCs are quantified by calculating intakes for representative receptor populations that may use or access the Site under the various current and possible future land use conditions. This section describes the process that is used to quantify COPC exposure in each of the media evaluated in the BHHRA.

The process for calculating intakes involves two principal components:

1. Identifying the representative concentration of COPC in each medium that a receptor population is exposed to. This term is called the EPC. EPCs are derived for each exposure area and exposure route for which potentially complete exposure pathways may exist, as described in Section 7.2.3.1. The methods used to derive EPCs are identified in Section 7.2.3.2.
2. Quantifying the amount of each medium that a receptor population is exposed to. This is derived by considering the types of activities that a receptor population would be engaged in (e.g., excavation work vs. playing outdoors) and the ages of the receptor population (e.g., children vs. adults). From this information, receptor exposure scenarios are developed that relate the activities that could result in exposure to values that can be used to quantify exposure. The quantitative values are called exposure parameters. The types of exposure parameters and descriptions of the exposure scenarios used to quantify exposure are provided in Section 7.2.3.1.

Fundamentally, intake is thus a function of EPC and exposure parameters:

Intake = (EPC) x (Exposure Parameters)

Appendix F-11 presents the specific equations used to calculate average daily intake per media.

The exposure parameters selected to evaluate health risks associated with the potentially complete exposure pathways under current and possible future land use in this BHHRA are generally based on the upper-end distributions from USEPA guidance that are referred to as the RME. The selected exposure parameters and their sources are presented as **Appendix F-9 Risk Tables 4.1** through **4.3 and** described below:

Current Land Use:

- Hunter: Adolescents and adults may utilize the IAAAP for hunting purposes and may come into contact with surface soil/sediment at CC-IAAP-002 while hunting. The length of Iowa's deer season (including blow, rifle, antlerless, etc.) changes each year. An exposure frequency of 26 days a year at CC-IAAP-002 was selected as an upper bound estimate of a 30 year exposure period. The incidental ingestion rate and dermal contact parameters used are USEPA recommended default parameters for the outdoor worker receptor (USEPA, 2002b).

Future Land Use:

- Hunter: The future hunter is assumed to have the same exposure parameters as the current hunter.
- Outdoor worker: The future outdoor commercial/industrial worker scenario (e.g. landscaper, maintenance worker, etc.) is a long-term receptor that spends the majority of each work day outdoors (8 hours per day, 225 days per year, for 25 years per USEPA, 2002b) where incidental ingestion of soil, dermal contact with soil and inhalation of wind-borne dust occur. The incidental ingestion rate and dermal contact parameters used are the USEPA recommended default parameters for the outdoor worker receptor (USEPA, 2002b). This receptor is also evaluated for consumption of groundwater. In accordance with the dispute resolution document (USEPA, 2013c), it is assumed that the receptor drinks 1 liter of water per day, 250 days per year, for 25 years.
- Construction worker: The construction worker scenario provides an estimate of potential risks associated with a short-term, high-intensity contact with surface and subsurface soil. The construction worker scenario assumes that a worker spends each work-day over a one year period at the Site (resulting in a frequency of 8 hours per day, 5 days per week, or 250 days per year). Incidental soil ingestion and dermal contact exposures have been evaluated using UESPA recommended default parameters for this scenario assuming dermal exposure is limited to the head, hands, and forearms of the construction worker (USEPA, 2002b). Also inhalation of fugitive dusts or particulates generated was evaluated using USEPA recommended default parameters (USEPA, 2002b).

7.2.4 Toxicity Assessment

The objective of the toxicity assessment is to quantify the relationship between the intake, or dose, of COPCs and the likelihood that adverse health effects may result from exposure to the COPCs.

There are two major types of adverse health effects evaluated in the BHHRA: non-carcinogenic, and carcinogenic. Non-carcinogenic health effects refer to toxicological effects other than cancer which may result from exposure to a substance, such as toxicity to the liver, skin, or central nervous system. Carcinogenic health effects refer to the development of cancer which may result from exposure to a substance. Following USEPA guidance (USEPA, 1989), these two types of effects (non-carcinogenic and carcinogenic) are evaluated separately.

There are two types of toxicity values, or dose-response values, for evaluating health risks: cancer slope factors (CSFs) and unit risk (UR) values for carcinogens; and reference doses (RfDs) and reference concentrations (RfCs) for non-carcinogens. For potentially carcinogenic COPCs, both types of values have been developed by USEPA because these COPCs may elicit both carcinogenic and non-carcinogenic (systemic) effects. In addition, because toxicity and/or carcinogenicity can depend on the route of exposure (i.e., oral or inhalation), unique dose-response values have been developed for the oral, dermal, and inhalation exposure routes.

Section 7.2.4.1 describes the types of toxicity values that are used for evaluation of carcinogenic risks, and **Section 7.2.4.2** describes the types of toxicity values that are used for evaluation of non-cancer hazards.

7.2.4.1 Toxicity Assessment for Carcinogenic Effects

The toxicity assessment followed the USEPA two-part evaluation to characterize the carcinogenicity of a chemical. The first part involves assigning a weight-of-evidence classification to a chemical, which describes the strength of available information with respect to the association of chemical exposure and human cancer. The second part involves calculation of a CSF or UR to reflect the carcinogenic potency.

Historically, USEPA has used an alphanumeric system to describe the weight-of-evidence:

Group A - Human Carcinogen. This category indicates there is sufficient evidence from epidemiological studies to support a causal association between an agent and human cancer.

Group B - Probable Human Carcinogen. This category generally indicates there is at least limited evidence from epidemiologic studies of carcinogenicity to humans (Group B1) or that, in the absence of data on humans, there is sufficient evidence of carcinogenicity in animals (Group B2).

Group C - Possible Human Carcinogen. This category indicates that there is limited evidence of carcinogenicity in animals in the absence of data on humans.

Group D - Not Classified. This category indicates that the evidence for carcinogenicity in animals is inadequate.

Group E - No Evidence of Carcinogenicity to Humans. This category indicates that there is evidence of noncarcinogenicity in at least two adequate animal tests in different species or in both epidemiologic and animal studies.

This assessment also followed the revised Guidelines for Carcinogenic Risk Assessment (USEPA, 2005), wherein USEPA revised the approach to describing the carcinogenic potential of an agent from an alphanumeric system to a weight-of-evidence-based descriptive narrative. Descriptors are as follows:

Carcinogenic to Humans. This descriptor indicates strong evidence of human carcinogenicity, and is appropriate A) when there is convincing epidemiologic evidence of a causal association between human exposure and cancer; or B) when all of the following conditions are met: (a) there is strong evidence of an association between human exposure and either cancer or the key precursor events of the agent's mode of action but not enough for a causal association, and (b) there is extensive evidence of carcinogenicity in animals, and (c) the mode(s) of carcinogenic action and associated key precursor events have been identified in animals, and (d) there is strong evidence that the key precursor events that precede the cancer response in animals are anticipated to occur in humans and progress to tumors, based on available biological information.

Likely to be Carcinogenic to Humans. This descriptor is appropriate when the weight of the evidence is adequate to demonstrate carcinogenic potential to humans but does not reach the weight of evidence for the descriptor "Carcinogenic to Humans". The use of the term "likely" as a weight of evidence descriptor does not correspond to a quantifiable probability. Supporting data for this descriptor may include: an agent demonstrating a plausible (but not definitively causal) association between human exposure and cancer, in most cases with some supporting biological, experimental evidence, though not necessarily carcinogenicity data from animal experiments; an agent that has tested positive in animal experiments in more than one species, sex, strain, site, or exposure route, with or without evidence of carcinogenicity in humans; a positive tumor study that raises additional biological concerns beyond that of a statistically significant result, for example, a high degree of malignancy, or an early age at onset; a rare animal tumor response in a single experiment that is assumed to be relevant to humans; or a positive tumor study that is strengthened by other lines of evidence, for example, either plausible (but not definitively causal) association between human exposure and cancer or evidence that the agent or an important metabolite causes events generally known to be associated with tumor formation (such as DNA reactivity or effects on cell growth control) likely to be related to the tumor response in this case.

Suggestive Evidence of Carcinogenic Potential. This descriptor is appropriate when the weight of evidence is suggestive of carcinogenicity; a concern for potential carcinogenic effects in humans is raised, but the data are judged not sufficient for a stronger conclusion. This descriptor covers a spectrum of evidence associated with varying levels of concern for carcinogenicity, ranging from a positive cancer result in the only study on an agent to a single positive cancer result in an extensive database that includes negative studies in other species.

Data Inadequate for an Assessment of Human Carcinogenic Potential. This descriptor is appropriate when available data are judged inadequate for applying one of the other descriptors.

Not Likely to be Carcinogenic in Humans. This descriptor is appropriate when the available data are considered robust for deciding that there is no basis for human hazard concern. In some instances, there can be positive results in experimental animals when there is strong, consistent evidence that each mode of action in experimental animals does not operate in humans. In other cases, there can be convincing evidence in both humans and animals that the agent is not carcinogenic.

The weight of evidence classification in Integrated Risk Information System (IRIS) for a given chemical may reflect either of the two classification schemes identified above, depending on when USEPA most recently reviewed and revised the carcinogenicity assessment for any given chemical.

It has been generally assumed historically that carcinogenic effects are non-threshold effects. This means that any dose, no matter how small, has been assumed to pose a finite probability of generating a response. Thus, no dose of a carcinogen has been thought to be risk-free. More contemporary evaluations that focus on the mechanisms of action by which a chemical may cause cancer have, for some chemicals, identified threshold doses below which carcinogenesis does not occur. In consideration of the nature of the toxicological data that are available for a given chemical, USEPA uses one or more of several different models to identify the relationship between the dose of the chemical and a carcinogenic response.

The common measures of cancer potency assessment are the CSF (ingestion and dermal exposure) or a UR (commonly applied to inhalation). The CSF is the estimated upper-bound ELCR associated with a lifetime average daily dose of a chemical agent of 1 mg/kg/day and the inhalation UR is the upper-bound ELCR associated with a lifetime average daily exposure of 1 $\mu g/m^3$ in air. CSF values are expressed as risk per mg/kg/day $[(mg/kg/day)^{-1}]$ and UR values are expressed as risk per ($\mu g/m^3$) $[(\mu g/m^3)^{-1}]$. USEPA and other regulatory and scientific organizations have typically calculated CSFs and URs for chemicals in weight of evidence Groups A, B1, B2, and "Carcinogenic to humans" and "Likely to be carcinogenic to humans". For some, but not all chemicals with Group C weight of evidence classification, USEPA and other organizations have also calculated cancer dose-response values.

In this BHHRA, CSFs are used to estimate the incremental risks associated with ingestion and dermal exposures, and URs are used to estimate the cancer risks associated with inhalation of COPCs in air (airborne dust). The CSF and UR values and supporting documentation are provided in **Appendix F-9 Risk Tables 6.1** and **6.2**.

7.2.4.2 Toxicity Assessment for Non-Carcinogenic Effects

Unlike carcinogenic effects, non-carcinogenic effects are threshold effects and were evaluated accordingly. This means that at some level of exposure there is a threshold below which adverse effects would not be expected, and above which adverse effects could potentially occur. Examples of non-carcinogenic (i.e., threshold) effects include liver toxicity, kidney toxicity, reproductive effects, neurotoxicity, and teratogenicity. The same process that is used to identify toxicity data to support carcinogenic potency assessment is also used to identify toxicity data to support the identification of dose-response relationships for non-carcinogenic effects.

Non-cancer toxicity values include RfDs and RfCs. The RfD expressed in units of mg/kg/day, is defined as an estimate (with uncertainty spanning perhaps an order of magnitude or greater) of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime (USEPA, 1989). Unlike a CSF or UR, which represents a probability of incurring a carcinogenic effect following exposure to a substance, the RfD represents a threshold dose below which adverse health effects are unlikely to occur, and above which the potential for adverse health effects exists. The RfD is derived from the following equation:

$$RfD\ (mg/kg/day) = \frac{NOAEL\ or\ LOAEL}{UF\ and/or\ MF}$$

The NOAEL represents the dose of a chemical at which there are no statistically or biologically significant differences in the frequency of an adverse effect between the exposed population and its appropriate control. The LOAEL represents the lowest dose at which a statistically significant difference in the frequency of an effect is noted. Both the NOAEL and the LOAEL are reported in terms of mg/kg/day. An uncertainty factor (UF) is used to account for inter-species and intra-species differences, whether the dose was an NOAEL or an LOAEL, and the adequacy of the data. The magnitude of the UF will therefore vary from chemical to chemical, ranging from 3 to 3,000. A modifying factor (MF), ranging from 1 to 10 may also be included to reflect qualitative uncertainties not explicitly addressed in the UFs. The toxicity endpoint upon which the RfD is derived and the UF and/or MF used in the calculation are presented in the dose-response tables provided in **Appendix F-9 Risk Tables 5.1** and **5.2.**

The RfC, in units of mg/m^3, is analogous to the RfD and is developed through a similar process. However, unlike RfDs, which represent a dose (in mg/kg/day) at which adverse or deleterious effects are unlikely, RfCs represent air concentrations (in mg/m^3) at which adverse or deleterious effects are unlikely (i.e., an air concentration corresponding to a HI = 1.0). In this BHHRA, inhalation RfCs are used to estimate the non-cancer risks associated with inhaling COPCs.

