RCRA Facility Investigation-Remedial Investigation/ Corrective Measures Study-Feasibility Study Report for the Rocky Flats Environmental Technology Site Appendix A – Comprehensive Risk Assessment

Volume 4 of 15

Rock Creek Drainage Exposure Unit

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ACRONYMS AND ABBREVIATIONS

μg/kg	microgram per kilogram
μg/L	microgram per liter
AEU	Aquatic Exposure Unit
AI	adequate intake
bgs	below ground surface
BZ	Buffer Zone
CAD/ROD	Corrective Action Decision/Record of Decision
CD	compact disc
CDPHE	Colorado Department of Public Health and Environment
CMS	Corrective Measures Study
CNHP	Colorado Natural Heritage Program
COC	contaminant of concern
CRA	Comprehensive Risk Assessment
DOE	U.S. Department of Energy
DQA	Data Quality Assessment
DQO	data quality objective
DRI	dietary reference intake
ECOC	ecological contaminant of concern
ECOI	ecological contaminant of interest
ECOPC	ecological contaminant of potential concern
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERA	Ecological Risk Assessment
ESL	ecological screening level

EU	Exposure Unit
FWS	U.S. Fish and Wildlife Service
HHRA	Human Health Risk Assessment
HRR	Historical Release Report
IA	Industrial Area
IAG	Interagency Agreement
IDEU	Inter-Drainage Exposure Unit
IHSS	Individual Hazardous Substance Site
K-H	Kaiser-Hill Company, L.L.C.
LOAEL	lowest observed adverse effect level
MDC	maximum detected concentration
mg	milligram
mg/day	milligram per day
mg/kg	milligram per kilogram
mg/kg BW/day	milligram per kilogram receptor body weight per day
N/A	not applicable or not available
NFAA	No Further Accelerated Action
NOAEL	no observed adverse effect level
NWTC	National Wind Technology Center
OU	Operable Unit
PAC	Potential Area of Concern
PCOC	potential contaminant of concern
PMJM	Preble's meadow jumping mouse
PRG	preliminary remediation goal
QA/QC	quality assurance/quality control

QAPjP	Quality Assurance Project Plan
RCEU	Rock Creek Drainage Exposure Unit
RCRA	Resource Conservation and Recovery Act
RDA	recommended daily allowance
RDI	recommended daily intake
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
RI/FS	Remedial Investigation/Feasibility Study
SAP	Sampling and Analysis Plan
SCM	site conceptual model
tESL	threshold ecological screening level
UBC	Under Building Contamination
UCL	upper confidence limit
UL	upper limit (daily intake)
UT	uncertain toxicity
UTL	upper tolerance limit
VOC	volatile organic compound
WAEU	West Area Exposure Unit
WRS	Wilcoxon Rank Sum
WRV	wildlife refuge visitor
WRW	wildlife refuge worker

EXECUTIVE SUMMARY

This report presents the Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA) for the 735-acre Rock Creek Drainage Exposure Unit (EU) (RCEU) at the Rocky Flats Environmental Technology Site (RFETS). The purpose of this report is to assess risks to human health and ecological receptors posed by exposure to contaminants of concern (COCs) and ecological contaminants of potential concern (ECOPCs) remaining at the RCEU after completion of accelerated actions at RFETS.

Results of the COC selection process for the HHRA indicate that no COCs were selected and, therefore, no significant human health risks exist at the RCEU from RFETS-related operations.

No COCs were selected in surface soil/surface sediment and subsurface soil/subsurface sediment during completion of the HHRA COC selection process. Only four analytes in surface soil/surface sediment, arsenic, cesium-137, manganese, and radium-228, had concentrations in the RCEU that were statistically greater than RFETS background. However, these analytes were subsequently eliminated as COCs in the professional judgment evaluation step of the COC selection process because the weight of evidence supports the conclusion that concentrations of these analytes in the RCEU are not the result of RFETS activities, but rather are representative of naturally occurring concentrations. For comparative purposes, the cancer risks and noncancer hazard quotients (HQs) were estimated for the wildlife refuge worker (WRW) and wildlife refuge visitor (WRV) in RCEU surface soil/surface sediment and in RFETS background surface soil/surface sediment. The estimated risks were similar for the WRW for RCEU and RFETS background: arsenic had an estimated cancer risk of 2E-06 in the RCEU and 2E-06 in background; cesium-137 had an estimated cancer risk of 7E-06 in the RCEU and 6E-06 in background; and radium-228 had an estimated cancer risk of 3E-05 in the RCEU and 2E-05 in background. The estimated HQ for the WRW for arsenic in samples collected in the RCEU is 0.02 versus 0.01 in RFETS background samples. The estimated HQ for the WRW for manganese in samples collected from the RCEU is 0.2 versus 0.1 in RFETS background samples. The estimated risks were also similar for the WRV for RCEU and RFETS background: arsenic had an estimated cancer risk of 2E-06 in the RCEU and 1E-06 in background; cesium-137 had an estimated cancer risk of 2E-06 in the RCEU and 2E-06 in background; and radium-228 had an estimated cancer risk of 9E-06 in the RCEU and 8E-06 in background. The estimated HQ for the WRV for arsenic in samples collected in the RCEU is 0.01 versus 0.007 in RFETS background samples. The estimated HQ for the WRV for manganese in samples collected from the RCEU is 0.1 versus 0.04 in RFETS background samples. No analytes in subsurface soil/subsurface sediment were statistically greater than RFETS background. These results indicate that potential health risks for the WRW and WRV in the RCEU are expected to be similar to background risks, and there are no significant human health risks from RFETS-related operations at the RCEU.

The ECOPC identification process streamlines the ecological risk characterization by focusing the assessment on ecological contaminants of interest (ECOIs) that are present in the RCEU. The ECOPC identification process is described in the Comprehensive Risk Assessment (CRA) Methodology (U.S. Department of Energy [DOE] 2005a) and additional details are provided in Appendix A, Volume 2 of the Remedial Investigation/Feasibility Study (RI/FS) Report. There are a number of Preble's meadow jumping mouse (PMJM) patches within RCEU. Manganese and tin were identified as ECOPCs for PMJM receptors in surface soil. No ECOPCs were identified for non-PMJM receptors in surface soil. No ECOPCs were identified in subsurface soil for burrowing receptors.

ECOPCs for PMJM were evaluated in the risk characterization using conservative default exposure and risk assumptions as defined in the CRA Methodology. In addition, a refinement of the exposure and risk models based on chemical-specific uncertainties associated with the initial default exposure models were considered to provide a refined estimate of potential risk.

Using Tier 1 EPCs and default exposure and risk assumptions, no observed adverse effect level (NOAEL) hazard quotients (HQs) ranged from 7 (manganese/PMJM in Patch #3B and tin/PMJM in Patch #3A and #3B) to less than 1 (tin and manganese in a number of PMJM patches). All of the patches in RCEU had LOAEL HQs less than 1 for both manganese and tin using the default risk model.

Based on default calculations, site-related risks are likely to be low for the ecological receptors evaluated in the RCEU. In addition, data collected on wildlife abundance and diversity indicate that wildlife species richness remains high at RFETS. There are no significant risks to ecological receptors or high levels of uncertainty with the data, and therefore, there are no ecological contaminants of concern (ECOCs) for the RCEU.

1.0 INTRODUCTION

This volume of the Comprehensive Risk Assessment (CRA) presents the Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA) for the Rock Creek Drainage Exposure Unit (EU) (RCEU) at the Rocky Flats Environmental Technology Site (RFETS) (Figure 1.1).

The HHRA and ERA methods and selection of receptors are described in detail in the Final CRA Work Plan and Methodology (DOE 2005a), hereafter referred to as the CRA Methodology. A summary of the risk assessment methods, including updates made in consultation with the regulatory agencies, are summarized in Appendix A, Volume 2, Section 2.0 of the Resource Conservation and Recovery Act (RCRA) Facility Investigation-Remedial Investigation (RI)/Corrective Measures Study (CMS)-Feasibility Study (FS) Report (hereafter referred to as the RI/FS Report).

The anticipated future land use of RFETS is a wildlife refuge. Consequently, two human receptors, a wildlife refuge worker (WRW) and a wildlife refuge visitor (WRV), are evaluated in this risk assessment consistent with this land use. A variety of representative terrestrial and aquatic receptors are evaluated in the ERA. The assessment of the RCEU includes all terrestrial receptors named in the CRA Methodology including the Preble's meadow jumping mouse (PMJM), a federally listed threatened species present at the RFETS.

1.1 Rock Creek Drainage Exposure Unit Description

This section provides a brief description of the RCEU, including its location at RFETS, historical activities in the area, topography, surface water features, vegetation, and ecological resources. A more detailed description of these features and additional information regarding the geology, hydrology, and soil types at RFETS is included in Section 2.0, Physical Characteristics of the Study Area, of the RI/FS Report. This information is also summarized in Appendix A of Volume 2 of the RI/FS Report.

The Historical Release Report (HRR) and its annual updates provide descriptions of known or suspected releases of hazardous substances that occurred at RFETS (DOE, 2005b). The original HRR (DOE 1992) organized these known or suspected historical sources of contamination as Individual Hazardous Substance Sites (IHSSs), Potential Areas of Concern (PACs), or Under Building Contamination (UBC) sites (hereafter collectively referred to as historical IHSSs). Individual historical IHSSs and groups of historical IHSSs were also designated as Operable Units (OUs). Over the course of cleanup under the 1991 Interagency Agreement (IAG 1991) and the 1996 Rocky Flats Cleanup Agreement (RFCA 1996), the U.S. Department of Energy (DOE) has thoroughly investigated and characterized contamination associated with these historical IHSSs. Historical IHSSs have been dispositioned through appropriate remedial actions or by determining that No Further Accelerated Action (NFAA) is required, pursuant to the applicable IAG and RFCA requirements. Some OUs have also been dispositioned in accordance with an OU-specific Corrective Action Decision/Record of Decision (CAD/ROD).

A more detailed description of the regulatory agreements and the investigation and cleanup history under these agreements is contained in Section 1.0 of the RI/FS Report. Section 1.4.3 of the RI/FS Report describes the accelerated action process, while Table 1.4 of the RI/FS Report summarizes the disposition of all historical IHSSs at RFETS. The 2005 Annual Update to the HRR (DOE 2005b) provides a description of the potential contaminant releases for each IHSS and any interim response to the releases; identification of potential contaminants based on process knowledge and site data; data collection activities; accelerated action activities (if any); and the basis for recommending NFAA.

The RCEU is located within the Buffer Zone (BZ) OU, northwest of the Industrial Area (IA), which was used for RFETS operations (Figure 1.1). There are no known sources of groundwater or soil contamination within this EU based on the 2005 Annual Update to the HRR (DOE 2005b). No historical IHSSs or PACs are designated in the RCEU (Figure 1.2). There are historical IHSSs and PACs in the adjacent Inter-Drainage Exposure Unit (IDEU); however, because the RCEU is hydraulically isolated from the IDEU and generally upwind, contaminant transport to the RCEU from the IDEU is unlikely.

1.1.1 Exposure Unit Characteristics and Location

The 735-acre RCEU is located in the northern and western portions of RFETS (Figure 1.1) and contains several distinguishing features:

- The RCEU is located within the BZ OU and outside of areas that were used historically for operation of RFETS.
- The RCEU is located generally upwind and hydraulically cross-gradient of the Industrial Area (IA).
- The RCEU is a functionally distinct exposure area. It encompasses much of the Rock Creek drainage area and contains relatively abundant vegetation, water, and wetland habitat.

The RCEU is bounded by the West Area EU (WAEU) to the west and the Inter-Drainage EU (IDEU) to the south and east. The RCEU adjoins the DOE National Wind Technology Center (NWTC) to the northwest and State Highway 128 to the north.

1.1.2 Topography and Surface Water Hydrology

The RCEU encompasses the Rock Creek drainage basin. The basin consists of an alluvial terrace that slopes gently to the northeast and is dissected by Rock Creek and its tributaries, which flow generally from southwest to northeast. The principal surface features in the RCEU include Short Ear Branch, Plum Branch, Mahonia Branch, Snowberry Branch, Lobelia Branch, Grape Draw, and Gentian Draw (Figure 1.2). Two ponds are visible along the main stem of Rock Creek. The westernmost of the two ponds, located at the southern end of the RCEU, is designated Lindsay 2, and the pond other is Lindsay 1. An abandoned ranch house and barn are present directly west of Lindsay 1. The ponds and ranch buildings predate the RFETS.

The drainages and gravel roads that cross the central portion of the RCEU are visible on a July 2005 aerial photograph (Figure 1.3). The roads are used for site security patrols and environmental monitoring activities.

1.1.3 Flora and Fauna

Vegetation in the RCEU is predominantly grassland consisting chiefly of mesic mixed grasslands and xeric tallgrass prairie (Figure 1.4), but most of the plant communities found at RFETS are also present within the Rock Creek drainage. In addition to those mentioned above, these plant communities include tall upland shrubland and seep-fed wetlands on hillsides, with riparian woodlands and wetlands on the valley floor. Other shrublands and Ponderosa pine (*Pinus ponderosa*) woodlands also exist in the western portion of the EU. More information on the plant communities found in Rock Creek is provided in Section 2.0 of the RI/FS Report and also in the Rocky Flats National Wildlife Refuge Final Comprehensive Conservation Plan (USFWS 2005).

No federally listed plant species are known to occur at RFETS. However, the xeric tallgrass prairie, tall upland shrubland, riparian shrubland, and plains cottonwood riparian woodland communities are considered rare and sensitive plant communities by the Colorado Natural Heritage Program (CNHP). RFETS also supports populations of four rare plant species that are listed as rare or imperiled by the CNHP (CNHP 1994). These include: forktip three-awn (*Aristida basiramea*), mountain-loving sedge (*Carex oreocharis*), carrionflower greenbriar (*Smilax herbacea var. lasioneuron*), and dwarf wild indigo (*Amorpha nana*).

Land within the RCEU was heavily grazed during past land use. However, since the purchase of land by DOE, grazing has not occurred in decades within RCEU and plant communities have nearly returned to their pre-grazed conditions. These plant communities are in near-pristine condition and comprise important natural heritage areas. The CNHP concluded that Rock Creek contains plant communities and wildlife species important to the protection of Colorado’s natural diversity (CNHP 1994). As mentioned above, CNHP classifies the xeric tallgrass prairie plant community as very rare. Portions of this plant community in the Rock Creek drainage, along with other areas within RFETS and surrounding lands, comprise the largest remnants of xeric tallgrass prairie in Colorado.

Seeps commonly occur along the edge of the pediment in the RCEU, creating ideal conditions for seep-fed wetlands and tall upland shrub communities. These seep-fed wetlands, along with the Antelope Springs wetland complexes in Woman Creek, are significant because they are large, contiguous wetlands and support the most complex plant associations on RFETS (PTI 1997). Tall upland shrubland communities commonly occur just above seeps and wetlands, and the RCEU contains the majority of tall upland shrubland acreage within RFETS. Tall upland shrublands contain the preponderance of plant species found on the site. CNHP identified the tall upland shrubland associations as potentially unique plant communities that may not occur elsewhere. Riparian woodlands, classified by CNHP as Great Plains riparian woodlands and shrublands, are rare and declining plant communities throughout the Great Plains. The RCEU contains unique and important plant communities and supports healthy and vibrant ecosystems.

The RCEU contains three plant species recognized by CNHP as rare or imperiled: the carrionflower greenbriar, mountain-loving sedge, and dwarf wild indigo (K-H 2002b). The carrionflower grows in moist areas beneath the canopy of chokecherry (*Prunus virginana*) and hawthorne (*Crataegus erythropoda*). The mountain-loving sedge grows in dry grasslands and prefers locations off the edge of the pediment on north-facing slopes, while the shrub, dwarf indigo, occurs in the RCEU near the top of the pediment at the edge of the xeric tallgrass prairie.

Numerous animal species have been observed at RFETS and most of these species are expected to be present in the RCEU. Common large and medium-sized mammals likely to live in or frequent the RCEU include the mule deer (*Odocoileus hemionus*), coyote (*Canis latrans*), raccoon (*Procyon lotor*), and desert cottontail (*Sylvilagus audubonii*). The most common reptile observed at RFETS is the western prairie rattlesnake (*Crotalis viridus*), and the most common amphibian is the boreal chorus frog (*Pseudacris tryseriatus*). Common birds include the red-winged blackbird (*Agelaius phoeniceus*), song sparrow (*Melospiza melodia*), meadowlark (*Sturnella neglecta*), and vesper sparrow (*Pooecetes gramineus*). The most common small mammal species include the deer mouse (*Peromyscus maniculatus*), prairie vole (*Microtus ochrogaster*), meadow vole (*Microtus pennsylvanicus*), and different species of harvest mice (*Reithrodontomys sp*.).

RFETS supports two wildlife species listed as threatened or endangered species under the Endangered Species Act (USFWS 2005). The PMJM (*Zapus hudsonius preblei*) and the bald eagle (*Haliaeetus leucocephalus*) are listed as threatened species. The PMJM is a federally listed threatened species found at RFETS. The preferred habitat for the PMJM is the riparian corridors bordering RFETS' streams, ponds, and wetlands with an adjacent thin band of upland grasslands. The bald eagle occasionally forages at RFETS although no nests have been identified on site.

There are also a number of wildlife species that have been observed at RFETS that are species of concern by the State of Colorado (USFWS 2005). The plains sharp-tailed grouse (*Tympanuchus phasianellus jamesii*) is listed as endangered by the State and has been observed infrequently at RFETS. The western burrowing owl (*Athene cunicularia hypugea*) is listed as threatened by the State and is a known resident or regular visitor at RFETS. The ferruginous hawk (*Buteo regalis*), American peregrine falcon (*Falco peregrinus*), and the northern leopard frog (*Rana pipiens*) are listed as species of special concern by the State and are considered known residents or regular visitors at RFETS. The following species are listed as species of special concern and are observed infrequently at RFETS: greater sandhill crane (*Grus canadensis tibida*), long-billed curlew (*Numenius americanus*), mountain plover (*Charadrius montanus*), and the common garter snake (*Thamnophis sirtalis*).

More information on the plant communities and animal species that exist within RFETS is provided in Section 2.0 of the RI/FS Report.

1.1.4 Preble's Meadow Jumping Mouse Habitat within Rock Creek Drainage Exposure Unit

The RCEU supports habitat for the federally protected PMJM (Figure 1.5), and PMJM have been captured within the RCEU for more than a decade (Ebasco 1992; K-H 1997, 1999a, 1999b, 2002a). The RCEU supports approximately 70 (±7) individuals in the middle and lower portions of the EU (K-H 1999a). Although habitat is found throughout the RCEU, few PMJM have been found in the upper portion of the RCEU, and PMJM observed in the lower portion of the RCEU do not travel upstream to the middle portion, suggesting varying habitat quality or habitat discontinuity.

Sitewide PMJM habitat patches were identified in an effort to characterize habitat discontinuity and provide indications of varying habitat quality. Figure 1.5 presents PMJM patches within the RCEU. These patches aid in the evaluation of surface soil within PMJM habitat, giving a spatial understanding of areas that may be used by individual PMJM or subpopulations of PMJM. More detail on the methodology of creating sitewide PMJM habitat patches can be found in Appendix A, Volume 2, Section 3.2 of the RI/FS Report.

PMJM habitat within the RCEU was divided into 10 habitat patches, each containing habitat capable of supporting at least several PMJM individuals. The patches vary in size and shape dependent on their location within the Rock Creek drainage and the discontinuity or habitat quality of surrounding patches. The following is a brief discussion of the 10 patches within the RCEU and the reasons why each is considered distinct:

- Patch #1 – This patch contains habitat within the upper reach of Rock Creek, including the Mahonia and Plum Branches. The vegetation is dominated by tall upland shrubs, and the presence of narrow creek channels with steep rocky banks. Although all the habitat components are present, the narrow channels and steep rocky banks are of lower-quality habitat compared to areas downstream. Patch #1 also includes a small section of habitat that extends into the WAEU.

- Patch #2 – This is the largest patch located within upper Rock Creek where several of the Rock Creek branches come together. Large expanses of seep-fed wetlands are found here along with riparian shrublands and tall upland shrubs. This patch contains some of the highest-quality PMJM habitat on RFETS and supports a number of PMJM (K-H 1999a).

- Patch #3A and #3B – This patch is a combination of habitat along a creek corridor (#3A) and an adjacent seep area (#3B). These areas can be considered one unit based on observations of PMJM that used the seep area along with the creek corridor (K-H 1999a).

- Patch #4 – This patch is within the lower Rock Creek habitat and is composed of riparian shrubland and woodlands with adjacent upland shrubs such as snowberry and wild plum. Immediately upstream of this patch is a scoured stream reach with little understory vegetation and exposed cobble lining the channel and banks. This area creates the western boundary of this patch. On the downstream side of the patch is a culvert under State Highway 128, which creates the northern boundary. No PMJM inhabiting this patch have ever been observed using or migrating to upstream patches. Conversely, no PMJM inhabiting upstream patches have been observed migrating into this patch.

- Patch #5 – This area contains seep-fed wetlands, tall upland shrubs, mesic grasslands, and riparian shrublands (similar to Patch #2). It represents high-quality habitat and supports a number of PMJM. Individual mice captured and tracked in this patch did not appear to venture into other patches (K-H 1999a), preferring to stay in this area using the main channel of Rock Creek and Lobilia Branch (branch extending southwest). This patch also includes a small portion of habitat that extends into the IDEU.