The use of chronic RfDs and RfCs to evaluate the potential for adverse health effects resulting from substantially less-than-lifetime exposures may be overly protective. Subchronic Reference Doses and Subchronic Reference Concentrations (RfD_ss/RfC_ss) have been developed for some chemicals to evaluate the potential non-carcinogenic effects of limited duration exposures. Subchronic RfD_ss/RfC_ss are similar to chronic RfDs/RfCs; the distinction is the length of exposure duration. The construction worker scenario is the only scenario evaluated in this risk assessment that is associated with subchronic exposures. Therefore, when available subchronic RfDs and RfCs are used to evaluate potential non-cancer risks for the construction worker. Chronic RfDs and RfCs are used for all other receptor scenarios.

The RfDs and RfCs and supporting documentation for the chemicals selected as COPCs are provided in **Appendix F-9 Risk Tables 5.1** and **5.2**.

7.2.4.3 Adjustment for Dermal Exposure

Oral Cancer CSFs and non-cancer RfDs were developed to evaluate risk associated with the ingestion exposure route (typically based on the applied dose). In accordance with USEPA guidance (USEPA, 2004), dermal dose-response values are calculated from oral dose-response values using an oral absorption factor. The dermal dose-response values are appropriate for evaluating the calculated absorbed dose associated with dermal exposures. The oral absorption factor represents the fraction of ingested amount that is absorbed from the gastrointestinal tract following oral administration of a substance. The absorbed dose represents the amount of substance that is potentially available for biological interaction. The calculated dermal dose-response value is appropriate for evaluating the absorbed dermal doses.

Thus, for potentially carcinogenic substances, the dermal dose-response value is calculated as follows:

$$CSF_d = CSF_o / Oral\ ABS$$

The dermal dose-response value for evaluating non-carcinogenic effects is calculated as follows:

$$RfD_d = RfD_o\ X\ Oral\ ABS$$

Chemical-specific oral ABS values are published by USEPA (USEPA, 2004). In accordance with USEPA guidance (USEPA, 2004), oral dose-response values are only adjusted using an oral ABS value if the COPC has an oral ABS value less than 50 percent. Otherwise, the oral dose-response value is used as the dermal dose-response value.

Dermal CSFs and RfDs are presented in **Appendix F-9 Tables 6.1 and 5.1, respectively**.

7.2.4.4 Sources of Dose Response Values

USEPA guidance (USEPA, 2003a) was followed when selecting dose-response values.

The main source of dose-response values is the Tier 1 source, IRIS, which is a database established by USEPA containing all validated data on many toxic substances found at hazardous waste sites. This database (USEPA, 2013b), current as of August 2013, was used to identify the CSFs, URs, RfDs, and RfCs applied in this risk assessment. The Health Effects Assessment Summary Tables (HEAST, 2011), dated December 2011, was used to obtain a subchronic arsenic RfD. The CSF for hexavalent chromium was obtained from the NJDEP in accordance with the USEPA Region 7 Memorandum regarding Recommended Chromium (VI) Toxicity Values (USEPA, 2010b).

7.2.4.5 Chemical-Specific Considerations

Arsenic: Arsenic was evaluated using the USEPA 2012 guidance, Recommendations for Default Value for Relative Bioavailability of Arsenic in Soil, OSWER 9200.1-113 (USEPA, 2012c). This guidance recommends that in the absence of site-specific bioavailability testing, for soil ingestion exposures, a default Relative Bioavailability (RBA) of 60% be included in the dose calculations. This reflects that arsenic is soil is less bioavailable than from drinking water (the exposure medium upon which the toxicity values were based). The drinking water-based toxicity values are relevant for the water soluble arsenic species, but would overestimate biovailability of arsenic in soils and other solid media where the arsenic is not in a highly water soluble form. This 60% RBA is incorporated in the risk calculations for arsenic in soils.

7.2.5 Risk Characterization

Risk characterization, including uncertainty analysis, is the final step in the risk assessment process. The risk characterization integrates the exposure and toxicity information generated in previous sections to quantitatively evaluate the potential health risks associated with exposure to chemicals at the Site. Risk estimates are then evaluated through a comparison to CERCLA risk management criteria. Section 7.2.5.1 describes the methodology used to calculate risks for each COPC and to sum risk estimates among COPCs, exposure pathways, and exposure media to derive cumulative receptor risks. Section 7.2.5.2 provides the risk assessment results for each of the scenarios evaluated in the BHHRA. Section 7.2.5.3 identifies and discusses uncertainties in the BHHRA and their potential impact on the results and conclusions of the risk assessment.

7.2.5.1 Risk Characterization Methods

Quantitative estimates of both carcinogenic and non-carcinogenic risks are calculated for each exposure scenario selected for evaluation in the exposure assessment, in accordance with USEPA (1989) guidance.

An estimate of the ELCR associated with exposure to each COPC in a given medium is calculated by multiplying the exposure route pathway-specific lifetime average daily dose (e.g., dermal exposure to surface soil) or lifetime average exposure concentration (e.g., inhalation of dust) by its exposure route-specific CSF (e.g., oral CSF) or UR.

$$ELCR = \text{Lifetime Average Daily Dose or Exposure } (mg/kg/day \text{ or } \mu g/m^3) \times CSF\ (mg/kg/day)^{-1} \text{ or } UR\ (\mu g/m^3)^{-1}$$

The ELCR represents an upper bound of the probability of an individual developing cancer over a lifetime as the result of exposure to a COPC. The ELCR is calculated for each carcinogenic COPC for each medium and exposure route combination for each receptor at each exposure area. The ELCR for all COPCs in a given medium are summed to identify a route-specific total ELCR (e.g., soil ingestion) and the ELCR for all exposure routes for a given receptor/medium combination (e.g., soil ingestion and dermal contact) are summed to yield a total ELCR (e.g., for surface soil).

The non-cancer HQ associated with exposure to each COPC is calculated by dividing the exposure route pathway-specific average daily dose or exposure concentration by its exposure route-specific RfD or RfC.

$$HQ = \text{Average Daily Dose or Exposure } (mg/kg/day \text{ or } \mu g/m^3) \ /\ RfD\ (mg/kg/day) \text{ or } RfC\ (\mu g/m^3)$$

The HQ is calculated for each COPC for each medium and exposure route combination for each receptor at each exposure area. For a given medium/receptor/age group combination (e.g., surface soil and adult outdoor worker), HQs for all COPCs are summed by route (e.g., dermal contact) to identify a medium/route HI, and the HIs for multiple exposure routes (e.g., incidental ingestion and dermal contact) are summed to identify a medium-specific total HI (e.g., for surface soil ingestion and dermal contact). An HI less than 1 indicates that non-carcinogenic toxic effects are unlikely to occur as a result of COPC exposure. HIs greater than 1 may be indicative of a possible non-carcinogenic toxic effect. As the HI increases, so does the likelihood that adverse effects might be associated with exposure.

Risk calculations are documented in **Appendix F-12** (RAGS Part D Table 7s) and **Appendix F-13** (RAGS Part D Table 9s). **Tables 7.1** through **7.6** (called RAGS Part D tables 7s) in **Appendix F-12**, present, for a given receptor/age group and exposure point, COPC-specific cancer risk and HQs for each medium/exposure route combination (e.g., surface soil ingestion) and presents cumulative or total cancer risk and screening HI for each medium/exposure route combination (e.g., surface soil ingestion), the cumulative or total cancer risk and screening HI for each medium (e.g., surface soil), and the cumulative or total cancer risk and screening HI for the receptor/age group.

Tables 9.1 through **9.6** (called RAGS Part D table 9s) in **Appendix F-13** present the same calculated risk information in a slightly different structure, but also provides information beyond the simple, screening HI (it is assumed that non-cancer hazards of all COPCs are additive).

7.2.5.2 Risk Characterization Results

The calculated cancer and non-cancer risks are evaluated in the context of risk management criteria established in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and discussed in the preamble to the NCP (USEPA, 1990). The results of the baseline risk assessment are evaluated by comparing them to the USEPA's remedial goals. With respect to cancer risk, USEPA sets remediation goals for total cancer risk "that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} to 10^{-6} lifetime excess cancer risk." USEPA sets remediation goals for noncancer risk "such that exposures present no appreciable risk of significant adverse effects to individuals, based on comparison of exposures to the concentration associated with reliable toxicity information such as USEPA's reference doses." For cumulative risks due to noncarcinogens, "EPA will set the remediation goals at levels for individual chemicals such that cumulative effects of multiple chemicals will not result in adverse effects." USEPA has stated that "acceptable exposure for noncarcinogens is one to which human populations, including sensitive subgroups such as pregnant women and children may be exposed without adverse effects during a lifetime or part of a lifetime, incorporating an adequate margin of safety." Given the stated remediation goals, the results of the baseline risk assessment are evaluated in accordance with the NCP - cancer risk estimates for a site are compared to an ELCR range of 10^{-6} (one in a million) to 10^{-4} (one in ten-thousand). Total risks at or below 10^{-4} do not generally warrant a response action. Risks greater than 10^{-4} generally warrant development and evaluation of remedial alternatives. Non-cancer risks are compared to a HI value of 1, which corresponds to levels of exposure that people (including sensitive individuals) could experience without expected adverse effects.

Table 7-4 presents summaries of risks calculated for the current and future land use exposure scenarios for each exposure area, respectively. As indicated on Table **7-4** all of the total receptor ELCRs fall within the USEPAs acceptable risk range of 10^{-4} to 10^{-6} lifetime excess cancer risk. ELCRs range from $1x10^{-4}$ (for the future commercial/industrial worker) to $2x10^{-7}$ (for the future adolescent hunter). As indicated on Table 7-4, HIs range from 1(for the future construction worker worker) to 0.003 (for the current and future adult hunter). All cumulative HIs for a receptor are less than or equal to the USEPA acceptable risk level of 1.

Despite the very conservative assumptions built into this BHHRA, total ELCR to all receptors, with the exception of the commercial/industrial worker, yield risks ranging from $2x10^{-7}$ to $5x10^{-7}$, lower than USEPA's acceptable risk range of 10^{-4} to 10^{-6}. The risk estimate for the commercial/industrial worker is $1x10^{-4}$, which does not exceed USEPAs acceptable risk range of 10^{-4} to 10^{-6}. Arsenic contributes most to the carcinogenic risk estimates, primarily through dermal contact with soil ($1x10^{-6}$) and ingestion (hypothetical drinking water) of groundwater ($9x10^{-5}$). The future construction worker has an HI of 1.0 due to arsenic via inhalation of particulates. This does not exceed USEPA risk goals.

The risk estimates presented herein provide an upper estimate of risk posed to receptors at CC-IAAP-002 and are likely overly conservative for the following reasons:

- An outdoor worker, per USEPA guidance, was evaluated for the commercial/industrial worker scenario. This evaluation included dermal exposure to soil, performing work outdoors 225 days per year. However, it is much more likely that a future commercial/industrial worker would perform indoor work with occasional work outdoors. The standard USEPA commercial/industrial scenario for an indoor worker does not evaluate the dermal pathway and includes a lower ingestion rate (50 mg_{soil}/day in lieu of 100 mg_{soil}/day).
- The commercial/industrial worker was evaluated for consumption of groundwater from the site. This scenario is purely hypothetical as State regulations preclude the use of groundwater at the IAAAP from being used as a water supply. Further, maximum detected total metals concentrations were used as the EPCs in the consumption of groundwater scenario. Generally, water from a water supply well would be filtered prior to reaching the tap and dissolved metals concentrations would be representative of exposure rather than total metals. In addition, the maximum detected concentration is unlikely representative of the EPC rather an average would be more representative as the well captures water from a larger area than is represented by one monitoring well.

7.2.5.3 Uncertainty Analysis

This subsection identifies and discusses uncertainties in the risk assessment. These uncertainties are identified to provide perspective on the quantitative risk estimates. Unlike some other assessments, risk assessments rely not just on measured or certain facts, but also on assumptions and estimates, and also policy decisions, in the face of limited or nonexistent data. Historically, many risk assessments have used highly conservative assumptions in the place of unavailable data, with the net result often being a substantial overestimation of potential risks. It is important, however, to evaluate the assumptions and choices made in any risk assessment to evaluate their impact on the results and conclusions.

The following types of uncertainties should be considered in any BHHRA:

- uncertainties in the nature and extent of release of COPC;
- uncertainties associated with the identification of future land uses and potential receptors;
- uncertainties in estimating the frequency, duration, and magnitude of possible exposures (including the identification of representative EPCs in environmental media);
- uncertainties associated with assigning exposure parameters to a heterogeneous population that includes both men and women and young and old (e.g., BW and ingestion rates);
- uncertainties in estimating CSFs and URs and/or non-carcinogenic measures of toxicity (e.g., RfDs or RfCs); and

<u>Uncertainties in the nature and extent of release of COPCs</u>: There is some uncertainty associated with the delineation of the nature and extent of contamination. This is typical for most investigations, and is true for this investigation in particular due to lack of information regarding site history. However, every effort was made to collect sufficient data to characterize the nature and extent of contamination and adequately characterize risk. Sample collection was focused in locations where contamination was considered more likely to be present (i.e., in the immediate vicinity of the construction debris). Therefore, the data that have been collected for the site are likely a conservative representation of nature and extent, and are also more likely to result in overestimates rather than underestimates of the potential risk to human health posed by the site

Incremental risk comparing risk from site COPCs to background was not calculated, as the conservative risk estimates presented in this BHHRA did not calculate risk above USEPA's acceptable risk criteria. However, it should be noted that background concentrations of arsenic are similar to the concentrations detected at the site (minimum 0.5 mg/kg, maximum 30 mg/kg, average 7.327 mg/kg) and it is likely that background may contribute to the risk posed by arsenic at CC-IAAP-002.