- Patch #6 – This patch surrounds a specific seep area. Surface water from the seep does not connect to Rock Creek, but infiltrates to groundwater and isolates this patch from habitat along the main channel. A break in tall upland shrub vegetation separates this patch from Patch #5.

- Patch #7 – Similar to Patch #6, this patch surrounds two seeps that support tall upland shrubs and short upland shrubs including snowberry (*Symphoricarpos occidentalis*) and sumac (*Rhus aromatica*). The habitat of this patch is of lower quality based on drier conditions and its isolated location.

- Patch #8 – Similar to Patch #1, this patch is located in the upper reaches of Rock Creek. Although it is supported by seeps, Patch#8 also has a wider creek floodplain and lacks the rocky banks found in branches to the south. Vegetation consists of riparian and tall upland shrubs over a lush understory of grasses and forbs. Because it is in the upper reaches of one branch of Rock Creek, the habitat is drier than downstream areas and, therefore, is of lower quality, especially in late summer.

- Patch #32 – This patch is in the upper reaches of Lindsay Branch. It contains an ephemeral pond that is usually dry, with marshlands below the pond and thick grasses adjacent to the marshlands. Shrubs and trees are present but not to the extent of the higher-quality habitat areas found downstream. Ponderosa pine woodlands border the patch to the south.

- Patch #33 – This patch contains tall upland shrublands above Lindsay Branch. From east to west along the patch, the vegetation gets drier although it still supports shrubs. Short upland shrubs along Lindsay Branch create habitat within the western third of the patch. A break in tall upland shrub vegetation separates this patch from Patch #2.

1.1.5 Data Description

Data have been collected at RFETS under regulatory agency-approved Work Plans, Sampling and Analysis Plans (SAPs), and Quality Assurance Project Plans (QAPjPs) to meet data quality objectives (DQOs) and appropriate U.S. Environmental Protection Agency (EPA) and Colorado Department of Public Health and Environment (CDPHE) guidance. Surface soil/surface sediment, subsurface soil/subsurface sediment, surface water, and groundwater samples were collected from the RCEU. The data set for the CRA was prepared in accordance with data processing steps described in Appendix A, Volume 2, Attachment 2 of the RI/FS Report. Surface soil/surface sediment, subsurface soil/subsurface sediment, surface soil, and subsurface soil are the only media evaluated in the HHRA and ERA (Table 1.1). The sampling locations for these media are shown on Figures 1.6 and 1.7, and data summaries for detected analytes in each medium are provided in Tables 1.2 through 1.6. Potential contaminants of concern (PCOCs) and ecological contaminants of interest (ECOIs) that were analyzed for but not detected or detected in less than 5 percent of RCEU samples are presented in Attachment 1. Detection limits are compared to preliminary remediation goals (PRGs) and ecological screening levels (ESLs), and discussed in Attachment 1 (Tables A1.1 through A1.4).

In accordance with the CRA Methodology (DOE 2005a), only data from June 1991 to the present are used in the CRA because these data meet the approved analytical quality assurance/quality control (QA/QC) requirements. Additionally, only data for subsurface soil and subsurface sediment samples with a starting depth less than or equal to 8 feet below ground surface (bgs) are used in the CRA. Subsurface soil and subsurface sediment data are limited to this depth because it is not anticipated that the WRW or burrowing animals will dig to deeper depths. A detailed description of data storage and processing methods is provided in Appendix A, Volume 2 of the RI/FS Report.

The CRA analytical data set for the RCEU is provided on a compact disc (CD) presented in Attachment 6 that includes the data used in the CRA as well as data not considered useable. Additional criteria for exclusion of data from use in the CRA are presented in Appendix A, Volume 2 of the RI/FS Report.

The sampling data used for the RCEU HHRA and ERA are as follows:

- Combined surface soil/surface sediment data (HHRA);
- Combined subsurface soil/subsurface sediment data (HHRA);
- Surface soil data (ERA); and
- Subsurface soil data (ERA).

These data for these media are briefly described below.

In addition, because ECOPCs were identified for soil in this EU, surface water data were used in the ERA as part of the overall intake of ECOPCs by ecological receptor. The surface water data used in the ERA are summarized in Table 8.5. Surface water and sediment are assessed for ecological receptors on an aquatic exposure unit (AEU) basis in Appendix A, Volume 15B of the RI/FS Report. An assessment of the surface water, groundwater-to-surface water, and volatilization pathways for human health are presented in Appendix A, Volume 2 of the RI/FS Report.

Surface Soil/Surface Sediment

The combined surface soil/surface sediment data set for RCEU consists of up to 64 samples for various analyte groups (Table 1.1). The surface soil/surface sediment data set includes data from six shallow sediment sampling locations shown on Figure 1.6. All sample locations within the RCEU were not necessarily analyzed for all analyte groups (see Table 1.2). The sediment samples were collected from depths less than 0.5 feet bgs was from the sediment surface. For the grid sampling, five individual surface soil samples were collected and composited from each 30-acre cell, one from each quadrant and one in the center, as described in the CRA SAP Addendum 04-01 (DOE 2004). The samples were collected from 1991 to 1993 and in 2004, and were analyzed for inorganics, organics, and radionuclides. In the combined surface soil/surface sediment data set, data exist for 51 inorganic, 32 organic, and 64 radionuclide samples (Table 1.1).

The data summary for detected analytes in surface soil/surface sediment for the RCEU is presented in Table 1.2. Detected analytes included representatives from the inorganic, organic, and radionuclide analyte groups. A summary of analytes that were either not detected in or detected in less than 5 percent of in surface soil/surface sediment samples is presented and discussed in Attachment 1.

Subsurface Soil/Subsurface Sediment

The combined subsurface soil/subsurface sediment data set for RCEU consists of up to 15 samples for various analyte groups (Table 1.1). Subsurface sediment samples (that is, sediment samples with a starting depth of less than or equal to 8 feet bgs and an ending depth greater than 0.5 feet bgs) were collected from three locations as shown on Figure 1.7. All sample locations within the RCEU were not necessarily analyzed for all analyte groups (see Table 1.3). The combined subsurface soil/subsurface sediment data set contains analyses for 11 inorganic, 15 organic, and 11 radionuclide samples (Table 1.1).

The data summary for subsurface soil/subsurface sediment in the RCEU is presented in Table 1.3. Detected analytes included representatives from the inorganic, organic, and radionuclide analyte groups. A summary of analytes that were either not detected in or detected in less than 5 percent of subsurface soil/subsurface sediment samples is presented and discussed in Attachment 1.

Surface Soil

The surface soil data set for RCEU consists of up to 50 samples for various analyte groups (Table 1.1). The surface soil samples were collected in the RCEU in February 1992, March 1993, and March 2004 from the locations shown on Figure 1.6. All sample locations within the RCEU were not necessarily analyzed for all analyte groups (see Tables 1.4 and 1.5). The samples collected in 2004 were located on a 30-acre grid, as described in CRA SAP Addendum #04-01 (DOE 2004). For the grid sampling, five individual samples were collected from each 30-acre cell, one from each quadrant and one in the center, as described in the Addendum (DOE 2004). Surface soil sampling location numbers with a prefix starting with A, B, or C on Figure 1.6 represent the 30-acre grid samples. In the surface soil data set, data exist for 36 inorganic, 17 organic, and 50 radionuclide samples, and for PMJM surface soil data set, data exist for 19 inorganic, seven organic, and 29 radionuclide samples (Table 1.1).

The data summary for detected analytes in RCEU surface soil is presented in Table 1.4, while the data summary for the detected analytes for those samples within designated PMJM habitat is presented in Table 1.5. Radionuclides, organics, and inorganics were all detected in RCEU surface soil samples. A summary of analytes that were either not detected in or detected in less than 5 percent of surface soil samples in the RCEU is presented and discussed in Attachment 1.

Subsurface Soil

The subsurface soil data set for the RCEU consists of up to 12 samples for various analyte groups (Table 1.1). Samples were collected in 1991 and 1992 from four locations in the RCEU (Figure 1.7). All sample locations within the RCEU were not necessarily analyzed for all analyte groups (see Table 1.6). Subsurface soil samples to be used in the CRA are defined in the CRA Methodology as soil samples with a starting depth less than or equal to 8 feet bgs and an ending depth greater than 0.5 feet bgs.

The data summary for detected analytes in subsurface soil for the RCEU is presented in Table 1.6. Subsurface soil samples were analyzed for inorganics (eight samples), organics (12 samples), and radionuclides (eight samples), and representatives from all three analyte groups were detected. A summary of analytes that were either not detected in or detected in less than 5 percent of subsurface soil samples is presented and discussed in Attachment 1.

1.2 Data Adequacy Assessment

A data adequacy assessment was performed to determine whether the available data set discussed in the previous section is adequate for risk assessment purposes. The data adequacy assessment rules are presented in the CRA Methodology, and a detailed data adequacy assessment for the data used in the CRA is presented in Appendix A, Volume 2, Attachment 3 of the RI/FS Report. The adequacy of the data was assessed by comparing the number of samples for each analyte group in each medium as well as the spatial and temporal distributions of the data to data adequacy guidelines. If the data do not meet the guidelines, other lines of evidence (e.g., information on potential historical sources of contamination, migration pathways, and the concentration levels in the media) are examined to determine if it is possible to make risk management decisions given the data limitations.

The findings from the data adequacy assessment applicable to all EUs are as follows:

- The radionuclide and inorganic surface soil data are adequate for the purposes of the CRA.

- For herbicides and pesticides, although the existing surface soil and sediment data may not meet the minimal data adequacy guidelines for each EU, there is considerable site-wide data, and pesticides and herbicides are infrequently detected at low concentrations, generally below PRGs and ESLs. This line of evidence indicates that it is possible to make risk management decisions without additional sampling for these analyte groups.

- For dioxins, although the existing surface soil and sediment data do not meet the minimal data adequacy guidelines for each EU, sample locations were specifically targeted for dioxin analysis at historical IHSSs in and near the former Industrial Area where dioxins may have been released based on process knowledge. Some of the dioxin concentrations at the historical IHSSs exceed the PRG and/or ESL. Additional samples were collected in targeted locations that represented low-lying or depositional areas where dioxin contamination may have migrated via runoff from these specific IHSSs. Results indicate that dioxin concentrations are not above the minimum ESL in sediment and dioxins are not detected in surface water. Therefore, although the existing data do not meet the minimal data adequacy guidelines for each EU/AEU, it is possible to make risk management decisions without additional sampling. However, unlike pesticides and herbicides where there is considerably more site-wide data, there is greater uncertainty in the overall risk estimates because fewer samples were collected at the site for dioxins.

- Subsurface soil contamination is largely confined to historical IHSSs (that is, areas of known or suspected historical releases). These areas have been characterized to understand the nature and extent of potential releases. For historical IHSSs where subsurface soil samples were not collected for an analyte group, the presence of this type of subsurface contamination was not expected based on process knowledge. Therefore, the existing subsurface soil data are adequate for the purposes of the CRA.

The findings from the data adequacy report applicable to the RCEU are as follows:

- For surface soil and surface soil/surface sediment, the number of samples for all analyte groups (except dioxins) meets the data adequacy guideline.

- No surface soil or sediment samples were collected for dioxins in the RCEU. Although this does not meet the minimal data adequacy guideline, as noted above, dioxins are not expected to have been released in RCEU and it is possible to make risk management decisions without additional sampling,.

- Surface soil sample locations for organics are clustered in the central portion of the EU, which does not meet the data adequacy guideline for spatial representativeness. With the addition of the sediment data, the data are more evenly distributed throughout the EU. Because the RCEU contains no historical

IHSSs, and is hydraulically isolated from and generally upwind of potential historical source areas in and near the former Industrial Area, organics are not expected to be present in surface soil in the RCEU, it is possible to make risk management decisions without additional sampling.

- The number of surface soil samples in PMJM habitat patch #2 meets the data adequacy guideline. The data adequacy guideline for number of samples is not met for most analyte groups for the other patches in the RCEU. Because the RCEU contains no historical IHSSs, and is hydraulically isolated from and generally upwind of potential historical source areas in and near the former Industrial Area, concentration gradients should not be present and the data for habitat patch #2 should be representative of the other habitat patches. Furthermore, based on this rationale, surface soil data for the PMJM habitat patches can be aggregated for the purpose of conducting a statistical background comparison. Accordingly, it is possible to make risk management decisions without additional sampling.

- The data adequacy guideline for number of surface water samples for radionuclides, metals, VOCs, and SVOCs is met, but only 2 samples were collected for PCB analysis. However, PCBs were not detected in surface water or in surface soil/surface sediment in the RCEU. Furthermore, there are no historical sources for this type of contamination within the EU and no likely pathways for this contamination to migrate to the RCEU. Therefore, although the RCEU PCB data do not meet the minimal data adequacy guidelines, it is possible to make risk management decisions without additional sampling.

- Surface water sampling locations are well distributed throughout the RCEU, particularly those for radionuclides and metals. Therefore, the surface water sample locations meet the data adequacy guideline for spatial representativeness.

- There are no surface water data from 2001 to the present for PCBs. Although the data do not meet the data adequacy guideline for temporal representativeness, as discussed above, available information on potential historical sources of contamination and migration pathways indicate concentration trends PCBs are unlikely, and it is possible to make risk management decisions without additional sampling.

- For analytes not detected or detected in less than 5 percent of the samples in surface soil/surface sediment, 5 analytes have detection limits that exceed PRGs, however, the frequencies of PRG exceedance are either very low, or the analytes are not expected to be present in surface soil/surface sediment in the EU. All detection limits are below the PRGs/ESLs for subsurface soil/subsurface sediment and subsurface soil samples There are 16 analytes in surface soil where some percent of the detection limits exceed the lowest ESLs. However, those analytes that have detection limits that exceed the lowest ESLs contribute only minimal uncertainty to the overall risk assessment process because either only a small fraction of the detection limits are greater than the lowest ESL, or professional judgment indicates they are not likely to be ECOPCs in RCEU surface soil even if detection limits had been lower. Although some of the analytes would present a potential for adverse ecological effects if they were detected at their maximum detection limits, because they are not expected to be ECOPCs in RCEU surface soil, uncertainty in the overall risk assessment process is low (see Attachment 1 for a more detailed discussion).

1.3 Data Quality Assessment

A Data Quality Assessment (DQA) of the RCEU data was conducted to determine whether the data were of sufficient quality for risk assessment use. The DQA is presented in Attachment 2, and an evaluation of the entire RFETS data set is presented in Appendix A, Volume 2 of the RI/FS Report. The quality of the laboratory results were evaluated for compliance with the CRA Methodology DQOs through an overall review of precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters. This review concluded that the data are of sufficient quality for use in the CRA and the CRA DQOs have been met.

2.0 SELECTION OF HUMAN HEALTH CONTAMINANTS OF CONCERN

The human health contaminant of concern (COC) screening process is described in Section 4.4 of the CRA Methodology and summarized in Appendix A, Volume 2 of the RI/FS Report (Section 2.2).

The human health COC selection process was conducted for surface soil/surface sediment and subsurface soil/subsurface sediment in the RCEU. Results of the COC selection process are summarized below.

2.1 Contaminant of Concern Selection for Surface Soil/Surface Sediment

Detected PCOCs in surface soil/surface sediment samples (Table 1.2) are screened in accordance with the CRA Methodology to identify the COCs.

2.1.1 Surface Soil/Surface Sediment Cation/Anion and Essential Nutrient Screen

The major cations and anions that do not have toxicological factors are eliminated from assessments in surface soil/surface sediment in accordance with the CRA Methodology.

The essential nutrient screen for analytes detected in surface soil/surface sediment is presented in Table 2.1. The screen includes PCOCs that are essential for human health and do not have toxicity values. The PRG screen in Section 2.1.2 includes essential nutrients for which toxicity criteria are available. Table 2.1 shows the maximum detected concentrations (MDCs) for essential nutrients, daily intake estimates based on the MDCs, and dietary reference intakes (DRIs). The DRIs are identified in the table as recommended daily allowances (RDAs), recommended daily intakes (RDIs), adequate intakes (AIs), and upper limit daily intakes (ULs). The estimated daily maximum intakes based on the nutrients' MDCs and a surface soil/surface sediment ingestion rate of

100 milligrams per day (mg/day)are less than the DRIs. Therefore, these PCOCs were not further evaluated as COCs for surface soil/surface sediment.

2.1.2 Surface Soil/Surface Sediment Preliminary Remediation Goals Screen

Table 2.2 compares MDCs and upper confidence limits (UCLs) to the WRW PRGs for each PCOC. If the MDC and the UCL are greater than the PRG, the PCOC is retained for further screening; otherwise, it is not further evaluated. Arsenic, manganese, cesium-134, cesium-137, and radium-228 in surface soil/surface sediment had MDCs and UCLs that exceeded the PRGs and were retained as PCOCs.

PRGs were not available for several PCOCs in surface soil/surface sediment. Analytes without PRGs are listed on Table 2.2 and their effect on the conclusions of the risk assessment results is discussed in the uncertainty section (Section 6.0).

2.1.3 Surface Soil/Surface Sediment Detection Frequency Screen

Arsenic and manganese were detected in more than 5 percent of surface soil/surface sediment samples and, therefore, were retained for further evaluation in the COC screen (Table 1.2). A detection frequency screen was not performed for cesium-134, cesium-137, and radium-228 in surface soil/surface sediment because all reported values for radionuclides are considered detects.

2.1.4 Surface Soil/Surface Sediment Background Analysis

Results of the background statistical comparison for arsenic, manganese, cesium-134, cesium-137, and radium-228 are presented in Table 2.3 and discussed in Attachment 3. Box plots for these constituents (both RCEU and background) are provided in Attachment 3. Arsenic, manganese, cesium-137, and radium-228 were statistically greater than background at the 0.1 significance level, and are evaluated further in the professional judgment section.

2.1.5 Surface Soil/Surface Sediment Professional Judgment Evaluation

Based on the weight of available evidence evaluated by professional judgment, PCOCs will either be included for further evaluation as COCs or excluded as COCs. The professional judgment evaluation takes into account process knowledge, spatial trends, and pattern recognition. As discussed in Section 1.2 and Attachment 2, the sample results are adequate for use in the professional judgment because they are of sufficient quality for use in the CRA.

Based on the weight of evidence described in Attachment 3, arsenic, manganese, cesium-137, and radium-228 in surface soil/surface sediment in the RCEU are not considered COCs and are not further evaluated quantitatively. There is no identified source or pattern of release in the RCEU and the slightly elevated median values of the RCEU data for these PCOCs are most likely due to natural variation. The weight of evidence presented in Attachment 3, Section 4.0 supports the conclusion that concentrations of arsenic and manganese, and activities of cesium-137 and radium-228 are naturally occurring and not due to site activities.

2.2 Contaminant of Concern Selection for Subsurface Soil/Subsurface Sediment

Detected PCOCs in subsurface soil/subsurface sediment samples (Table 1.3) are screened in accordance with the CRA Methodology to identify the COCs.

2.2.1 Subsurface Soil/Subsurface Sediment Cation/Anion and Essential Nutrient Screen

The major cations and anions that do not have toxicological criteria are eliminated from assessments in subsurface soil/subsurface sediment in accordance with the CRA Methodology.

Essential nutrients without toxicity criteria that were detected in subsurface soil/subsurface sediment in the RCEU are compared to DRIs in Table 2.4. The estimated daily maximum intakes for these PCOCs, based on the nutrient's MDCs and a subsurface soil/subsurface sediment ingestion rate of 100 mg/day, are less than the DRIs. Therefore, these PCOCs were not further evaluated as COCs for subsurface soil/subsurface sediment.

2.2.2 Subsurface Soil/Subsurface Sediment Preliminary Remediation Goal Screen

The PRG screen for detected analytes in subsurface soil/subsurface sediment is presented in Table 2.5. The MDCs for all PCOCs were less than the PRGs. Therefore, no analytes detected in subsurface soil/subsurface sediment were retained beyond the PRG screen.

PRGs were not available for several PCOCs in subsurface soil/subsurface sediment. Analytes without PRGs are listed on Table 2.5 and their effect on the conclusions of the risk assessment results is discussed in the uncertainty section (Section 6.0).

2.2.3 Subsurface Soil/Subsurface Sediment Detection Frequency Screen

The detection frequency screen was not performed for subsurface soil/subsurface sediment because there are no PCOCs with concentrations greater than the PRGs.

2.2.4 Subsurface Soil/Subsurface Sediment Background Analysis

The background analysis was not performed for subsurface soil/subsurface sediment because there are no PCOCs with concentrations greater than the PRGs.

2.2.5 Subsurface Soil/Subsurface Sediment Professional Judgment Evaluation

The professional judgment step was not performed for subsurface soil/subsurface sediment because there are no PCOCs with concentrations greater than the PRGs.

2.3 Contaminant of Concern Selection Summary

A summary of the results of the COC screening process is presented in Table 2.6. No COCs were selected for any of the media at the RCEU.

3.0 HUMAN HEALTH EXPOSURE ASSESSMENT

The site conceptual model (SCM), presented in Figure 2.1 of the CRA Methodology and discussed in Appendix A, Volume 2 of the RI/FS Report, provides an overview of potential human exposures at RFETS for reasonably anticipated land use. However, all PCOCs were eliminated from further consideration as human health COCs for the RCEU based on comparisons of MDCs and UCLs to PRGs, background comparisons, or professional judgment (see Section 2.0). A quantitative risk characterization is not necessary for the RCEU and, therefore, an exposure assessment was not conducted.