Dimethyl phthalate was selected as COPC because no screening value was available for the compound. Dimethyl phthalate in surface soil, subsurface soil, and sediment at concentrations just slightly above the reporting limit. No toxicity value is published for dimethyl phthalate in IRIS. Given the very low detected concentrations it is unlikely that dimethyl phthalate contributes significantly to risk at CC-IAAP-002.

Benzo(a)pyrene was selected as a COPC in sediment at 0.3255 mg/kg, which is just slightly above the applicable RSL of 0.21 mg/kg. Benzo(a)pyrene was not evaluated for non-cancer risk, as an RfD has not been published for it; however, benzo(a)pyrene is expected to contribute negligibly to non-cancer risk in sediment. It was detected at very low concentrations and was screened against the USEPA RSLs for soil, adjusted to an HI of 0.1. This is a very conservative process as soil RSLs are based on frequent exposure to soils, and exposure to sediment would be expected to be less intense and less frequent.

<u>Uncertainties associated with the identification of future land uses and potential receptors</u>: There is little uncertainty associated with future land use and receptors. The Army is the current property owner and has indicated that they do not foresee developing the site in the future. Additionally, other receptors that

may access the site (e.g., trespassers) would have similar exposures as the hunter.

Uncertainties in estimating the frequency, duration, and magnitude of possible exposures (including the identification of representative EPCs in environmental media): A number of conservative assumptions were used when estimating the frequency duration, and magnitude of potential exposures. It is likely that these assumptions overestimate rather than underestimate risk associated with the receptors at the CC-IAAP-002. These conservative assumptions are described below.

The assumption that hunters will be present at CC-IAAP-002 one day a week for 26 weeks a year is very conservative; CC-IAAP-002 is a very small area of land (0.62-acres) with steep embankments. The likelihood that a hunter would do more than pass through CC-IAAP-002 is minimal.

The assumption that a commercial/industrial worker will be working outdoors 225 days per year is highly conservative as well. If CC-IAAP-002 is developed for commercial/industrial use, it is more likely that an indoor worker would be exposed to CC-IAAP-002 on a frequent basis (i.e., 250 days per year) and an outdoor worker (e.g., landscaper or maintenance worker) would be exposed on an infrequent basis. Additionally, the consumption of groundwater was evaluated based on an agreement in the dispute resolution document [USEPA 2013c]. However, groundwater at CC-IAAP-002 is not a current drinking water source. Additionally, due to State regulations and the fact that the Army has near total control over land use at the IAAAP; it is highly unlikely that groundwater will become a drinking water source. Lastly, the groundwater evaluation was performed using total metals concentrations. If groundwater were to be developed for future use it is most likely that it would be filtered prior to consumption.

Uncertainties associated with assigning exposure parameters to a heterogeneous population that includes both men and women and young and old (e.g., BW and ingestion rates): Again, conservative assumptions were used when developing the exposure scenarios. These assumptions are designed to address the most sensitive populations, so it likely overestimates rather than underestimates risk.

7.2.5.4 Risk Assessment Conclusions

Consistent with the current and foreseeable future land use, the BHHRA has evaluated potential exposures to surface soil, subsurface soil, groundwater, and surface water for current and future hunters, future outdoor workers, and future construction workers. This evaluation was performed using conservative exposure assumptions, which represent the very conservative estimates of potential site exposure. The conclusions of the BHHRA can be summarized as follows:

- The cancer risk estimates for the current adolescent hunter, current adult hunter, future adolescent hunter, future adult hunter, future commercial industrial worker, and future construction worker are within or below the Superfund acceptable risk range.
- The non-cancer HI estimates for the current adolescent hunter, current adult hunter, future adolescent hunter, future adult hunter, future commercial industrial worker, and future construction worker are below a value of 1.

Based on this evaluation, response actions are not recommended for CC-IAAP-002.

7.3 CC-IAAP-001 SLERA

This section presents the SLERA for construction debris site CC-IAAP-001. The SLERA is organized into three sections:

- The Problem Formulation (Section 7.3.1);
- The Exposure Estimate and Effects Evaluation (Section 7.3.2); and
- The Risk Characterization, Uncertainty Discussion, and Conclusions (Section 7.3.3).

7.3.1 Problem Formulation

The problem formulation provides the framework upon which the ecological risk assessment is organized. This section:

- Describes the environmental setting of CC-IAAP-001;
- Identifies rare, threatened and endangered species;
- Presents the data used in the SLERA;
- Presents the Ecological Conceptual Site Model;
- Identifies complete exposure pathways; and
- Identifies the assessment and measurement endpoints evaluated in the SLERA.

7.3.1.1 Environmental Setting

This section describes the environmental setting of CC-IAAP-001. Site background information, describing current and historical Site operations, can be found in Section 2.0 of the RI. Information on the physical characteristics of the Site including the climate, ecology, topography and surface water features, geology and hydrogeology can be found Section 4.0 of the RI.

An AMEC ecologist qualitatively assessed the dominant habitats and natural communities present at CC-IAAP-001 on June 13, 2013. Observations made during the habitat assessment were recorded on field forms which are presented along with representative photographs in Appendix G. Appendix G also provides the completed *Checklist for Ecological Assessment/Sampling* from Appendix B of the Process Document.

Weather conditions in the week prior to the habitat assessment included severe thunderstorms. Conditions the day of the habitat assessment were clear and sunny with temperatures between 80 to 90 °F.

CC-IAAP-001 is an approximately 1 acre parcel of land southwest of the intersection of Roads I and H. CC-IAAP-001 is bordered on three sides by roads and railroad tracks (Figure 2-2):

- To the north by Road I;
- To the east by Road H;

- To the south and southwest by an arching railroad spur and that crosses Road H; and
- To the west by woodlands which are also adjacent to the arching railroad.

This alignment of roads and railroads isolates CC-IAPP-001 from the Brush Creek riparian corridor that lies to the south and west. Land use to the east of CC-IAAP-001 is agricultural crop land. To the north of CC-IAAP-001 is the Line 2 industrial complex. The northeastern portion of CC-IAAP-001 was mowed. Additional areas were brush-hogged to allow for access to sampling areas.

Topography at CC-IAAP-001 slopes from north to south with high, steep embankments along Road H and the railroad spur.

At the base of the Road H embankment is an unnamed drainage way that crosses through CC-IAAP-001. The drainage way flows from north to south, first daylighting into CC-IAAP-001 from a 6 foot corrugated steel culvert under Road I. From there the drainage way continues approximately 200 feet before entering another 6 foot corrugated steel culvert under the railroad spur. Downstream of the railroad spur, south of CC-IAAP-001, the drainage way continues to the south flowing through the Brush Creek riparian corridor, eventually discharging into Brush Creek.

The segment of the unnamed drainage way in CC-IAAP-001 is characterized by steep banks and a straight, narrow channel. The Road H embankment, forming the eastern bank of the channel, is 15 to 20 feet high with a slope of approximately 30 to 45 degrees. The Road H embankment is thickly vegetated with willow (*Salix* sp.), blackberry (*Rubus* sp.), gray dogwood (*Cornus racemosa*), grape vines (*Vitis riparia*), staghorn sumac (*Rhus typhina*), gooseberry (*Ribes uva-crispa*), and poison ivy (*Rhus radicans*). The western bank of the channel is a steep (>45 degree), 10 to 12 foot sand bank. The western bank is vegetated primarily with poison ivy and grasses. The western bank is steepest at the northern end of the channel immediately adjacent to the Road I culvert. In places along the northern end of the channel, the western bank is collapsed, exposing areas of unvegetated sand. Towards the southern end of the channel the western sand bank is less steep (<45 degree) and the vegetation is more developed with a shrub layer present.

At the north end of the unnamed drainage way, the wetted width of the channel during the June 2013 habitat assessment was approximately 3.5 feet with a bank-full width of 5 to 6 feet. The water the day of the assessment was observed to be 3 to 6 inches deep and highly turbid, likely due to the severe thunderstorms in the days prior to the habitat assessment. At the north and south ends of the drainage way there are small, shallow pools (approximately 3 feet wide by 5 feet long and 6 inches deep). The rest of the drainage way channel is a single run. Substrate in the channel is mostly sand (80%) with some gravel (20%) at the north end of the channel, transitioning to mostly gravel (60%) with some cobbles (20%) and sand (20%) at the south end of the channel. Near the middle of the drainage way the wetted width of the channel decreases to approximately 1 foot wide. Flow in the middle of the drainage way (approximately 2 inches per second) decreased relative to upstream and downstream flow (3 to 4 inches per second).

To the west of the unnamed drainage way, habitat in CC-IAAP-001 transitions from grasses and shrubs to a small patch of woods dominated by the invasive eastern red cedar (*Juniperus virginiana*) and red pine (*Pinus resinosa*). Shrub species present throughout the transitional zone and forested area include American elderberry (*Sambucus nigra* subsp. *Canadensis*), prickly ash (*Xanthoxylum americanum*), and greenbrier (*Smilax rotundifolia*).

During the habitat assessment, bird calls and numerous insects were observed in CC-IAAP-001. However, the fragmentation of CC-IAAP-001 by the railroad spur to the south and west from the Brush Creek riparian corridor and the developed land use to the north and east likely limits the area's ability to support wildlife. Habitat use is likely limited to transitory use by most species.

The culverts at both ends of the unnamed drainage way likely prevent migration of fish from downstream. No fish were observed during the habitat assessment. The drainage is also likely intermittent. The unnamed drainage way is not marked on the 7 ½ minute topographic map of the West Burlington, Iowa Quadrangle (USGS, 2010a), further suggesting the unnamed drainage way is not a permanent water body. Intermittent streams typically support only the most stress tolerant benthic invertebrate species. No benthic invertebrates or amphibians were observed during the habitat assessment.

Construction and demolition debris in CC-IAAP-001 was visible in several eroded areas along the Road H embankment. Surface debris also exists along the drainage located at the base of the embankment along Road H. Visible debris observed included scattered bricks, corrugated metal, metal parts, wire, and metal banding.

7.3.1.2 Rare, Threatened, and Endangered Species

The federally endangered Indiana bat (*Myotis sodalis*) is the only federally-listed species known to occur in the vicinity of the site but has never been observed at IAAAP (see Section 4.2).

State-listed species known to occur at the site include:

- Western worm snake (*Carphophis amoenus vermis*) (state-listed threatened),
- Henslow's sparrow (*Ammodramus henslowii*) (state-listed threatened), and
- Bald eagle (*Haliaeetus leucocephalus*) (state-listed special concern species).

Bald eagles have been observed at the site, however they are not known to have any nesting sites on the installation. The bald eagle was federally delisted in 2007.

One state listed (threatened) species, the orangethroat darter (*Etheostoma spectabile*), is known to occur in Brush Creek. However, the presence of a perched culvert approximately 1,500 feet downstream of CC-IAAP-001 likely prevents these fish from migrating upstream to the vicinity of the construction debris site (personal communication with IAAAP Natural Resources Manager Joe Halfner).

No federally-listed plant species have been recorded on IAAAP; however, six state-listed threatened vascular plant species have been identified including:

- Blue ash (*Frasinus quadrangulata*)
- Virginia-snakeroot (*Aristolochia serpentaria*),
- mint (*Blephilia ciliata*),
- false hellebore (*Veratrum woodii*),
- slender ladies' tresses (*Spiranthes lacera*)
- sharpwing monkey flower (*Mimulus alatus*)

In addition, the butternut tree (*Juglans cinerea*), a former federal candidate species, is known to occur at the IAAAP and is a conservation concern as most of the installation's population is dying from butternut canker fungus (Horton *et al*. 1996).

None of the plant or animal species listed above were observed within the boundaries of CC-IAAP-001 during the habitat assessment.

7.3.1.3 Data Used in the SLERA

Analytical data used in the SLERA were collected during RI field sampling in June, 2013. Data were collected and analyzed in accordance with the Final RI Work Plan (PIKA, 2013) as described in detail in Section 3.0. In the SLERA, field sample results were averaged with corresponding field duplicate sample results. Averages were calculated using ½ the reporting limit for non-detects.

CC-IAAP-001 samples evaluated in the SLERA include:

- Seven surface soil samples (including one averaged set of field and field duplicate samples) collected from 0 to 0.5 feet below ground surface (bgs);
- Three surface water samples (including one averaged set of field and field duplicate samples); and
- Four sediment samples (including one averaged set of field and field duplicate samples) collected from 0-0.5 feet bgs.

Table G-1 lists samples used in the CC-IAAP-001 SLERA. Groundwater and subsurface soil (1 to 10 feet bgs) are not evaluated in the SLERA as ecological receptors are not expected to have substantial exposure to those media.

Background soil data were also used in the SLERA to characterize naturally occurring levels of metals in surface soil at IAAAP. Background surface soil concentrations were developed in the "*Line 1 and Firing Site Supplemental Remedial Investigation Report*" for the Site (T&N Associates, 2001). Background levels were derived as average concentrations from 107 samples collected between 1991 and 1993 from locations in the northern portion of the installation, upgradient (with respect to overland surface drainage and groundwater flow) from all site features, production activities, and waste handling and disposal operations.

7.3.1.4 Complete Exposure Pathways

Chemicals may move from environmental media to ecological receptors through several major biological exposure mechanisms:

- Ingestion of chemicals bound to sediment (aquatic invertebrates, amphibians and semi-aquatic birds and mammals);
- Ingestion of dissolved chemicals in surface water (benthic invertebrates, amphibians and semi-aquatic birds and mammals);
- Ingestion of chemicals in soil (terrestrial invertebrates and terrestrial birds and mammals);
- Ingestion of chemicals through consumption of affected plants (herbivores, omnivores);
- Ingestion of chemicals through consumption of affected prey (all predators).