4.0 HUMAN HEALTH TOXICITY CRITERIA

Procedures and assumptions for the toxicity criteria are presented in the CRA Methodology. All PCOCs were eliminated from further consideration as human health COCs for the RCEU based on comparisons of MDCs and UCLs to PRGs, background comparisons, or professional judgment (see Section 2.0). A quantitative risk characterization is not necessary for the RCEU and, therefore, a toxicity assessment was not conducted.

5.0 HUMAN HEALTH RISK CHARACTERIZATION

Information from the exposure assessment and the toxicity criteria sections is integrated in this section to characterize risk to the WRW and WRV receptors. However, all PCOCs were eliminated from further consideration as human health COCs based on comparisons of MDCs and UCLs to PRGs, background comparisons, or professional judgment (see Section 2.0). Therefore, a quantitative risk characterization was not performed for the RCEU.

6.0 UNCERTAINTIES ASSOCIATED WITH THE HUMAN HEALTH RISK ASSESSMENT

There are various types of uncertainties associated with steps of an HHRA. General uncertainties common to the EUs are discussed in Appendix A, Volume 2 of the RI/FS Report. Uncertainties specific to the EU are described below.

6.1 Uncertainties Associated with the Data

Data adequacy for this CRA is evaluated and discussed in Appendix A, Volume 2 of the RI/FS Report. Although there are some uncertainties associated with the sampling and analyses conducted for surface soil/surface sediment and subsurface soil/subsurface sediment at the RCEU, data are considered adequate for the characterization of risk at the EU. The environmental samples for the RCEU were collected from 1991 through 2004. The CRA sampling and analysis requirements for the BZ (DOE 2004, 2005a) specify that the minimum sampling density requirement for surface soil/surface sediment is one five-sample composite for every 30-acre grid cell. This sampling density is exceeded for most of the RCEU given that there are up to 64 surface soil/surface sediment samples for the entire 735-acre EU. In subsurface soil/subsurface sediment, there are up to 15 samples in the RCEU.

Another source of uncertainty in the data is the relationship of detection limits to the PRGs for analytes eliminated as COCs because they were either not detected or had a low detection frequency (i.e., less than 5 percent). The detection limits were appropriate for the analytical methods used, and this is examined in greater detail in Attachment 1.

6.2 Uncertainties Associated with Screening Values

The COC screening analyses utilized RFETS-specific PRGs based on a WRW scenario. The assumptions used in the development of these values were conservative. For example, it is assumed that a future WRW will consume 100 mg of surface soil/surface sediment for 230 days a year for 18.7 years. In addition, a WRW is assumed to be dermally exposed and to inhale surface soil and surface sediment particles in the air. These assumptions are likely to overestimate actual exposures to surface soil for WRWs in the RCEU because a WRW will not spend 100 percent of his or her time in this area. Exposure to subsurface soil and subsurface sediment is assumed to occur 20 days per year. The WRW PRGs for subsurface soil/subsurface sediment are also expected to conservatively estimate potential exposures because it is unlikely a WRW will excavate extensively in the RCEU.

6.2.1 Uncertainties Associated with Potential Contaminants of Concern without Preliminary Remediation Goals

PCOCs for the RCEU for which PRGs are not available are listed in Table 6.1.

Uncertainties associated with the lack of PRGs for analytes listed in Table 6.1 are considered small. The listed inorganics are not usually included in HHRAs because they are not expected to result in significant human health impacts. Phenanthrene is the only organic without a PRG available and has a low detection frequency and, therefore, is not expected to affect the results of the HHRA. Radionuclide PRGs are available for all detected individual radionuclides. Therefore, the lack of PRGs for gross alpha and gross beta activities is also not expected to affect the results of the HHRA.

6.3 Uncertainties Associated with Eliminating Potential Contaminants of Concern Based on Professional Judgment

Arsenic, manganese, cesium-137, and radium-228 in surface soil/surface sediment were eliminated as COCs based on professional judgment. There is no identified source or pattern of release in the RCEU and the slightly elevated median values of the RCEU data for these PCOCs are most likely due to natural variation. The weight of evidence presented in Attachment 3, Section 4.0 supports the conclusion that concentrations of arsenic, manganese, cesium-137, and radium-228 are naturally occurring and not due to site activities. Uncertainty associated with the elimination of these chemicals as COCs is low.

6.4 Uncertainties Evaluation Summary

Evaluation of the uncertainties associated with the data and the COC screening processes indicates there is reasonable confidence in the conclusions of the RCEU risk characterization.

7.0 IDENTIFICATION OF ECOLOGICAL CONTAMINANTS OF POTENTIAL CONCERN

The ecological contaminant of potential concern (ECOPC) identification process streamlines the ecological risk characterization for each EU by focusing the assessment on ECOIs that are present in the RCEU. ECOIs are defined as any chemical detected in the RCEU and are assessed for surface soils and subsurface soils. ECOIs for sediments and surface water are assessed in Appendix A, Volume 15B of the RI/FS Report. The ECOPC process is described in the CRA Methodology (DOE 2005a) and additional details are provided in Appendix A, Volume 2 of the RI/FS Report. A detailed discussion of the ecological SCM, including the receptors of concern, exposure pathways, and endpoints used in the ERA for the RCEU, is also provided in Appendix A, Volume 2 of the RI/FS Report.

The SCM presents the pathways of potential exposure from documented historical source areas (IHSSs and PACs) to the receptors of concern. Generally, the most significant exposure pathways for wildlife at the RCEU are the ingestion of plant, invertebrate, or animal tissue that could have accumulated ECOIs from the source areas through direct uptake or dietary routes, as well as the direct ingestion of potentially contaminated media. For terrestrial plants and invertebrates, the most significant exposure pathway is direct contact with potentially contaminated soil.

The receptors of concern that were selected for assessment are listed in Table 7.1 and discussed in detail in Appendix A, Volume 2 of the RI/FS Report, and include representative birds and mammals in addition to the general plant and terrestrial invertebrate communities. The receptors were selected based on several criteria, including their potential to be found in the various habitats present within the RCEU, their potential to have contact with ECOIs, and the amount of life history and behavioral information available.

The ECOPC identification process consists of two separate evaluations, one for the PMJM receptor and one for non-PMJM receptors. The ECOPC identification process for the PMJM is conducted separately from non-PMJM receptors because the PMJM is a federally listed threatened species under the Endangered Species Act (63 FR 26517).

7.1 Data Used in the Ecological Risk Assessment

The following RCEU data are used in the CRA:

- A total of 50 surface soil samples were collected and analyzed for inorganics (36 samples), organics (17 samples), and radionuclides (50 samples) (Table 1.2).
- A total of 12 subsurface soil samples were collected and analyzed for inorganics (eight samples), organics (12 samples), and radionuclides (eight samples) (Table 1.2).

A data summary is provided in Table 1.4 for surface soil and Table 1.6 for subsurface soil.

Sediment and surface water data for the RCEU also were collected (Section 1.1.5) and are evaluated for the ERA in Appendix A, Volume 15B of the RI/FS Report. As discussed in Section 8.0, surface water EPCs are used in the risk model to estimate exposure via the surface water ingestion pathway. Sixty-five distinct surface water samples were collected in the RCEU and analyzed for inorganics (65 samples), organics (32 samples), and radionuclides (32 samples).

As described in Section 1.1.4, there are 29 sample locations occurring in PMJM habitat within the RCEU. Surface soil samples were collected and analyzed for inorganics (19 samples), organics (seven samples), and radionuclides (29 samples). A data summary is provided in Table 1.5 for surface soil in PMJM habitat. Sampling locations and PMJM habitat patches within the RCEU are shown on Figure 1.5.

7.2 Identification of Surface Soil Ecological Contaminants of Potential Concern

ECOPCs for surface soil were identified for non-PMJM and PMJM receptors in accordance with the sequence presented in the CRA Methodology.

7.2.1 Comparison with No Observed Adverse Effect Level Ecological Screening Levels

In the first step of the ECOPC identification process, the MDCs of ECOIs in surface soil were compared to receptor-specific no observed adverse effect level (NOAEL) ESLs. NOAEL ESLs for surface soil were developed in the CRA Methodology for three receptor groups: terrestrial vertebrates, terrestrial invertebrates, and terrestrial plants.

Non-PMJM Receptors

The NOAEL ESLs for non-PMJM receptors are compared to MDCs in surface soil in Table 7.1. The results of the NOAEL ESL screening analyses for all receptor types are summarized in Table 7.2. Analytes with a “Yes” in any of the “Exceedance” columns in Table 7.2 are evaluated further.

NOAEL ESLs were not available for several ECOI/receptor pairs (Tables 7.1 and 7.2). These ECOI/receptor pairs are discussed as ECOIs with uncertain toxicity in Section 10.0, along with the potential impacts to the risk assessment.

PMJM Receptors

The NOAEL ESLs for PMJM receptors were compared to the MDCs of ECOIs in surface soil collected from PMJM habitat (Table 7.3). The MDCs in surface soil that exceed the NOAEL ESLs are identified in Table 7.3 with a "Yes" under the column heading "EPC>PMJM ESL?"

Analytes for which a PMJM NOAEL ESL is not available are identified with a "N/A" in Table 7.3 under the column heading "PMJM NOAEL ESL." These analytes are discussed in the uncertainty section (Section 10.0) as ECOIs with uncertain toxicity.

7.2.2 Surface Soil Frequency of Detection Evaluation

The ECOPC identification process for non-PMJM receptors involves an evaluation of detection frequency for each ECOI retained after the NOAEL screening step. If the detection frequency is less than 5 percent, population-level risks are considered highly unlikely, and the ECOI is not further evaluated. None of the chemicals detected in surface soil at the RCEU that were retained after the NOAEL ESL screening step had a detection frequency less than 5 percent. Therefore, no ECOIs were excluded based on the detection frequency evaluation for surface soil in the RCEU.

7.2.3 Surface Soil Background Comparisons

ECOIs retained after the NOAEL ESL screening and the detection frequency evaluation were then compared to site-specific background concentrations where available. The background comparison is presented in Tables 7.4 and 7.5 and discussed in Attachment 3. The statistical methods used for the background comparison are summarized in Appendix A, Volume 2 of the RI/FS Report.

Non-PMJM Receptors

The results of the background comparisons for the non-PMJM receptors are presented in Table 7.4. The analytes listed as being retained as ECOIs in Table 7.4 are evaluated further using upper-bound EPCs in the following section.

PMJM Receptors

The background comparison for PMJM receptors is performed using the same methods as for non-PMJM receptors, but the EU data set is restricted to soil samples from within PMJM areas. Table 7.5 presents the results of the PMJM comparison to background. Attachment 3 presents further discussion of the PMJM background analysis. The analytes listed as '"yes" on Table 7.5 are further evaluated in the professional judgment evaluation.

7.2.4 Upper-Bound Exposure Point Concentration Comparisons to Threshold ESLs

The ECOIs retained after completion of all previous evaluations for non-PMJM receptors were then compared to threshold ESLs (tESLs) using upper-bound exposure point concentrations (EPCs) specific to small and large home-range receptors. The calculation of EPCs is described in Attachment 3 and Appendix A, Volume 2 of the RI/FS Report.

Statistical concentrations for each ECOI retained for the tESL screen are presented in Table 7.6. The EPC for small home-range receptors is the 95 percent UCL of the 90th percentile (upper tolerance limit [UTL]), or the MDC in the event that the 95th UTL is greater than the MDC. The EPC for large home-range receptors is the UCL of the mean, or the MDC in the event that the UCL is greater than the MDC.

Small home-range receptors include terrestrial plants, terrestrial invertebrates, mourning dove, American kestrel, deer mouse, and black-tailed prairie dog. These receptors are evaluated by comparing the small home-range EPC (UTL) for each ECOI to the limiting (or lowest) small home-range receptor tESL (if available). In the event that tESLs are not available, the limiting NOAEL ESL is used in accordance with the CRA Methodology.

Large home-range receptors, such as coyote and mule deer, are evaluated by comparing the large home-range EPC (UCL) for each ECOI to the limiting large home-range receptor tESL (if available). In the event that tESLs are not available, the limiting NOAEL ESL is used in accordance with the CRA Methodology.

The upper-bound EPC comparison to limiting tESLs for small and large home-range receptors is presented in Table 7.7. Analytes that exceed the limiting tESLs are further evaluated by comparing them to the receptor-specific tESLs (if available) to identify receptors of potential concern. Analytes exceeding the limiting tESLs for small home-range receptors are compared to receptor-specific tESLs in Table 7.8, and analytes exceeding limiting tESLs for large home-range receptors are compared to receptor-specific tESLs in Table 7.9.

Chemicals that exceed any tESLs (if available) are assessed in the professional judgment evaluation. Any analyte/receptor pairs that are retained through professional judgment are identified as ECOPCs and are carried forward in the risk assessment.

7.2.5 Surface Soil Professional Judgment Evaluation

Non-PMJM Receptors

Based on the weight-of-evidence, professional judgment described in Attachment 3, aluminum, barium, boron, chromium, lithium, manganese, molybdenum, nickel, tin, vanadium, zinc, bis(2-ethylhexyl)phthalate, and di-n-butylphthalate in surface soil at the RCEU were not considered ECOPCs for non-PMJM receptors and are not further evaluated quantitatively.

PMJM Receptors

Based on the weight-of-evidence, professional judgment described in Attachment 3, chromium, molybdenum, nickel, and vanadium in surface soil within PMJM habitat at the RCEU were not considered ECOPCs for PMJM receptors and are not further evaluated quantitatively.

Manganese and tin were identified as ECOPCs for the PMJM receptor and retained for further evaluation in the risk characterization.

7.2.6 Summary of Surface Soil Ecological Contaminants of Potential Concern

The ECOPC identification process for surface soil is summarized below for non-PMJM receptors and PMJM receptors.

Non-PMJM Receptors

Most inorganic, organic, and radionuclide surface soil ECOIs for non-PMJM receptors in the RCEU were eliminated from further consideration in the ECOPC identification process based on one of the following: 1) the MDC of the ECOI was less than the lowest ESL; 2) no ESLs were available (these ECOIs are discussed in Section 10.0); 3) the concentration of the ECOI in RCEU surface soils was not statistically greater than background surface soils; 4) the upper-bound EPC did not exceed the limiting tESL; or 5) the weight-of-evidence, professional judgment evaluation indicated that the ECOI was not a site-related contaminant of potential concern. No chemicals were retained as ECOPCs.

A summary of the ECOPC screening process for non-PMJM receptors is presented in Table 7.10.

PMJM Receptors

ECOIs in surface soil in PMJM habitat located within the RCEU were evaluated in the ECOPC identification process. Most ECOIs were removed from further evaluation in the ECOPC identification process based on one of the following: 1) the MDC of the ECOI was less than the NOAEL ESL for PMJM; 2) no NOAEL ESLs were available (these ECOIs are discussed in Section 10.0); 3) the ECOI concentrations within the PMJM habitat in RCEU were not statistically greater than those from background surface soils; or 4) the weight-of-evidence, professional judgment evaluation indicated that the ECOI was not a site-related contaminant of potential concern. Chemicals that were retained are identified as ECOPCs and are presented in Table 7.11.

A summary of the ECOPC identification process for PMJM receptors is presented in Table 7.11. The ECOPC/PMJM pairs are evaluated further in Section 8.0 (Ecological Exposure Assessment), Section 9.0 (Ecological Toxicity Assessment), and Section 10.0 (Ecological Risk Characterization).

7.3 Identification of Subsurface Soil Ecological Contaminants of Potential Concern

Subsurface soil sampling locations with a starting depth of 0.5 to 8 feet bgs in the RCEU are identified on Figure 1.6. A data summary is presented in Table 1.6 for subsurface soil less than 8 feet deep.

7.3.1 Comparison to No Observed Adverse Effect Level Ecological Screening Levels

The CRA Methodology indicates subsurface soil is evaluated for those ECOIs that have greater concentrations in subsurface soil than in surface soil. As a conservative screening step, subsurface soil is evaluated for all EUs regardless of the presence/absence of a change in concentrations from surface soil and subsurface soil. The MDCs of ECOIs in subsurface soil were compared to NOAEL ESLs for burrowing receptors (Table 7.12). ECOIs with MDCs greater than the NOAEL ESL for the prairie dog are further evaluated in the ECOPC identification process.

NOAEL ESLs are not available for some analytes, and these are identified as “UT” in Table 7.12. These constituents are considered ECOIs with uncertain toxicity and are discussed in the uncertainty analysis (Section 10.0).

7.3.2 Subsurface Soil Detection Frequency Evaluation

The ECOPC identification process for burrowing receptors involves an evaluation of detection frequency for each ECOI retained after the NOAEL ESL screening step. If the detection frequency is less than 5 percent, population-level risks are considered highly unlikely and the ECOI is not further evaluated. The detection frequencies for chemicals in subsurface soil are presented in Table 1.6. None of the chemicals (specifically arsenic) in subsurface soil at the RCEU that were retained after the NOAEL ESL screening step had a detection frequency of less than 5 percent. Therefore, no ECOIs were eliminated from further evaluation based on low detection frequencies for subsurface soil in the RCEU.

7.3.3 Subsurface Soil Background Comparison

The ECOIs retained after the ESL screening and detection frequency evaluation were compared to site-specific background concentrations where available. The background comparisons are presented in Table 7.13 and discussed in Attachment 3. The statistical methods used for the background comparison are summarized in Attachment 3.

Analyses were conducted to assess whether arsenic in RCEU subsurface soil is statistically greater than arsenic in sitewide background surface soil at the 0.1 level of significance. The results of the statistical comparisons of the RCEU data to background data indicate that site concentrations of arsenic in RCEU subsurface soil is statistically greater than background concentrations. Arsenic is evaluated further using upper-bound EPCs in the following section.

7.3.4 Upper-Bound Exposure Point Concentration Comparisons to Threshold ESLs

ECOIs retained after all previous evaluations for burrowing receptors are compared to tESLs using upper-bound EPCs specific to small home-range receptors. The calculation of upper-bound EPCs is discussed in the CRA Methodology (DOE 2005a).

Because only arsenic was retained following the background analysis step, statistical concentrations for arsenic are presented in Table 7.14. The EPC comparison to tESLs for burrowing receptors is presented in Table 7.15. The MDC was used as the EPC because the UTL was greater than the MDC. The subsurface soil UTL for arsenic is greater than the tESL for the prairie dog receptor; therefore, it was evaluated further using professional judgment.

7.3.5 Subsurface Soil Professional Judgment

ECOIs with subsurface soil concentrations that exceed NOAEL ESLs, which have been detected in more than 5 percent of samples, that have concentrations statistically higher than background data, and which exceed tESLs are subject to a professional judgment evaluation. Based on the weight-of-evidence, professional judgment evaluation described in Attachment 3, arsenic in subsurface soil at the RCEU was not considered an ECOPC for the prairie dog receptor.

7.3.6 Summary of Subsurface Soil Ecological Contaminants of Potential Concern

All subsurface soil ECOIs for burrowing receptors in the RCEU were eliminated from further consideration in the ECOPC identification process based on one of the following: 1) the MDC of the ECOI was less than NOAEL ESL for the burrowing receptor; 2) no ESLs were available (these ECOIs are discussed in Section 10.0); 3) the concentration of the ECOI in RCEU subsurface soils was not statistically greater than those in background subsurface soils; 4) the upper-bound EPC was less than the tESL; or 5) the weight-of-evidence, professional judgment evaluation indicated that the ECOI was not a site-related contaminant of potential concern. The results of the subsurface soil ECOPC identification process for burrowing receptors are summarized in Table 7.16.

7.4 Summary of Ecological Contaminants of Potential Concern

ECOIs in surface and subsurface soil in the RCEU were evaluated in the ECOPC identification process for non-PMJM receptors, PMJM receptors, and burrowing receptors. No chemicals were identified as ECOPCs for selected non-PMJM receptors (Table 7.10) or for burrowing receptors (Table 7.16). Manganese and tin were identified as ECOPCs for the PMJM receptor (Table 7.11). No other ECOIs were retained past the professional judgment step of the ECOPC identification process for any other receptor group (non-PMJM receptors, PMJM receptors, or burrowing receptors).

8.0 ECOLOGICAL EXPOSURE ASSESSMENT

The ECOPC identification process defined the steps necessary to identify those chemicals that could not reliably be removed from further consideration in the ERA process. The list of ECOPC/receptor pairs of potential concern (Table 8.1) represents those media, chemicals, and receptors in the RCEU that require further assessment. The characterization of risk defines a range of potential exposures to site receptors from the ECOPCs and a parallel evaluation of the potential toxicity of each of the ECOPCs as well as the uncertainties associated with the risk characterization. This section provides the estimation of potential exposure to surface soil ECOPCs for the receptors identified in Section 7.0 and Table 8.1. Exposure to ECOPCs via the ingestion of surface water is also considered a potentially significant exposure route as presented in the CRA Methodology (DOE 2005a). Details of the two exposure models, concentration-based exposure and dosage-based exposure, are presented in Appendix A, Volume 2 of the RI/FS Report.