Although inhalation and dermal absorption pathways are possibly complete for some receptors, these pathways are considered to be minor compared to dietary ingestion and are not evaluated.

The results of the field screening for radiological constituents of uranium found no evidence of radioactivity (Section 3.0). Radiological exposure pathways are considered incomplete and are not further assessed in this SLERA. Chemical risks from uranium are considered to be potentially complete are further assessed.

7.3.1.5 Ecological Conceptual Site Model

The ecological conceptual site model for CC-IAAP-001 (Figure G-1) illustrates initial estimates of contaminant fate and transport mechanisms, complete exposure pathways, and primary and secondary receptors. The ecological conceptual site model is based on the current understanding of Site conditions, and serves as a framework for evaluating ecological exposure and risk.

The ecological conceptual site model describes:

- Source areas – where chemical contaminants may have originated;
- Transport mechanisms – processes that partition chemicals among various environmental media;
- Exposure media – environmental media which may contain chemical contaminants; and
- Ecological receptors – organisms that may be exposed to chemical contaminants in exposure media.

7.3.1.6 Assessment and Measurement Endpoints

Assessment endpoints 1 and 2 are ecological attributes that are to be protected and measurement endpoints are measurable characteristic of those attributes. Assessment and measurement endpoints are used in a SLERA to gauge the degree of impact that has occurred or may occur from exposure of ecological receptors to chemical contaminants in exposure media.

Assessment endpoints in this SLERA are generic assessment endpoints associated with screening ecological toxicity endpoints. The endpoints are considered generic because they are based on a variety of organisms and are therefore considered to be representative of entire communities. Assessment Endpoint 3 focuses on Indiana bat. As a sensitive species, the risk assessment considers effects at the individual, rather than the population or community level. Though the Indiana bat has not been observed at CC-IAAP-001, it was identified as a separate assessment endpoint because the USFWS has historically requested that Indiana bat be evaluated at the IAAAP. The assessment and measurement endpoints for CC-IAAP-001 are presented below:

Assessment and Measurement Endpoints for CC-IAAP-001

Assessment Endpoint	**Measurement Endpoints**
1. Sustainability (survival, growth, reproduction) of local populations of aquatic and semi-aquatic organisms (aquatic invertebrates, amphibians and semi-aquatic birds and mammals) exposed to surface water and sediment.	a. Compare maximum surface water concentrations to surface water quality benchmarks. b. Compare maximum sediment concentrations to sediment quality benchmarks.
2. Sustainability (survival, growth, reproduction) of local populations of terrestrial organisms (terrestrial plants, terrestrial invertebrates and terrestrial birds and mammals) exposed to soil.	a. Compare maximum soil concentrations to soil quality benchmarks.

7.3.2 Screening Level Exposure Estimate and Effects Evaluation

The screening level exposure estimate and effects evaluation provides the screening level evaluation of risks to ecological receptors exposed to chemicals in environmental media. This section:

- Identifies exposure point concentrations (EPCs);
- Identifies screening benchmarks;
- Presents the methods used for the risk calculation; and
- Presents the results of the risk calculation.

Interpretation of the results of the risk calculation is reserved for Section 7.3.3 (Risk Characterization).

7.3.2.1 Screening Level Exposure Point Concentrations

Maximum detected concentrations (MDCs) of analytes in surface soil, surface water, and sediment data sets were used as screening level EPCs for CC-IAAP-001. MDCs were compared to screening benchmarks to select COPECs and to calculate risks as described in the following sections.

7.3.2.2 Screening Benchmarks

For this SLERA, screening benchmarks were used to assess the potential for risks to ecological receptors to occur from exposure to chemical constituents in surface soil, surface water, and sediment. Screening benchmark values are based on conservative assumptions and represent, where possible, no-observable-adverse-effects-levels (NOAELs) for chronic exposures.

The screening benchmarks were obtained following the selection hierarchy in the order presented below, by medium:

Soil

1. USEPA Ecological Soil Screening Levels (Eco-SSLs) (USEPA, 2003-2007);
2. USEPA Region V Ecological Screening Levels (ESLs) (USEPA, 2003b); and
3. Final selected NOAEL-based Critical Concentrations (CC's) for Terrestrial Receptors from the Site-Wide Baseline Ecological Risk Assessment (MWH, 2004) where CC's are lower than screening benchmarks identified from the above listed sources, as specified in the Final RI Work Plan (PIKA, 2013).

Surface Water

1. Iowa Water Quality Standards (Iowa Administrative Code, 2012);
2. USEPA freshwater chronic AWQC (USEPA, 2013d);
3. Oak Ridge National Laboratory (ORNL) Secondary Chronic Values (SCVs) for aquatic life (Suter & Tsao, 1996);
4. USEPA Region V ESLs (USEPA, 2003b); and
5. Final selected NOAEL-based CC's for Aquatic Receptors from the Site-Wide Baseline Ecological Risk Assessment (MWH, 2004) where CC's are lower than screening benchmarks identified from the above listed sources, as specified in the Final RI Work Plan (PIKA, 2013).

Sediment

1. Consensus-based threshold effects concentrations (TECs) (MacDonald *et al.*, 2000);
2. Ontario Ministry of the Environment (OMOE) Lowest Effects Levels (LELs) (OMOE, 1993);
3. ORNL Sediment SCVs (Jones, Suter, & Hull, 1997);
4. USEPA Region V ESLs (USEPA, 2003b);
5. Final selected NOAEL-based CC's for Aquatic Receptors from the Site-Wide Baseline

Ecological Risk Assessment (MWH, 2004) where CC's are lower than screening benchmarks identified from the above listed sources, as specified in the Final RI Work Plan (PIKA, 2013).

7.3.2.3 Screening Level Risk Calculation

Maximum detected concentrations were compared to screening benchmarks in order to calculate a HQ:

$$HQ = \frac{EPC}{Screening\ Benchmark\ Value} \qquad \text{(Equation 1)}$$

An HQ ≤1 conservatively indicates that the chemical constituent alone is unlikely to cause adverse ecological effects and can be eliminated from further discussion or evaluation. Analytes with an HQ > 1 are considered COPECs and were retained for further evaluation. Analytes that were not detected (by exposure area and medium) were eliminated from further evaluation. Screening benchmarks were not available for all detected analytes. In all cases, analytes lacking screening benchmarks were retained for further evaluation. Calcium, magnesium, and sodium were screened out as COPECs as they are macronutrients which naturally occur at high concentrations in the environment and are not expected to have effects on ecological receptors.

7.3.2.4 Risk Calculation Results

This section presents the results of the risk calculation by medium. Table G-2 through Table G-4 show the summary statistics for each data set and the risk calculation.

CC-IAAP-001 – Surface Soil

Analytes retained as COPECs in CC-IAAP-001 surface soil for which MDCs exceeded screening benchmarks include:

- Endrin Aldehyde (HQ=1.6);
- Cadmium (HQ=1.2);
- Lead (HQ=2.5); and
- Selenium (HQ=6.5).

Uranium was also detected in CC-IAAP-001 surface soil and retained as a COPEC as no screening benchmark was available.

CC-IAAP-001 – Surface Water

Analytes retained as COPECs in CC-IAAP-001 surface water for which MDCs exceeded screening benchmarks include:

- Total Barium (HQ=1.2);
- Dissolved Barium (HQ=1.2);
- Total Hexavalent Chromium (HQ=1.5); and
- Total Selenium (HQ=2.7).

Total and dissolved uranium were also detected in CC-IAAP-001 surface water and retained as COPECs as no screening benchmarks were available.

CC-IAAP-001 – Sediment

Analytes retained as COPECs in CC-IAAP-001 sediment for which MDCs exceeded screening benchmarks include:

- Arsenic (HQ=14);
- Barium (HQ=6.8); and
- Selenium (HQ=3.2).

Uranium and hexavalent chromium were also detected in CC-IAAP-001 sediment and were retained as COPECs as no screening benchmarks were available.

7.3.3 Risk Characterization, Uncertainties, Conclusions and Recommendations

This section characterizes the results of the benchmark screening, reviews ecological toxicity information available for COPECs, considers uncertainties, and summarizes final conclusions and recommendations.

7.3.3.1 Screening Level Risk Characterization

This section presents the screening level risk characterization. This section is organized by exposure area, media and contaminant class. Risks from analytes with HQs < 1 are considered negligible risk and therefore have not been further characterized.

CC-IAAP-001 – Surface Soil

One pesticide (endrin aldehyde) and four metals (cadmium, lead, selenium and uranium) were retained as COPECs in CC-IAAP-001 surface soil.

<u>Pesticides</u>

Endrin aldehyde was detected in six of the seven surface soil samples collected from CC-IAAP-001. The maximum detected concentration (MDC) (0.017 mg/kg) was slightly above the screening benchmark (0.0105 mg/kg) resulting in an HQ of 1.6. However, screening benchmarks are highly conservative (see Section 7.3.3.2). Considering the conservative nature of the screening benchmarks, and the low HQ (1.6), risks to ecological receptors from concentrations of endrin aldehyde in CC-IAAP-001 surface soil are likely negligible.

Metals

Cadmium was detected in all seven surface soil samples collected from CC-IAAP-001. The MDC (0.43 mg/kg) is slightly above the screening benchmark (0.36 mg/kg). However, the MDC of cadmium in CC-IAAP-001 surface soil is less than the IAAAP background concentration (0.73 mg/kg). Risk to ecological receptors from concentrations of cadmium in CC-IAAP-001 surface soil is therefore likely negligible.

Lead was detected in all seven surface soil samples collected from CC-IAAP-001. The MDC (28 mg/kg) is slightly above the screening benchmark (11 mg/kg) resulting in an HQ of 2.5. The MDC (28 mg/kg) is similar to the IAAAP background concentration (17.7 mg/kg). Considering the conservative nature of screening benchmarks (see Section 7.3.3.2), the low HQ (2.5), and background condition, risks to ecological receptors from concentrations of lead in CC-IAAP-001 surface soil are likely negligible.

Uranium was detected in all seven surface soil samples collected from CC-IAAP-001. No screening benchmark was available for uranium from the standard sources identified in Section 7.3.2.2; therefore it was retained as a COPEC for further evaluation. However, further review of the scientific literature suggests that concentrations of uranium detected in CC-IAAP-001 surface soil are substantially lower than those associated with chemical toxicity to ecological receptors.

Sheppard *et al.* (2005) reviewed data relating to uranium toxicity in terrestrial ecosystems and proposed predicted no effect concentrations (PNECs) for soil of 250 mg/kg for terrestrial plants and 100 mg/kg for soil organisms.

USGS (2010b) also reviewed the ecological toxicity data for uranium in soil and found the following lowest available chemical toxicity values for chronic effects:

- For plants: a No-Observed-Effect-Concentration (NOEC) of 10 mg/kg for effects on growth for Swiss chard (*Beta vulgaris*) (Sheppard *et. al*., 1983);
- For earthworms: a NOEC of 1,000 mg/kg for mortality (Sheppard & Evenden, 1992); and

For all species of soil invertebrates: an EC20 (concentration resulting in effects to 20% of the test population) of 92 mg/kg for mortality for the springtail (*Onychiurus folsomi*) (Sheppard *et. al.,* 2004).

The MDC of uranium in CC-IAAP-001 surface soil (1.1 mg/kg) is an order of magnitude lower than the lowest chemical toxicity values for chronic effects on terrestrial receptors (10 mg/kg for plants; USGS (2010b). Risks to ecological receptors from uranium in CC-IAAP-001 surface soil are therefore likely negligible.

CC-IAAP-001 – Surface Water

Four metals (barium, hexavalent chromium, selenium, and uranium were retained as COPECs in CC-

IAAP-001 surface water.

Metals

MDCs of total and dissolved barium in CC-IAAP-001 surface water were both 130 µg/L. These concentrations are slightly above the screening benchmark (110 µg/L) resulting in HQs of 1.2. However, considering the conservative nature of screening benchmarks (see Section 7.3.3.2) and the low HQs (1.2), risk to ecological receptors from concentrations of barium in CC-IAAP-001 surface water are likely negligible.

Hexavalent chromium was detected in CC-IAAP-001 surface water in one of three samples. Hexavalent chromium was not detected in filtered (*i.e.* dissolved) samples, suggesting that it is bound to particles and not in a readily bioavailable form. The detected concentration of hexavalent chromium (16 µg/L) is slightly above the screening benchmark (11 µg/L) resulting in an HQ of 1.5. Considering the conservative nature of screening benchmarks (See Section 7.3.3.2), the low HQ (1.5), and considering that hexavalent chromium is bound and not readily bioavailable, risk to ecological receptors from concentrations of hexavalent chromium in CC-IAAP-001 surface water are likely negligible.

Selenium was detected in CC-IAAP-001 surface water in one of three samples. Selenium was not detected in filtered (*i.e.* dissolved) samples, suggesting that it is bound to particles and not in a readily bioavailable form. The detected concentration (1.8 µg/L) concentration is slightly above the screening benchmark (0.66 µg/L). The screening benchmark is a CC NOAEL from the Site Wide BERA. As discussed further in Section 7.3.3.2, CC NOAELs are the lowest no-effect toxicity reference values (TRV) available in the scientific literature, do not incorporate site-specific estimates of contaminant bioavailability or receptor exposure, and thus are overly conservative.

Despite the selenium concentration being above the CC NOAEL, the MDC of selenium in CC-IAAP-001 surface water is less than other conservative and widely used benchmarks, such as the Iowa Surface Water Quality Standard for selenium (5 µg/L). Risks from selenium in CC-IAAP-001 surface water to aquatic and semi-aquatic receptors is likely negligible.

Uranium was detected in all three surface water samples collected from CC-IAAP-001, in both filtered (*i.e.* dissolved) and unfiltered (*i.e.* total) samples. No screening benchmark was available for uranium from the standard sources identified in Section 7.3.2.2; therefore it was retained as a COPEC for further evaluation. However, further review of the scientific literature suggests that concentrations of uranium detected in CC-IAAP-001 surface water are substantially lower than those associated with chemical toxicity to ecological receptors.

USGS (2010b) reviewed aquatic ecological toxicity data for uranium. In surface water, the lowest available chemical toxicity values for chronic effects on aquatic receptors include:

- For amphibians: a LOEC of 1,750 µg/L for effects on survival and growth for the Iberian green frog (*Rana perezi*) (Marques *et. at.* 2008); and

- For invertebrates: a NOEC of 1.5 µg/L and a LOEC of 2.7 µg/L, for reproduction endpoints on the water flea (*Ceriodaphnia dubia*) (Picket *et. al.* 1993).

MDCs of total and dissolved uranium in CC-IAAP-001 surface water are 1.7ug/L and 1.5ug/L, respectively. Concentrations of dissolved uranium, which represents the most bioavailable fraction, is consistent with the lowest NOEC, above. Risks to ecological receptors from the detected concentrations of uranium in CC-IAAP-001 surface water are therefore likely negligible.

CC-IAAP-001 – Sediment

Four metals (arsenic, barium, hexavalent chromium, selenium and uranium) were retained as COPECs in CC-IAAP-001 sediment.

Metals

Arsenic was detected in all four sediment samples collected from CC-IAAP-001 sediment. The MDC (8.4 mg/kg) is above the screening benchmark of 0.59 mg/kg. The screening benchmark is a CC NOAEL from the Site Wide BERA and overestimates risks more so than other benchmarks (see Section 7.3.3.2). Comparing the MDC to other benchmarks, such as the TEC of 9.79 mg/kg (MacDonald *et. al*., 2000), indicates that risk to ecological receptors from concentration of arsenic in CC-IAAP-001 sediment is likely negligible.

Barium was detected in all four sediment samples collected from CC-IAAP-001 sediment. The MDC (160 mg/kg) is above the screening benchmark (23.7 mg/kg). However, the MDC is below the IAAAP background concentration of barium in soil (201 mg/kg) which indicate that barium naturally occurs at high levels in the surficial geology (T&N Associates, 2001). Risks to ecological receptors from barium in CC-IAAP-001 sediment are therefore likely negligible.

Hexavalent chromium was detected in 3 of 4 samples collected from CC-IAAP-001 sediment at an MDC of 0.89 mg/kg. No ecological screening value (ESV) was available for hexavalent chromium as most studies evaluating the toxicity of chromium in sediment measure total chromium and do not provide information on the species of chromium present. This is largely due to nearly all chromium in sediments being present in the trivalent form (Environment Canada, 1994). Under anoxic conditions, such as those typical of sediments, hexavalent chromium is readily reduced to trivalent chromium by a number of chemical and microbial species found in the environment. Trivalent chromium is relatively insoluble and nontoxic. Trivalent chromium is rarely found in the dissolved form and is generally sorbed to organic particles and as such cannot readily pass through cell membranes and does not have the same oxidative potential as hexavalent chromium. (Rifkin *et. al* 2004). Total chromium toxicity in sediment is therefore largely a function of the more soluble and toxic hexavalent chromium, which is typically present only as a small fraction of total chromium in sediment.

In CC-IAAP-001 sediment, hexavalent chromium was 5.2% of total chromium. This is consistent with Environment Canada's (2004) finding that most chromium in sediment is present as trivalent chromium.

The Ecological Screening Value (ESV) for total chromium used in the SLERA is a Threshold Effect Concentration (TEC) from MacDonald *et al.* (2000) developed for total chromium from freshwater sediment samples. These sediments would be expected to show a distribution of trivalent and hexavalent chromium similar to that found in CC-IAAP-001 sediment. Since the maximum total chromium concentration in CC-IAAP-001 sediment (17 mg/kg) is substantially less than the ESV (43.4 mg/kg) and the ESV is based on total chromium in sediments expected to show similar distributions of trivalent and hexavalent chromium, risks to ecological receptors from concentrations of hexavalent chromium in CC-IAAP-001 sediment are unlikely.

Selenium was detected in all four sediment samples collected from CC-IAAP-001 sediment at an MDC of 3 mg/kg. The MDC is above the screening benchmark of 0.93 mg/kg. The screening benchmark is a CC NOAEL from the Site Wide BERA and overestimates risks more so than other benchmarks (see Section 7.3.3.2). Considering the conservative nature of the screening benchmark and the low HQ (3.2), risk to ecological receptors from concentrations of selenium in CC-IAAP-001 sediment are likely negligible.

Uranium was detected in all three sediment samples collected from CC-IAAP-001. No screening benchmark was available for uranium from the standard sources identified in Section 7.3.2.2; therefore it was retained as a COPEC for further evaluation. However, further review of the scientific literature suggests that concentrations of uranium detected in CC-IAAP-001 sediment are substantially lower than those associated with chemical toxicity to ecological receptors.

USGS (2010b) reviewed aquatic ecological toxicity data for uranium. In sediment the lowest available chemical toxicity values for effects on aquatic receptors include:

- For invertebrates: an LC50 (lethal concentration affecting 50% of the test population) of 57 mg/kg for the amphipod (*Hyalella azteca*) (CCME, 2007).

Chronic toxicity values are often estimated from acute values by applying a safety factor of between 10 and 100. The MDC of uranium in CC-IAAP-001 sediment is 0.78 mg/kg, approximately two orders of magnitude lower than lowest available chemical toxicity values for acute effects on aquatic receptors. Risks to ecological receptors from the detected concentrations of uranium in CC-IAAP-001 sediment are therefore likely negligible.

Indiana Bat

The Indiana bat is considered a protected species, thus it customary to assess risk at the individual, rather than the population level. It is also customary to use lines of evidence that emphasize conservative assumptions including maximum detected concentrations and no-observable-average-effects-levels (NOALEs). Since the screening level risk calculations for other terrestrial and aquatic receptors identified in assessment endpoint 1 and 2 were evaluated under those same conservative lines of evidence, the findings presented in the previous paragraphs also apply to Indiana bat. Therefore, risk to individual Indiana bats from constituents detected in CC-IAAP-001 surface soil, sediment, and surface is negligible.

7.3.3.2 Uncertainties

This section presents and discusses the uncertainties associated with the various measurements, calculations, and assumptions which form the basis of the risk characterization. Awareness of the uncertainties involved in each step of the risk assessment is critical to interpreting and understanding site risk.

Uncertainties Associated with EPCs

The use of MDCs as EPCs in the SLERA is highly conservative. MDCs represent a single point whereas populations of receptors would be exposed to the full range of concentrations throughout an exposure area. Average concentrations would be a more accurate estimate of EPCs, and can be used in subsequent steps of the ecological risk assessment process (if necessary).

Uncertainties Associated With Screening Benchmarks

Screening benchmarks are generally based on no-observable-adverse-effects-levels (NOAELs) for chronic exposures for a wide range of potential ecological receptors. As such, HQs >1 based on screening benchmark comparisons do not indicate that adverse effects may occur, only that detected concentrations are above those at which adverse effects are unlikely to occur.

In addition, screening benchmark comparisons incorporate numerous conservative assumptions. For example, screening benchmark comparisons assume 100% bioavailability. However, in natural environments, a variety of mechanisms related to site-specific conditions reduce the bioavailability of metals to ecological receptors, including:

- adsorption to mineral surfaces, particularly iron and manganese oxyhydroxides;
- adsorption to clays;
- sorption to organic matter; and
- formation of secondary solid metal phases such as carbonates, apatites, and sulfides (Barnett et. al., 2003).

Assuming 100% bioavailability therefore results in an overestimate of risk.

Other conservative assumptions incorporated into screening benchmark comparisons include the presence of the most sensitive receptor which may not be the case in the field. Also, conservative assumptions regarding receptors' dietary composition and ingestion rates generally result in overestimates of site risk in the SLERA.

Uncertainties Associated with Using CC NOAELs from the Site Wide BERA

In accordance with the Final RI Work Plan (PIKA, 2013), the SLERA used CC NOAELs from the Site Wide BERA as screening benchmarks when those values were lower than values in other sources listed in the selection hierarchy (see Section 7.3.2.2). CC NOAELs were selected as the lowest TRVs from the scientific literature; do not take into account data quality, geographic applicability, or other site or project specific factors; and incorporate numerous conservative assumptions associated with other benchmarks such as 100% bioavailability. As a result, CC NOAELs are generally more over-conservative than other sources of benchmarks used in this SLERA. In order to mitigate the degree of overestimation of risk, parameters that were identified as COPECs based on comparison to CC NOAELs were compared to other appropriate standards to characterize risk.

Additional Uncertainties

Some chemicals could not be ruled out based on ecological screening benchmarks because they lacked benchmarks. However, chemicals which lacked screening benchmarks were evaluated by other tools, including comparison to background, where possible. Hexavalent chromium in sediment lacked both benchmarks and background so could not be assessed.

7.3.3.3 Conclusions and Recommendations

This SLERA of construction debris site CC-IAAP-001 evaluated the potential for chemical constituents of concern detected in surface soil, surface water and sediment to adversely affect ecological receptors. This SLERA followed the approach outlined in *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA, 1997). In accordance with this Process Document, the SLERA identified complete exposure pathways, conducted a conservative assessment of all COPECs.

Based on the screening level risk estimate and considering the conservative nature of screening level ecological risk assessment tools:

- Risks to ecological receptors (including Indiana bat) from constituents in CC-IAAP-001 surface soil are likely negligible.
- Risks to ecological receptors (including Indiana bat) from constituents in CC-IAAP-001 surface water are likely negligible.
- Risks to ecological receptors (including Indiana bat) from constituents in CC-IAAP-001 sediment are likely negligible.

No further evaluation of risk to ecological receptors in CC-IAAP-001 is necessary.

7.4 CC-IAAP-002 SLERA

This section presents the SLERA for construction debris site CC-IAAP-002. The SLERA is organized into three sections:

- The Problem Formulation (Section 7.4.1);
- The Exposure Estimate and Effects Evaluation (Section 7.4.2); and
- The Risk Characterization, Uncertainty Discussion, and Conclusions (Section 7.4.3).

7.4.1 Problem Formulation

The problem formulation provides the framework upon which the ecological risk assessment is organized. This section:

- Describes the environmental setting of CC-IAAP-002;
- Identifies rare, threatened and endangered species;
- Presents the data used in the SLERA;
- Presents the Ecological Conceptual Site Model;
- Identifies complete exposure pathways; and
- Identifies the assessment and measurement endpoints evaluated in the SLERA.

7.4.1.1 Environmental Setting

This section describes the environmental setting of CC-IAAP-002. Site background information, describing current and historical Site operations, can be found in Section 2.0 of the RI. Information on the physical characteristics of the Site including the climate, ecology, topography and surface water features, geology and hydrogeology can be found Section 4.0 of the RI.

An AMEC ecologist qualitatively assessed the dominant habitats and natural communities present at CC-IAAP-002 on June 13, 2013. Observations made during the habitat assessment were recorded on field forms which are presented along with representative photographs in Appendix G. Appendix G also provides the completed *Checklist for Ecological Assessment/Sampling* from Appendix B of the Process Document.

Weather conditions in the week prior to the habitat assessment included severe thunderstorms. Conditions the day of the habitat assessment were clear and sunny with temperatures between 80 to 90 °F.

CC-IAAP-002 is an approximately 0.63 acre parcel of land within the Brush Creek riparian corridor (Figure 3-2). The dominant habitat in CC-IAAP-002 is early to mid-successional forest. Tree species present include the invasive eastern red cedar, bitternut hickory (*Carya cordiformis*), box elder (*Acer negundo*), slippery elm (*Ulmus rubra*), Ohio buckeye (*Aesculus glabra*), American basswood (*Tilia americana*), black locust (*Robinia pseudoacacia*), and wild cherry (*Prunus* sp.). The shrub layer is dominated by greenbriar, highbush blueberry (*Vaccinium corymbosum*), blackberry, and the invasives multiflorarose (*Rosa multiflora*) and glossy buckthorne (*Rhamnus frangula*). Herbaceous plants present include poison ivy, Virginia creeper (*Parthenocissus quinquefolia*), sweet cicely (*Osmorhiza claytonii*), trillium (*Trillium* spp.), mayapple (*Podophyllum peltatum*) and Virginia waterleaf (*Hydrophyllum virginianum*).