8.1 Exposure Point Concentrations

Surface soil EPCs for PMJM receptors were calculated for each PMJM habitat patch assuming that all samples were randomly located and weighted equally. The habitat patches showing sample locations exceeding the NOAEL ESL, or three times the NOAEL ESL are shown for ECOPCs in Figure 8.1 (manganese) and Figure 8.2 (tin). The UCL concentrations for each ECOPC were used as EPCs to calculate HQs. The UCL was not used if there were not sufficient numbers of samples to calculate this value or if it exceeded the MDC. In either case, the MDC was used as a surrogate EPC. The surface soil EPCs for each PMJM patch are presented in Table 8.2. The ECOPCs shown in Table 8.2 represent ECOPCs with patch-specific MDCs greater than their respective ESLs. All ECOPCs that are not detected in a specific patch or at concentrations less than their ESLs are excluded from the table.

The surface water EPCs were calculated for ECOIs that were identified as soil ECOPCs using the same statistical basis as determined for the soil ECOPCs. For example, if the soil EPC statistic was the UCL, then the UCL concentration in surface water (total values only) was calculated as described for soils and selected as the EPC. Surface water EPCs for all ECOPCs are presented in Table 8.3. All surface water data are provided on CD in Attachment 6.

8.2 Receptor-Specific Exposure Parameters

Receptor-specific exposure factors are needed to estimate exposure to ECOPCs for the PMJM. These include body weight; food, water, and media ingestion rates; and diet composition and respective proportion of each dietary component. Daily rates for intake of forage, prey, water, and incidental ingestion of soils were developed in the CRA Methodology (DOE 2005a) and are presented in Table 8.4 for the PMJM carried forward in the ERA for the RCEU.

8.3 Bioaccumulation Factors

The measurement or estimation of concentrations of ECOPCs in wildlife food is necessary to evaluate how much of a receptor's exposure is via food versus direct uptake of contaminated media. Conservative bioaccumulation factors (BAFs) were identified in the CRA Methodology (DOE 2005a). These BAFs are either simple ratios between chemical concentrations in biota and soil or are based on quantitative relationships such as linear, logarithmic, or exponential equations. The values reported in the CRA Methodology are used as the BAFs for purposes of risk estimation.

8.4 Intake and Exposure Estimates

Intake and exposure estimates were completed for each ECOPC/PMJM pair identified in Table 8.1. The estimates use the default exposure parameters and BAFs presented in Appendix B of the CRA Methodology (DOE 2005a) and described in the previous subsection. These intake calculations represent conservative estimates of food tissue concentrations calculated from the range of upper-bound EPCs.

PMJM Receptors

The intake and exposure estimates for ECOPC/PMJM receptor pairs are presented in Attachment 4 and are summarized in Table 8.5 for:

- Manganese; and
- Tin.

9.0 ECOLOGICAL TOXICITY ASSESSMENT

Exposure to wildlife receptors was estimated for representative species of functional groups based on taxonomy and feeding behavior in Section 8.0 in the form of a daily rate of intake for each ECOPC/receptor pair. To estimate risk, soil concentrations (plants and invertebrate exposure) and calculated intakes (birds and mammals) must then be compared to the toxicological properties of each ECOPC. The laboratory-based toxicity benchmarks are termed toxicity reference values (TRVs) and are of several basic types. The NOAEL and no observed effect concentration (NOEC) TRVs are intake rates or soil concentrations below which no ecologically significant effects are expected. The NOAEL and NOEC TRVs were used to calculate the NOAEL ESLs employed in screening steps of the ECOPC identification process to eliminate chemicals that have no potential to cause risk to the representative receptors. The lowest observed adverse effects level (LOAEL) TRV is a concentration above which the potential for some ecologically significant adverse effect could be elevated. The threshold TRVs represent the hypothetical dose at which the response for a group of exposed organisms may first begin to be significantly greater than the response for unexposed receptors and is calculated as the geometric mean of the NOAEL and LOAEL. Threshold TRVs were calculated based on specific data quality rules for use in the ECOPC identification process for a small subset of ECOIs in the CRA Methodology (DOE 2005a).

TRVs for ECOPCs identified for RCEU were obtained from the CRA Methodology. The pertinent TRVs for the RCEU are presented for mammals in Table 9.1.

10.0 ECOLOGICAL RISK CHARACTERIZATION

Risk characterization includes risk estimation and risk description. Details of these components are described in the CRA Methodology (DOE 2005a) and Appendix A, Volume 2 of the RI/FS Report. Predicted risks should be viewed in terms of the potential for the assumptions used in the risk characterization to occur in nature, the uncertainties associated with the assumptions, and in the potential for effects on the population of receptors that could inhabit the RCEU.

Potential risks to terrestrial mammals are evaluated using a hazard quotient (HQ) approach. An HQ is the ratio of the estimated exposure of a receptor to a TRV that is associated with a known level of toxicity, either a no effect level (NOAEL or NOEC) or an effect level (LOAEL or lowest effects concentration [LOEC]):

$$HQ = Exposure / TRV$$

As described in Section 8.0, the units used for exposure and TRV depend upon the type of receptor evaluated. For mammals, exposures and TRVs are expressed as ingested doses (mg/kg BW/day).

In general, if the NOAEL-based HQ is less than 1, then no adverse effects are predicted. If the LOAEL-based HQ is less than 1 but the NOAEL-based HQ is above 1, then some adverse effects are possible, although it is expected that the magnitude and frequency of the effects will usually be low (assuming the magnitude and severity of the response at the LOAEL are not large and the endpoint of the LOAEL accurately reflects the assessment endpoints for that receptor). If the LOAEL-based HQ is greater than or equal to 1, the risk of an adverse effect is of potential concern, with the probability and/or severity of effect tending to increase as the value of the HQ increases.

When interpreting HQ results for non-PMJM ecological receptors, it is important to remember that the assessment endpoint to non-PMJM receptors is based on the sustainability of exposed populations, and risks to some individuals in a population may be acceptable if the population is expected to remain healthy and stable. For threatened and endangered species, such as the PMJM, the interpretation of HQ results is based on potential risks to individuals rather than populations.

HQs were calculated for each ECOPC/PMJM pair based on the exposures estimated and TRVs presented in the preceding sections. The NOAEL and NOEC TRVs along with default screening-level exposure assumptions are first used to calculate HQs. However, these no effects HQs are typically considered as screening level results and do not necessarily represent realistic risks for the site. EPA risk assessment guidance (EPA 1997) recommends a tiered approach to evaluation, and following the first tier of evaluation "the risk assessor should review the assumptions used (e.g., 100 percent bioavailability) against values reported in the literature (e.g., only up to 60 percent for a particular contaminant), and consider how the HQs would change if more realistic conservative assumptions were used instead." Accordingly, LOAEL and threshold TRVs are also used in this evaluation to calculate HQs. Where LOAEL HQs greater than 1 are calculated using default exposure assumptions, and the uncertainty analysis indicates that alternative BAFs and/or TRVs would be beneficial to reduce uncertainty and conservatism, alternative HQs are calculated.

10.1 Chemical Risk Characterization

Chemical risk characterization uses quantitative methods to evaluate potential risks to ecological receptors. In this risk assessment, the quantitative method used to characterize chemical risk is the HQ approach. As noted above, HQs are usually interpreted as follows:

HQ Values		Interpretation of HQ Results
NOAEL-based	LOAEL-based	
≤ 1	≤ 1	Minimal or no risk
> 1	≤ 1	Low-level risk[a]
> 1	> 1	Potential adverse effects

[a] Assuming magnitude and severity of response at LOAEL are relatively small and based on endpoints appropriate for the assessment endpoint of the receptor considered.

One potential limitation of the HQ approach is that calculated HQ values may sometimes be uncertain due to simplifications and assumptions in the underlying exposure and toxicity data used to derive the HQs. Where possible, this risk assessment provides information on three potential sources of uncertainty, described below.

- **EPCs.** Because surface soil sampling programs in the EU sometimes tended to focus on areas of potential contamination (IHSS/PAC/UBCs), EPCs calculated using the Tier 1 approach (which assumes that all samples are randomly spread across the EU and are weighted equally) may tend to yield an EPC that is biased high. For this reason, a Tier 2 area-weighting approach was used to derive additional EPCs that help compensate for this potential bias. HQs were always calculated based on both Tier 1 and Tier 2 EPCs for non-PMJM receptors. For PMJM receptors, only Tier 1 EPCs were used.

- **BAFs.** For wildlife receptors, concentrations of contaminants in dietary items were estimated from surface soil using uptake equations. When the uptake equation was based on a simple linear model (e.g., $C_{tissue} = BAF * C_{soil}$), the default exposure scenario used a high-end estimate of the BAF (the 90th percentile BAF). However, the use of high-end BAFs may tend to overestimate tissue concentrations in some dietary items. To estimate more typical tissue concentrations, where necessary, an alternative exposure scenario calculated total chemical intake using a 50th percentile (median) BAF and HQs were calculated. The use of the median BAF is consistent with the approach used in the ecological soil screening level (Eco-SSL) guidance (EPA 2005).

- **TRVs.** The CRA Methodology used an established hierarchy to identify the most appropriate default TRVs for use in the ECOPC selection process. However, in some instances, the default TRV selected may be overly conservative with regard to characterizing population-level risks. The determination of whether the default TRVs are thought to yield overly conservative estimates of risk is addressed on a chemical-by-chemical basis in the following subsections. When an alternative TRV is identified, the chemical-specific subsections provide a discussion of why the alternative TRV is thought to be appropriate to provide an alternative estimate of toxicity (e.g., endpoint relevance, species relevance, data quality, chemical form, etc.), and HQs were calculated using both default and alternative TRVs where necessary.

The influences of each of these uncertainties on the calculated HQs were evaluated both alone and in concert in the risk description for each chemical. Uncertainties related to the BAFs, TRVs, and background risk are presented for each chemical in Attachment 5. Where uncertainties were deemed to be high, Attachment 5 provides alternative BAFs and/or TRVs that are then incorporated into the risk characterization, as appropriate.

HQs calculated using the default BAFs and Tier 1 EPCs are provided in Table 10.1 for each ECOPC/PMJM pair. Shaded cells represent default HQ calculations based on exposure and toxicity models specifically identified in the CRA Methodology. Where no LOAEL HQs exceed 1 using the default exposure and toxicity values, no further HQs were calculated. Since the default HQs are generally the most conservative risk estimations, if low risk is estimated using these values then further reductions of conservatism would only serve to reduce risk estimates further.

Where LOAEL HQs greater than 1 are calculated using default assumptions, and the uncertainty analysis indicates that median BAFs and/or additional TRVs would be beneficial to reduce uncertainty and conservatism, alternative HQs are calculated and presented in Table 10.1 as appropriate.

The selection of which EPC (e.g., UTL or UCL) is of primary importance will depend upon the type of receptor and the relative home-range size. Only the UCL is provided for PMJM receptors.

All calculated exposure estimates and HQ values are also provided in Attachment 4. These include the default and refined HQs if needed. The results for each ECOPC are discussed in more detail below.