Numerous deer runs were observed throughout CC-IAAP-002, identified by the disturbance of herbaceous vegetation and abundance of deer tracks. The Brush Creek riparian corridor surrounding CC-IAAP-002 likely supports a large population of white-tailed deer (*Odocoileus virginianus*). Other wildlife species known to occur at IAAAP which likely inhabit CC-IAAP-002 and its vicinity include (MWH, 2004):

- eastern cottontail (*Sylvilagus floridanus*)
- eastern fox (*Sciurus niger*)
- eastern gray squirrel (*S. carolinensis*)
- raccoon (*Procyon lotor*)
- coyote (*Canis latrans*)
- red fox (*Vulpes vulpes)*
- gray fox *Urocyon cinereoargenteus*)
- bobcat (*Lynx rufus*)
- striped skunk (*Mephitis mephitis*)
- opossum (*Didelphis virginiana*)
- badger (*Taxidea taxus*)
- woodchuck (*Marmota monax*)
- wild turkey (*Meleagris gallopavo*)
- northern bobwhite quail (*Colinus virginianus*)
- American woodcock (*Philohela minor*)
- American crow (*Corvus brachyrhynchos*)
- turkey vulture (*Cathartes aura*)
- red-tailed hawk (*Buteo jamaicensis*)
- mourning dove (*Zenaidura macroura*)
- red-headed woodpecker (*Melanerpes erythrocephalus*)
- American robin (*Turdus migratorius*)
- European starling (*Sturnus vulgaris*)
- northern cardinal (*Cardinalis cardinalis*)
- song sparrow (*Melospiza melodia*)
- eastern meadowlark (*Sturnella magna*)
- American goldfinch (*Carduelis tristis*)

Transecting CC-IAAP-002 is an unnamed creek that runs from southwest to northeast. During the habitat assessment, sediment in the creek was saturated and standing water was absent. Herbaceous growth was present throughout the dry creek bed indicating that it is only seasonally inundated. The creek channel ends approximately 80 feet northeast of CC-IAAP-002 at an outlet to Brush Creek. Along the western bank of the unnamed creek, within CC-IAAP-002, is a large exposed pile of building debris consisting mostly of Transite tile. Small piles of barbed wire were also observed in various locations throughout CC-IAAP-002.

7.4.1.2 Rare, Threatened, and Endangered Species

Section 7.3.1.2 identifies rare, threatened and endangered species known to occur at IAAAP. None of the species discussed in Section 7.3.1.2 were observed within the boundaries of CC-IAAP-002 during the habitat assessment.

7.4.1.3 Data Used in the SLERA

Analytical data used in the SLERA were collected during RI field sampling in June, 2013. Data were collected and analyzed in accordance with the Final RI Work Plan (PIKA, 2013) as described in detail in Section 3.0. In the SLERA, field sample results were averaged with corresponding field duplicate sample results. Averages were calculated using ½ the reporting limit for non-detects.

CC-IAAP-002 samples evaluated in the SLERA include:

- Five surface soil samples collected from 0 to 0.5 feet bgs; and
- Three sediment samples (including one averaged set of field and field duplicate samples).

Table G-5 lists samples used in the SLERA of CC-IAAP-002. Surface water was not collected in CC-IAAP-002 as standing water was absent from the unnamed creek during the sampling event, and the creek is believed to lack standing water most of the year. Groundwater and subsurface soil (1 to 10 feet bgs) are not evaluated in the SLERA as ecological receptors are not expected to have substantial exposure to those media.

Background soil data were also used in the SLERA to characterize naturally occurring levels of metals in surface soil at IAAAP. Background surface soil concentrations were developed in the "*Line 1 and Firing Site Supplemental Remedial Investigation Report*" for the Site (T&N Associates, 2001). Background levels were derived as average concentrations from 107 samples collected between 1991 and 1993 from locations in the northern portion of the installation, upgradient (with respect to overland surface drainage and groundwater flow) from all site features, production activities, and waste handling and disposal operations.

7.4.1.4 Complete Exposure Pathways

Chemicals may move from environmental media to ecological receptors through several major biological exposure mechanisms:

- Ingestion of chemicals bound to sediment (aquatic invertebrates, amphibians and semi-aquatic birds and mammals);
- Ingestion of chemicals in soil (terrestrial invertebrates and terrestrial birds and mammals);
- Ingestion of chemicals through consumption of affected plants (herbivores, omnivores);
- Ingestion of chemicals through consumption of affected prey (all predators).

Although inhalation and dermal absorption pathways are possibly complete for some receptors, these pathways are considered to be minor compared to dietary ingestion and are not evaluated.

The results of the field screening for radiological constituents of uranium found no evidence of radioactivity (Section 3.0). Radiological exposure pathways are considered incomplete and are not further assessed in this SLERA. Chemical risks from uranium are considered to be potentially complete are further assessed.

7.4.1.5 Ecological Conceptual Site Model

The ecological conceptual site models for CC-IAAP-002 (Figure G-2) illustrates initial estimates of contaminant fate and transport mechanisms, complete exposure pathways, and primary and secondary receptors. The ecological conceptual site model is based on current understandings of Site conditions, and serves as a framework for evaluating ecological exposure and risk.

The ecological conceptual site model describes:

- Source areas – where chemical contaminants may have originated;
- Transport mechanisms – processes that partition chemicals among various environmental media;
- Exposure media – environmental media which may contain chemical contaminants; and
- Ecological receptors – organisms that may be exposed to chemical contaminants in exposure media.

7.4.1.6 Assessment and Measurement Endpoints

Assessment endpoints 4 and 5 are ecological attributes that are to be protected and measurement endpoints are measurable characteristic of those attributes. Assessment and measurement endpoints are used in a SLERA to gauge the degree of impact that has occurred or may occur from exposure of ecological receptors to chemical contaminants in exposure media.

Assessment endpoints in this SLERA are generic assessment endpoints associated with screening ecological toxicity endpoints. The endpoints are considered generic because they are based on a variety of organisms and are therefore considered to be representative of entire communities. Assessment Endpoint 6 focuses on Indiana bat. As a sensitive species, the risk assessment considers effects at the individual, rather than the population or community level. Though the Indiana bat has not been observed at CC-IAAP-001, it was identified as a separate assessment endpoint because the USFWS has historically requested that Indiana bat be evaluated at the IAAAP. The assessment and measurement endpoints for this SLERA are presented below:

Assessment and Measurement Endpoints for CC-IAAP-002

Assessment Endpoint	Measurement Endpoints
4. Sustainability (survival, growth, reproduction) of local populations of aquatic and semi-aquatic organisms (aquatic invertebrates, amphibians, and semi-aquatic birds and mammals) exposed to sediment.	a. Compare maximum sediment concentrations to sediment quality benchmarks.
5. Sustainability (survival, growth, reproduction) of local populations of terrestrial organisms (terrestrial plants, terrestrial invertebrates, and terrestrial birds and mammals) exposed to soil.	a. Compare maximum soil concentrations to soil quality benchmarks.

7.4.2 Screening Level Exposure Estimate and Effects Evaluation

The screening level exposure estimate and effects evaluation provides the screening level evaluation of risks to ecological receptors exposed to chemicals in environmental media. This section:

- Identifies exposure point concentrations (EPCs);
- Identifies screening benchmarks;
- Presents the methods used for the risk calculation; and
- Presents the results of the risk calculation.

Interpretation of the results of the risk calculation is reserved for Section 7.4.3.2 (Risk Characterization).

7.4.2.1 Screening Level Exposure Point Concentrations

MDCs of analytes in surface soil and sediment data sets were used as screening level EPCs for CC-IAAP-002. MDCs were compared to screening benchmarks to select COPECs and to calculate risks as described in the following sections.

7.4.2.2 Screening Benchmarks

For this SLERA, screening benchmarks were used to assess the potential for risks to ecological receptors to occur from exposure to chemical constituents in surface soil and sediment. Screening benchmark values are based on conservative assumptions and represent, where possible, NOAELs for chronic exposures.

The screening benchmarks were obtained following the selection hierarchy in the order presented below, by medium:

Soil

1. USEPA Eco-SSLs (USEPA Ecological Soil Screening Levels 2003-2007);
2. USEPA Region V ESLs (USEPA, 2003b); and
3. Final selected NOAEL-based Critical Concentrations (CC's) for Terrestrial Receptors from the Site-Wide Baseline Ecological Risk Assessment (MWH, 2004) where CC's are lower than screening benchmarks identified from the above listed sources, as specified in the Final RI Work Plan (PIKA, 2013).

Sediment

1. Consensus-based TEC (MacDonald *et. al.* 2000);
2. OMOE Lowest Effects Levels (LELs) (OMOE, 1993);
3. ORNL Sediment SCVs (Jones, Suter, & Hull, 1997).
4. USEPA Region V ESLs (USEPA, 2003b); and
5. Final selected NOAEL-based CC's for Aquatic Receptors from the Site-Wide Baseline Ecological Risk Assessment (MWH, 2004) where CC's are lower than screening benchmarks identified from the above listed sources, as specified in the Final RI Work Plan (PIKA, 2013).

7.4.2.3 Screening Level Risk Calculation

Maximum detected concentrations were compared to screening benchmarks in order to calculate HQ, as shown in Equation 1 (re-stated):

$$HQ = \frac{EPC}{Screening\ Benchmark\ Value} \qquad \text{(Equation 1)}$$

An HQ ≤1 conservatively indicates that the chemical constituent alone is unlikely to cause adverse ecological effects and can be eliminated from further discussion or evaluation. Analytes with an HQ > 1 are considered COPECs and were retained for further evaluation. Analytes that were not detected (by exposure area and medium) were eliminated from further evaluation. Screening benchmarks were not available for all detected analytes. In all cases, analytes lacking screening benchmarks were retained for further evaluation. Calcium, magnesium, and sodium were screened out as COPECs as they are macronutrients which naturally occur at high concentrations in the environment and are not expected to have effects on ecological receptors.

7.4.2.4 Risk Calculation Results

This section presents the results of the risk calculation by medium. Tables G-6 through Table G-7 show the summary statistics for each data set and the risk calculation.

CC-IAAP-002 – Surface Soil

Analytes retained as COPECs in CC-IAAP-002 surface soil for which MDCs exceeded screening benchmarks include:

- Lead (HQ=4.2); and
- Selenium (HQ=6.9).

Uranium was also detected in CC-IAAP-002 surface soil and retained as a COPEC as no screening benchmark was available.

CC-IAAP-002 – Sediment

Analytes retained as COPECs in CC-IAAP-002 sediment for which MDCs exceeded screening benchmarks include:

- Acenaphthalene (HQ=2.2);
- Acenaphthylene (HQ=7.8);
- Benzo(a)anthracene (HQ=2.1);
- Benzo(a)pyrene (HQ=2.2);
- Benzo(b)fluoranthene (HQ=2.4);
- Benzo(g,h,i)perylene (HQ=1.7);
- Chrysene (HQ=2.8);
- Dibenzo(a,h)anthracene (HQ=1.7);
- Fluoranthene (HQ=3.3);
- Indeno(1,2,3-cd)pyrene (HQ=1.6);
- Phenanthrene (HQ=5.5);
- Pyrene (HQ=5.1);
- Arsenic (HQ=19);
- Barium (HQ=11)
- Lead (HQ=3.4); and
- Selenium (HQ=4.7).

Carbazole, dimethyl phthalate, hexavalent chromium and uranium were also detected in CC-IAAP-002 sediment and retained as COPECs as no screening benchmarks were available.

7.4.3 Risk Characterization, Uncertainties, Conclusions and Recommendations

This section characterizes the results of the benchmark screening, reviews ecological toxicity information available for COPECs, considers uncertainties, and summarizes final conclusions and recommendations.

7.4.3.1 Screening Level Risk Characterization

This section presents the screening level risk characterization. This section is organized by exposure area, media and contaminant class. Risks from analytes with HQs < 1 are considered negligible and therefore have not been further characterized.

CC-IAAP-002 - Surface Soil

Three metals (lead, selenium and uranium) were retained as COPECs in CC-IAAP-002 surface soil.

<u>Metals</u>

Lead was detected in all five CC-IAAP-002 surface soil samples. The MDC (46 mg/kg) is above the screening benchmark (11 mg/kg) resulting in an HQ of 4.2. Also, the MDC is only slightly above the IAAAP background concentration of lead in surface soil (17.7 mg/kg). Considering the conservative nature of screening benchmarks (see Section 7.4.3.2), the low HQ (4.2), and background conditions, risks to ecological receptors from concentrations of lead in CC-IAAP-002 surface soil are likely negligible.

Selenium was detected in all five CC-IAAP-002 surface soil samples. The MDC (3.6 mg/kg) is above the screening benchmark (0.52 mg/kg) resulting in an HQ of 6.9. However, considering the conservative nature of screening benchmarks (see Section 7.4.3.2) and the low HQ (6.9), risks to ecological receptors from concentrations of selenium in CC-IAAP-002 surface soil are likely negligible.

Uranium was detected in all five CC-IAAP-002 surface soil samples. No screening benchmark was available for uranium from the standard sources identified in Section 7.4.2.2; therefore it was retained as a COPEC for further evaluation. However, further review of the scientific literature suggests that concentrations of uranium detected in CC-IAAP-002 surface soil are substantially lower than those associated with chemical toxicity to ecological receptors.

Sheppard *et al.* (2005) reviewed data relating to uranium toxicity in terrestrial ecosystems and proposed predicted no effect concentrations (PNECs) for soil of 250 mg/kg for terrestrial plants and 100 mg/kg for soil organisms.

USGS (2010b) also reviewed the ecological toxicity data for uranium in soil and found the following lowest available chemical toxicity values for chronic effects:

- For plants: a NOEC of 10 mg/kg for effects on growth for Swiss chard (*Beta vulgaris*) (Sheppard *et. al.,* 1983);
- For earthworms: a NOEC of 1,000 mg/kg for mortality (Sheppard & Evenden, 1992); and
- For all species of soil invertebrates: an EC20 (concentration resulting in effects to 20% of the test population) of 92 mg/kg for mortality for the springtail (*Onychiurus folsomi*) (Sheppard *et. al.,* 2004).

The MDC of uranium in CC-IAAP-002 surface soil (0.9 mg/kg) is an order of magnitude lower than the lowest chemical toxicity values for chronic effects on terrestrial receptors (10 mg/kg for plants; USGS (2010b). Risks to ecological receptors from uranium in CC-IAAP-002 surface soil are therefore likely negligible.

CC-IAAP-002 - Sediment

Fourteen SVOCs (acenaphthalene, acenaphthylene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, carbazole, chrysene, dimethyl phthalate, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, pyrene) and six metals (arsenic, barium, lead, selenium, hexavalent chromium, and uranium) were retained as COPECs in CC-IAAP-002 sediment.

<u>SVOCs</u>

The 14 SVOCs retained as COPECs CC-IAAP-002 all had relatively low MDCs (≤1 mg/kg) and low HQs (≤5.5). All of these SVOCs are PAHs. The bioavailability of PAHs in sediment can significantly affect their potential toxicity to benthic organisms. Bioavailability of PAHs is influenced by the amount of total organic carbon within the substrate and depends on the properties of the individual PAH constituents. The bioavailability of PAHs in sediment was further assessed using the ΣPAH method (*Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures*; USEPA, 2003c). This model calculates equilibrium partitioning sediment benchmarks (ESBs) using individual toxicity quotients (the quotient of the PAH concentration in sediment divided by the corresponding freshwater chronic toxicity value) based on measured sediment PAH concentrations and site-specific TOC concentrations. The individual toxicity quotients are summed to calculate the sediment benchmark toxic unit ($\Sigma ESBTU_{fcv}$) which is the final value calculated in the ΣPAH method. Freshwater sediments with a $\Sigma ESBTU_{fcv} \leq 1.0$ are considered protective of benthic organisms. Thus, the ΣPAH model is useful for predicting a lack of toxicity. This method cannot be applied to sediment having ≤ 0.2% TOC by dry weight.

Table G-8 presents the ΣPAH calculations for CC-IAAP-002 sediment. Two of the three sediment samples had $\Sigma ESBTU_{fcv} \leq 1.0$ at the 90% confidence level, indicating that those samples are unlikely to be toxic to ecological receptors. The one remaining sample had a $\Sigma ESBTU_{fcv}$ of 3.0 which is not likely to indicate toxic conditions. Additionally, the creek is unlikely to support sensitive species of ecological receptors due to its intermittent nature. Risks to benthic organisms from concentrations of PAHs in CC-

IAAP-002 sediment are therefore unlikely.

Metals

Arsenic was detected in all three sediment samples collected from CC-IAAP-002. The MDC (11.2 mg/kg) is above the screening benchmark (0.59 mg/kg). The screening benchmark is a CC NOAEL from the Site Wide BERA and overestimates risks more so than other benchmarks (see Section 7.4.3.2). Comparing the MDC to other benchmarks, such as the TEC of 9.79 mg/kg (MacDonald *et. al*., 2000), yields a much lower but still conservative HQ of 1. Risks to ecological receptors from arsenic in CC-IAAP-002 sediment are therefore likely negligible.

Barium was detected in all three sediment samples collected from CC-IAAP-002. The MDC (255 mg/kg) is above the screening benchmark (23.7 mg/kg). The screening benchmark is a CC NOAEL from the Site Wide BERA and likely overestimates risks (see Section 7.3.3.2). The MDC is also similar to the IAAAP background concentration (201 mg/kg). Risks to ecological receptors from barium in CC-IAAP-002 sediment are therefore likely negligible.

Hexavalent chromium was detected in all three sediment samples collected from CC-IAAP-002 at an MDC of 1.1 mg/kg. No ecological screening value (ESV) was available for hexavalent chromium as most studies evaluating the toxicity of chromium in sediment measure total chromium and do not provide information on the species of chromium present. This is largely due to nearly all chromium in sediments being present in the trivalent form (Environment Canada, 1994). Under anoxic conditions, such as those typical of sediments, hexavalent chromium is readily reduced to trivalent chromium by a number of chemical and microbial species found in the environment. Trivalent chromium is relatively insoluble and nontoxic. Trivalent chromium is rarely found in the dissolved form and is generally sorbed to organic particles and as such cannot readily pass through cell membranes and does not have the same oxidative potential as hexavalent chromium. (Rifkin *et. al* 2004). Total chromium toxicity in sediment is therefore largely a function of the more soluble and toxic hexavalent chromium, which is typically present only as a small fraction of total chromium in sediment.

In CC-IAAP-002 sediment, hexavalent chromium was 6.9% of total chromium. This is consistent with Environment Canada's (2004) finding that most chromium in sediment is present as trivalent chromium. The Ecological Screening Value (ESV) for total chromium used in the SLERA is a Threshold Effect Concentration (TEC) from MacDonald *et al.* (2000) developed for total chromium from freshwater sediment samples. These sediments would be expected to show a distribution of trivalent and hexavalent chromium similar to that found in CC-IAAP-002 sediment. Since the maximum total chromium concentration in CC-IAAP-002 sediment (16 mg/kg) is substantially less than the ESV (43.4 mg/kg) and the ESV is based on total chromium in sediments expected to show similar distributions of trivalent and hexavalent chromium, risks to ecological receptors from concentrations of hexavalent chromium in CC-IAAP-002 sediment are unlikely.

Lead was detected in all three sediment samples collected from CC-IAAP-002. The MDC (120.5 mg/kg) is above the screening benchmark (35.8 mg/kg) resulting in an HQ of 3.4. However, considering the conservative nature screening benchmarks (see Section 7.4.3.2) and the low HQ (3.4), risks to ecological receptors from concentrations of lead in CC-IAAP-002 sediment are likely negligible

Selenium was detected in all three sediment samples collected from CC-IAAP-002. The MDC (4.4 mg/kg) is slightly above the screening benchmark (0.93 mg/kg) resulting in an HQ of 4.7. The screening benchmark is a CC NOAEL from the Site Wide BERA and likely overestimates risks (see Section 7.4.3.2). Considering the conservative nature of the screening benchmark (see Section 7.4.3.2) and the low HQ (4.7), risks to ecological receptors from concentrations of selenium in CC-IAAP-002 sediment are likely negligible.

Uranium was detected in all three sediment samples collected from CC-IAAP-002. No screening benchmark was available for uranium from the standard sources identified in Section 7.4.2.2; therefore it was retained as a COPEC for further evaluation. However, further review of the scientific literature suggests that concentrations of uranium detected in CC-IAAP-002 sediment are substantially lower than those associated with chemical toxicity to ecological receptors.

USGS (2010b) reviewed aquatic ecological toxicity data for uranium. In sediment the lowest available chemical toxicity values for effects on aquatic receptors include:

- For invertebrates: an LC50 (lethal concentration affecting 50% of the test population) of 57 mg/kg for the amphipod (*Hyalella azteca*) (CCME, 2007).

Chronic toxicity values are often estimated from acute values by applying a safety factor of between 10 and 100. The MDC of uranium in CC-IAAP-002 sediment is 1.1 mg/kg, approximately an order of magnitude lower than the lowest available chemical toxicity values for acute effects on aquatic receptors. Risks to ecological receptors from the detected concentrations of uranium in CC-IAAP-002 sediment are therefore likely negligible.

Indiana Bat

The Indiana bat is considered a protected species, thus it customary to assess risk at the individual, rather than the population level. It is also customary to use lines of evidence that emphasize conservative assumptions including maximum detected concentrations and no-observable-average-effects-levels (NOALEs). Since the screening level risk calculations for other terrestrial and aquatic receptors identified in assessment endpoints 4 and 5 were evaluated under those same conservative lines of evidence, the findings presented in the previous paragraphs also apply to Indiana bat. Therefore, risk to individual Indiana bats from constituents detected in CC-IAAP-002 surface soil and sediment is negligible.

7.4.3.2 Uncertainties

This section presents and discusses the uncertainties associated with the various measurements, calculations, and assumptions which form the basis of the risk characterization. Awareness of the uncertainties involved in each step of the risk assessment is critical to interpreting and understanding site risk.

Uncertainties Associated with EPCs

The use of MDCs as EPCs in the SLERA is highly conservative. MDCs represent a single point whereas populations of receptors would be exposed to the full range of concentrations throughout an exposure area. Average concentrations would be a more accurate estimate of EPCs, and can be used in subsequent steps of the ecological risk assessment process (if necessary).

Uncertainties Associated With Screening Benchmarks

Screening benchmarks are generally based on no-observable-adverse-effects-levels (NOAELs) for chronic exposures for a wide range of potential ecological receptors. As such, HQs >1 based on screening benchmark comparisons do not indicate that adverse effects may occur, only that detected concentrations are above those at which adverse effects are unlikely to occur.

In addition, screening benchmark comparisons incorporate numerous conservative assumptions. For example, screening benchmark comparisons assume 100% bioavailability. However, in natural environments, a variety of mechanisms related to site-specific conditions reduce the bioavailability of metals to ecological receptors, including:

- adsorption to mineral surfaces, particularly iron and manganese oxyhydroxides;
- adsorption to clays;
- sorption to organic matter; and
- formation of secondary solid metal phases such as carbonates, apatites, and sulfides (Barnett *et. al.*, 2003).

Assuming 100% bioavailability therefore results in an overestimate of risk. Other conservative assumptions incorporated into screening benchmark comparisons include the presence of the most sensitive receptor, which may not be the case in the field, particularly in an ephemeral water body. Also, conservative assumptions regarding receptors' dietary composition and ingestion rates generally result in overestimates of site risk in the SLERA.

Uncertainties Associated with Using CC NOAELs from the Site Wide BERA

In accordance with the Final RI Work Plan (PIKA, 2013), the SLERA used CC NOAELs from the Site Wide BERA as screening benchmarks when those values were lower than values in other sources listed in the selection hierarchy (see Section 7.4.2.2). CC NOAELs were selected as the lowest TRVs from the scientific literature; do not take into account data quality, geographic applicability, or other site or project specific factors; and incorporate numerous conservative assumptions associated with other benchmarks, such as 100% bioavailability. As a result, CC NOAELs are generally more over-conservative than other sources of benchmarks used in this SLERA. In order to mitigate the degree of overestimation of risk, parameters that were identified as COPECs based on comparison to CC NOAELs were compared to other appropriate standards to characterize risk.

Additional Uncertainties

Some chemicals could not be ruled out based on ecological screening benchmarks because they lacked benchmarks. However, chemicals which lacked screening benchmarks were evaluated by other tools, including comparison to background, where possible. Hexavalent chromium in sediment lacked both benchmarks and background so could not be assessed.

7.4.3.3 Conclusions and Recommendations

This SLERA of construction debris site CC-IAAP-002 evaluated the potential for chemical constituents of concern detected in surface soil and sediment to adversely affect ecological receptors. This SLERA followed the approach outlined in Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (USEPA, 1997). In accordance with this Process Document, the SLERA identified complete exposure pathways, and conducted a conservative assessment of all COPECs.

Based on the screening level risk estimate and considering the conservative nature of screening level ecological risk assessment tools:

- Risks to ecological receptors (including Indiana bat) from constituents in CC-IAAP-002 surface soil are likely negligible;
- Risks to ecological receptors (including Indiana bat) from constituents in CC-IAAP-002 sediment are likely negligible.

No further evaluation of risk to ecological receptors in CC-IAAP-002 is necessary.

The exposed pile of construction debris in CC-IAAP-002 is expected to be addressed by excavating the debris and associated soils.

8.0 SUMMARY AND CONCLUSIONS

This section briefly summarizes the conditions at CC-IAAP-001 and CC-IAAP-002 that were found during the RI, the possible fate and transport of contaminants found at the site, and the risk assessments tasks that were completed. The conclusions are based on the findings of the BHHRA and SERA.

8.1 Summary

RI activities at CC-IAAP-001 were conducted between June 11 and June 16, 2013. During that period, five soil borings, seven site characterization borings, and four temporary well borings were constructed of which three yielded groundwater for sampling. A total of seven surface soil samples, four sediment samples, 15 subsurface samples, three surface water samples, and three ground water samples were collected.

Activities at CC-IAAP-002 were conducted between June 14 and June 18, 2013. Four sampling soil borings, six site characterization borings, and three temporary well borings were advanced which all yielded groundwater for sampling. A total of six surface soil samples, three sediment samples, 12 subsurface samples, three ground water samples, and four ACM samples were collected at CC-IAAP-002.

All soil, sediment, and water samples from both sites were scanned for radiation using a multi-spectrum detector (i.e. alpha/beta/gamma). The radiation detector indicated all radiation levels were below background. Therefore, no further radiation analyses were conducted. All soil and water samples collected from CC-IAAP-001 and CC-IAAP-002 were analyzed for asbestos. Asbestos was not detected in any of the samples from either site. A visual inspection of both sites was conducted by an Iowa licensed Asbestos Inspector. The visual inspection of CC-IAAP-001 identified no suspect ACM in the surface soil or in any of the soil boring cores. The visual inspection of CC-IAAP-002 identified three distinct areas of suspect ACM. Samples were collected of the cement panels and asbestos (chrysotile) was detected in all four samples. ACM was not identified in the surface soil or in any of the soil boring cores at CC-IAAP-002.

8.1.1 Nature and Extent of Contamination

The nature and extent of contamination in four media were investigated: soil, sediment, surface water, and groundwater. At CC-IAAP-001, there were analytical detections of metals, VOCs, SVOCs, pesticides, and one explosive compound. However, only seven metals (arsenic, barium, cadmium, total chromium, hexavalent chromium, lead, and selenium) and one pesticide (endrin aldehyde) exceeded their respective PALs or background concentrations.

- Soil - metals (arsenic, barium, cadmium, total chromium, lead, and selenium) and one pesticide (endrin aldehyde) exceeded their respective PALs or background concentrations.
- Sediment - metals (arsenic, barium, total chromium, and selenium) exceeded their respective

PALs.

- Surface Water - metals (arsenic, barium, hexavalent chromium, and selenium) exceeded their respective PALs.
- Groundwater - metals (arsenic, total chromium, hexavalent chromium, and lead) exceeded their respective PALs.

At CC-IAAP-002 there were analytical detections of metals, SVOCs, and VOCs. Seven metals (arsenic, barium, cadmium, total chromium, hexavalent chromium, lead, and selenium) and thirteen SVOCs (acenaphthene, acenaphthylene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene) exceeded their respective PALs or background concentrations.

- Soils, metals (arsenic, barium, total chromium, lead, and selenium) exceeded their respective PALs or background concentrations.
- Sediment - metals (arsenic, barium, total chromium, lead, and selenium) and thirteen SVOCs (acenaphthene, acenaphthylene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene) exceeded their respective PALs or background concentrations.
- Groundwater - metals (arsenic, total chromium, and hexavalent chromium) exceeded their respective PALs.

The concentrations of metals in surface and subsurface soils at both sites are within the range of the background samples collected across the installation, with the exception of selenium. The average concentration of selenium detected in soils at CC-IAAP-001 and CC-IAAP-002 is 2.75 mg/kg. The lowest detected concentration is 1.5 mg/kg and the highest detected concentration was 4.5 mg/kg. These numbers show that there was very little variation in selenium concentrations across the site.

8.1.2 Fate and Transport

The primary contaminant migration pathways for contaminants at CC-IAAP-001 and CC-IAAP-002 are:

- Leaching from soils to groundwater,
- Leaching from sediments to surface water, and
- Transport in surface drainage channels.

As described in Section 6.3.1, the age of the debris and the lack of wide-spread source materials for metals contamination in either soils or groundwater suggest that the CC-IAAP-001 and CC-IAAP-002 soils are in likely in steady-state condition whereby the rate of leaching of metals into the groundwater will not increase over time. Organic chemicals including VOCs, pesticides, and PAHs were detected in soil, but were not detected in groundwater with a few exceptions. This indicates the levels of these chemicals detected in soil do not present enough total mass to yield detectable groundwater concentrations after dilution, dispersion, and other natural mechanisms reduce their concentrations.

PAHs and metals were detected in sediment samples from both sites at concentrations greater than their respective PALs and or background concentrations. As discussed in the previous sections, PAHs, as a group, are much more likely to bind to soil and be transported via erosion and surface water runoff than to be solubilized to surface water. This may be a significant transport pathway. However, given, the small size of each site and the limited amount of actual sediment present, the amount of contaminants available for transport is limited. Therefore, while the drainage channels represent potential migration pathways, it does not appear that these migration pathways are significant.

8.1.3 Baseline Human Health Risk Assessment

A BHHRA was performed for CC-IAAP-001 and CC-IAAP-002 as part of the RI. The objective of the BHHRAs is to quantify the human health risks associated with potential exposures to site-related constituents under current and reasonably foreseeable future land use conditions, in the absence of any remedial actions. The BHHRAs were performed using United States Environmental Protection Agency (USEPA) Risk Assessment Guidance for Superfund. The BHHRAs uses the analytical data collected in 2013 that were obtained in support of the Remedial Investigation for the Site.

8.1.3.1 CC-IAAP-001 BHHRA Summary

The media evaluated in the BHHRA for CC-IAAP-001 include the following:

- Surface and subsurface soil
- Surface water and sediment – intermittent streams
- Overburden groundwater, as represented by overburden monitoring wells

Within these media, COPCs were selected in accordance with USEPA guidance. COPCs for surface soil, surface and subsurface soil, and sediment included arsenic only. COPCs for groundwater included dissolved/total arsenic, dissolved/total barium, total hexavalent chromium, total lead, and total uranium.

The BHHRA evaluated health risks to receptor populations that could potentially be exposed to COPCs under current and possible future land use conditions. The following receptor populations were evaluated:

- A current and future hunter scenario evaluated adolescents and adults potentially exposed to COPCs in soil, surface water and sediment.
- A future construction worker scenario evaluated an adult potentially exposed to COPCs in surface and subsurface soil.
- A future commercial/industrial worker scenario evaluated an adult potentially exposed to COPCs in surface and subsurface soil and a hypothetical drinking water scenario.

The potentially complete exposure pathways evaluated in the BHHRA included direct contact (incidental ingestion and dermal contact) with soil, surface water, and sediment, inhalation of COPCs in dust released from soil, and potable use of groundwater (ingestion with groundwater used as tap water in a commercial setting).

Health risks for each of the current and future land use exposure scenarios were quantified using algorithms specified in USEPA guidance. The majority of quantitative exposure parameters used in the exposure scenarios were USEPA RME default values published in USEPA guidance.

The BHHRA characterized cancer and non-cancer risks associated with the COPC, media and potential receptors identified above. The results of the BHHRA indicate, for current and potential future land uses, that potential exposure to soil, surface water, and sediment at the Site would be associated with cancer risks that do not exceed EPA's cancer risk range of $1x10^{-6}$ to 1x10-4, and non-cancer HI values that are lower than EPA's threshold value of 1. These conclusions are applicable to the following current and potential future land uses:

- Current and future hunter exposure to soil, surface water and sediment;
- Future construction worker exposure to soil and soil derived dust;
- Future commercial/industrial worker exposure to soil and groundwater hypothetically used as drinking water.

In addition, the results of the BHHRA indicate that combined exposures to soil, surface water, sediment, and groundwater used as drinking water would not result in risks that exceed the lower bound of the USEPA cancer risk range or a HI of 1.

Conclusions

In conclusion, the results of the BHHRA indicate that cancer and non-cancer risks associated with soil, surface water, sediment and groundwater at the Site do not exceed USEPA risk management thresholds and, therefore, no response actions to mitigate cancer and non-cancer risks are required for these media.

8.1.3.2 CC-IAAP-002 BHHRA Summary

The media evaluated in the BHHRA for CC-IAAP-002 include the following:

- Surface and subsurface soil
- Sediment – associated with intermittent streams
- Overburden groundwater, as represented by overburden monitoring wells

Within these media, COPCs were selected in accordance with USEPA guidance. COPCs for surface soil, surface and subsurface soil, included arsenic only. COPCs for sediment included arsenic and benzo(a)pyrene. COPCs for groundwater included dissolved/total arsenic, total barium, total cadmium, total hexavalent chromium, and bromomethane.

The BHHRA evaluated health risks to receptor populations that could potentially be exposed to COPCs under current and possible future land use conditions. The following receptor populations were evaluated:

- A current and future hunter scenario evaluated adolescents and adults potentially exposed to COPCs in soil and sediment.
- A future construction worker scenario evaluated an adult potentially exposed to COPCs in surface and subsurface soil.
- A future commercial/industrial worker scenario evaluated an adult potentially exposed to COPCs in surface and subsurface soil and a hypothetical drinking water scenario.

The potentially complete exposure pathways evaluated in the BHHRA included direct contact (incidental ingestion and dermal contact) with soil and sediment, inhalation of COPCs in dust released from soil, and potable use of groundwater (ingestion with groundwater used as tap water in a commercial setting).

Health risks for each of the current and future land use exposure scenarios were quantified using algorithms specified in USEPA guidance. The majority of quantitative exposure parameters used in the exposure scenarios were USEPA RME default values published in USEPA guidance.

The BHHRA characterized cancer and non-cancer risks associated with the COPC, media and potential receptors identified above. The results of the BHHRA indicate, for current and potential future land uses, that potential exposure to soil, surface water, and sediment at the site would be associated with cancer risks that do not exceed EPA's cancer risk range of $1x10^{-6}$ to $1x10^{-4}$, and non-cancer HI values that are less than or equal to EPA's threshold value of 1. These conclusions are applicable to the following current and potential future land uses:

- Current and future hunter exposure to soil and sediment;
- Future construction worker exposure to soil and soil derived dust;
- Future commercial/industrial worker exposure to soil and groundwater hypothetically used as drinking water.

In addition, the results of the BHHRA indicate that combined exposures to soil sediment, and groundwater used as drinking water would not result in risks that exceed the lower bound of the USEPA cancer risk range or a HI of 1.

Conclusions

In conclusion, the results of the BHHRA indicate that cancer and non-cancer risks associated with soil sediment and groundwater at the Site do not exceed USEPA risk management thresholds and, therefore, no response actions to mitigate cancer and non-cancer risks are required for these media.

8.1.4 SLERA

The SLERA of construction debris sites CC-IAAP-001 evaluated the potential for chemical constituents of concern detected in surface soil, surface water and sediment to adversely affect ecological receptors. This SLERA followed the approach outlined in Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (USEPA, 1997). In accordance with the Process Document, the SLERA identified complete exposure pathways, conducted a conservative assessment of all COPECs, and identified which COPECs can be eliminated from further consideration and which should be evaluated further in a BERA.

Based on the screening level risk estimate and considering the conservative nature of screening level ecological risk assessment tools:

- Risks to ecological receptors (including Indiana bat) from constituents in CC-IAAP-001 surface soil are likely negligible.
- Risks to ecological receptors (including Indiana bat) from constituents in CC-IAAP-001 surface water are likely negligible.
- Risks to ecological receptors (including Indiana bat) from constituents in CC-IAAP-001 sediment are likely negligible.

No further evaluation of risk to ecological receptors in CC-IAAP-001 is necessary.

- The SLERA of construction debris site CC-IAAP-002 evaluated the potential for chemical constituents of concern detected in surface soil and sediment to adversely affect ecological receptors. Based on the screening level risk estimate and considering the conservative nature of screening level ecological risk assessment tools:
- Risks to ecological receptors (including Indiana bat) from constituents in CC-IAAP-002 surface water are likely negligible;
- Risks to ecological receptors (including Indiana bat) from constituents in CC-IAAP-002 sediment are likely negligible; risk from hexavalent chromium could not be assessed.
- No further evaluation of risk to ecological receptors in CC-IAAP-002 is necessary.
- The exposed pile of construction debris in CC-IAAP-002 is expected to be addressed by excavating the debris and associated soils.

The SLERA of construction debris site CC-IAAP-002 evaluated the potential for chemical constituents of concern detected in surface soil and sediment to adversely affect ecological receptors. This SLERA followed the approach outlined in Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (USEPA, 1997). In accordance with this Process Document, the SLERA identified complete exposure pathways, and conducted a conservative assessment of all COPECs.

Based on the screening level risk estimate and considering the conservative nature of screening level ecological risk assessment tools:

- Risks to ecological receptors from constituents in CC-IAAP-002 surface water are likely negligible;
- Risks to ecological receptors from constituents in CC-IAAP-002 sediment are likely negligible.

No further evaluation of risk to ecological receptors in CC-IAAP-002 is necessary. The exposed pile of construction debris in CC-IAAP-002 is expected to be addressed by excavating the debris and associated soils.

8.2 Conclusions

The small reservoir of contamination in soil provides little total contaminant mass for migration to groundwater or other media. Metals associated with the aqueous phase of soils are subject to movement with soil water, and may be transported through the vadose zone to ground water. Metals, unlike the hazardous organics, cannot be degraded. Some metals, such as chromium, arsenic, and selenium can be transformed to other oxidation states in soil, reducing their mobility and toxicity. Immobilization of metals, by mechanisms of adsorption and precipitation, will prevent movement of the metals to groundwater.

Metal-soil interaction is such that when metals are introduced at the soil surface, downward transportation does not occur to any great extent unless the metal retention capacity of the soil is overloaded, or metal interaction with the associated waste matrix enhances mobility. Changes in soil environmental conditions over time, such as the degradation of the organic waste matrix, changes in pH, redox potential, or soil solution composition, due to various remediation schemes or to natural weathering processes, also may enhance metal mobility. The extent of vertical contamination is intimately related to the soil solution and surface chemistry of the soil matrix with reference to the metal and waste matrix in question.

Metals that exceeded their respective PALs and background concentrations at CC-IAAP-001 and CC-IAAP-002 include arsenic, barium, cadmium, total chromium, hexavalent chromium, lead, and selenium. However, the maximum concentrations of the metals detected in soil were within the range of the concentrations of the background samples collected from other areas of the facility, with the exception of selenium and lead. The sample data indicate that the total volume of contaminated soil is small. Since no background data for groundwater are available, it is unclear if the metals detected in groundwater samples are attributable to soil contamination or background concentrations.

The results of the BHHRA indicate that cancer and non-cancer risks associated with soil sediment and groundwater at either site do not exceed USEPA risk management thresholds and, therefore, no response actions to mitigate cancer and non-cancer risks are required for these media. The results of the SLERA indicate that risks to ecological receptors are negligible.

The extent of asbestos-containing material (ACM) is limited to the roofing material within the debris piles located within CC-IAAP-002. However, there are several areas within the debris piles, where the roofing material has disintegrated due to exposure to the elements. The ACM poses a threat of exposure to friable asbestos.

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8.2.1 Recommendations for Future Work

No action for chemical contaminants is recommended at either site. The ACM poses a threat of exposure to deteriorating non friable asbestos. Continuing exposure to the elements could lead to the non friable asbestos becoming friable. Therefore, it is recommended that the ACM debris pile be removed and the associated soil be excavated and disposed off-site.

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