The risk description incorporates results of the risk estimates along with the uncertainties associated with the risk estimations and other lines of evidence to evaluate potential chemical effects on PMJM receptors in the RCEU. Information considered in the risk description includes receptor groups potentially affected, type of TRV exceeded (e.g., NOAEL versus LOAEL), relation of EU concentrations to other criteria such as EPA Eco-SSLs, and risk above background conditions. In addition, other site-specific and regional factors are considered such as the use of a given ECOPC within the EU related to historical RFETS activities, comparison of ECOPC concentrations within the RCEU to the rest of the RFETS site as it relates to background, and/or comparison to regional background concentrations.

10.1.1 Manganese

Manganese HQs for the PMJM receptor are presented in Table 10.1. Figure 8.1 shows the spatial distribution of manganese in relation to the PMJM ESL.

For the PMJM receptor, none of the patches had LOAEL HQs greater than 1 using the default exposure assumptions and no additional HQs were calculated.

Care should, however, be taken to review the chemical specific uncertainties discussed in Attachment 5 when reviewing the results for the PMJM, regardless of whether refined HQs were calculated to address uncertainties in the default risk model.

Manganese Risk Description

Manganese was identified as an ECOPC for the PMJM receptor only. Information on the historical use and a summary of site data and background data are provided in Attachment 3.

PMJM Receptor

For the PMJM receptor, NOAEL HQs ranged from 7 (Patch #3B) to 0.7 (Patch #7) using the default risk model. NOAEL HQs for patch #3A, #3B, and #8 were equal to 2, 7 and 2, respectively.

LOAEL HQs were less than 1 for manganese in all patches within RCEU using the default risk model. Therefore, risks to PMJM receptors from exposure to manganese are likely to be low in all patches within RCEU.

10.1.2 Tin

Tin HQs for the PMJM receptor are presented in Table 10.1. Figure 8.2 shows the spatial distribution of tin in relation to the PMJM ESL.

For the PMJM receptor, none of the patches had LOAEL HQs greater than 1 using the default risk model and no additional HQs were calculated.

Care should, however, be taken to review the chemical specific uncertainties discussed in Attachment 5 when reviewing the results for the PMJM, regardless of whether refined HQs were calculated to address uncertainties in the default risk model.

Tin Risk Description

Tin was identified as an ECOPC for the PMJM receptor only. Information on the historical use and a summary of site data and background data are provided in Attachment 3.

PMJM Receptor

For the PMJM receptor, NOAEL HQs ranged from 7 (Patch #3A and #3B) to 0.2 (Patch #1 and #7) using the default risk model. NOAEL HQs for Patch #2, #3A, #3B, and #8 were equal to 6, 7, 7, and 4, respectively.

LOAEL HQs were less than 1 in all patches within RCEU using the default risk model. Therefore, risks to PMJM receptors from exposure to tin are likely to be low in all patches within RCEU.

10.2 Ecosystem Characterization

An ecological monitoring program has been underway since 1991 when baseline data on wildlife species was gathered (Ebasco 1992). The purpose of this long-term program was to monitor specific habitats to provide a sitewide database from which to monitor trends in the wildlife populations at RFETS. Although a comprehensive compilation of monitoring results has not been presented, the annual reports of the monitoring program provide localized information and insights on the general health of the RFETS ecosystem. Permanent transects through three basic habitats were run monthly for more than a decade (K-H 2002a). Observations were recorded concerning the abundance, distribution, and diversity of wide-ranging wildlife species, including observations of migratory birds, raptors, coyotes, and deer. Small mammal monitoring occurred through several tasks in the monitoring program. The Ecological Monitoring Program (DOE 1995) established permanent transects for small mammal monitoring in three habitat types: xeric grasslands, mesic grasslands, and riparian habitats. PMJM studies established small mammal trapping in nearly all riparian habitats across the site (K-H 1998, 1999a, 2000, 2001, 2002a).

Migratory birds were tracked during all seasons, but most notably during the breeding season. Over 8 years of bird survey data were collected on 18 permanent transects. Field observations were summarized into species richness and densities by habitat type. Habitats comprised the general categories of grasslands, woodlands and wetlands. However, summaries in annual reports are grouped by habitat types across RFETS and not within EUs because EU boundaries were determined well after the monitoring program had begun. Additionally, wide-ranging animals may use habitat in several EUs and do not recognize EU boundaries.

Summarizing songbird surveys over the breeding season, diversity indices for RFETS for all habitats combined over 8 years of observations (1991, 1993-1999) show a steady state in diversity of bird communities (K-H 2000). Among habitats, results were similar with the exception of an increasing trend in species richness and a decreasing trend in bird densities in woodland habitats. Woodland bird communities consistently show the highest diversity when compared with bird communities in wetlands and grasslands. The decreasing trend can be mostly attributed to transient species (i.e., those species not usually associated with woody cover) except for red-tail hawk (*Buteo jamaicensis*) and American goldfinch (*Carduelis tristis*). The red-tailed hawk change in density can be attributed to a loss of nesting sites in Upper Woman Creek during the survey period. Goldfinch abundance can be heavily influenced by the availability of food sources.

A subgroup of migratory birds is the neotropical migrants, which show declining populations in North America (Audubon 2005; Nature Conservancy 2005). Most of this decline is thought to be due to conversion of forest land to agriculture in the tropics, and conversion to real estate development in North America. Grassland birds that are neotropical migrants are also in decline. However, over the last 5 years at RFETS, the declining trends have not been observed and densities for this group show an increase.

Raptors, big game species, and carnivores were observed through relative abundance surveys and multi-species surveys (16 permanent transects) that provide species-specific sitewide counts. Raptors were noted on relative abundance surveys and nest sites were visited repeatedly during the nesting season to confirm nesting success. The three most common raptors at RFETS are red-tailed hawk, great horned owl (*Bubo virginianus*), and American kestrel (*Falco sparverius*) (K-H 2002a). One Swainson's hawk nest was noted in North Walnut Creek near the A-1 Pond, and one great horned owl nest was observed within South Walnut Creek. All nests typically fledged two young of each species, except kestrels, which usually fledged two to three young. Each species had a successful nesting season each year during the monitoring period from 1991 to 1999, with a single exception. This exception was the loss of the red-tail hawk nest in Upper Woman Creek (K-H 1997 and 1998) due to weather. The continued presence of nesting raptors at RFETS (K-H 2002a) indicates that habitat quality and protection from human disturbance have contributed to making RFETS a desirable location for raptors to reproduce. Adequate habitat provides essential seasonal requirements. RFETS is estimated to be at optimum population density for raptors given available habitat and territorial nature of these species (K-H 2000).

Two deer species inhabit RFETS: mule deer (*Odocoileus hemionus*) and white-tailed deer (*Odocoileus virginianus*). No white-tailed deer were present at RFETS in 1991 when monitoring began (K-H 2002a). In 2000 (K-H 2001) numbers of white-tailed deer were estimated to be between 10 and 15 individuals. Mule deer frequent all parts of RFETS (14 mi^2) year-round. The RFETS population from winter counts is estimated at a mean 125 individuals ($n = 7$), with a density of 14 deer per square mile (K-H 2000, 2002a). Winter mule deer counts have varied from 100 to 160 individuals over the monitoring period (1994 to 2000) with expected age/sex class distributions (K-H 2001). The mule deer populations from RFETS have been increasing at a steady state, with good age/sex distributions (K-H 2001) over time and similar densities when compared to other "open" populations that are not hunted. This provides a good indicator that habitat quality is high and that site activities have not affected deer populations. It is unlikely that deer populations are depressed or reproduction is affected by contaminants. A recent study on actinides in deer tissue found that plutonium levels were near or below detection limits

(Todd and Sattelberg 2004). This provides further support that the deer population is healthy.

Coyotes (*Canis latrans*) are the top mammalian predator at RFETS. They prey upon mule deer fawns and other smaller prey species. The number of coyotes using the site has been estimated at 14 to 16 individuals (K-H 2002a). Through surveys across the site, coyotes have been noted to have reproduction success with as many as six dens active in 1 year. Typically, at RFETS, three to six coyote dens support an estimated 14 to 16 individuals at any given time (K-H 2001). Coyotes have exhibited a steady population over time, thereby indicating their prey species continue to be abundant and healthy.

The RCEU has been trapped over several years (DOE 1995; K-H 1998, 2001) under the Ecological Monitoring Program. Initially (DOE 1995), two monitoring sites, a mesic grassland and a riparian site, were established for long-term monitoring. Results from this trapping effort revealed typical small mammal communities with normal densities of each species (DOE 1995; Fitzgerald et al. 1994). PMJM have been captured in the RCEU over the last decade (DOE 1995; K-H 1998, 2000) and have persisted at expected densities over time. Common species found in riparian areas have also been captured with PMJM, indicating a typical community of small mammals in the RCEU. Results of small mammal trapping from 1993 to 2000 give indications of diverse and healthy small mammal communities in the RCEU, and monitoring has revealed abundance and species diversity that would be expected in typical native ecosystems on the plains of Colorado (Fitzgerald et al. 1994).

The high species diversity and continued use of the site by numerous vertebrate species verify that habitat quality for these species remains acceptable and the ecosystem functions are being maintained (K-H 2000). Data collected on wildlife abundance and diversity indicate that wildlife populations are stable and species richness remains high during remediation activities at RFETS, including wildlife using the RCEU.

10.3 General Uncertainty Analysis

Quantitative evaluation of ecological risks is limited by uncertainties regarding the assumptions used to predict risk and the data available for quantifying risk. These limitations are usually addressed by making estimates based on the data available or by making assumptions based on professional judgment when data are limited. Because of these assumptions and estimates, the results of the risk calculations themselves are uncertain, and it is important for risk managers and the public to view the results of the risk assessment with this in mind. Chemical-specific uncertainties are presented in Attachment 5 of this document and were discussed in terms of their potential effects on the risk characterization in the risk description section for each ECOPC. The following general uncertainties associated with the ERAs for all the EUs may under- or overestimate risk to an unknown degree; a full discussion of these general uncertainties is provided in Volume 2 of Appendix A of the RI/FS Report:

- Uncertainties associated with data quality and adequacy;
- Uncertainties associated with the ECOPC identification process;

- Uncertainties associated with the selection of representative receptors;
- Uncertainties associated with exposure calculations;
- Uncertainties associated with the development of NOAEL ESLs;
- Uncertainties associated with the lack of toxicity data for ECOIs; and
- Uncertainties associated with eliminating ECOIs based on professional judgment.

The following sections are potential sources of general uncertainty that are specific to the RCEU ERA.

10.3.1 Uncertainties Associated With Data Adequacy and Quality

Sections 1.2 and 1.3 summarize the general data adequacy and data quality for the RCEU, respectively. A more detailed discussion is presented in Appendix A, Volume 2, Attachments 2 and 3 of the RI/FS Report, and Attachment 2 of this volume. The data quality assessment indicates the data are of sufficient quality for use in the CRA. The adequacy of the RCEU data was assessed by comparing the number of samples for each analyte group in each medium as well as the spatial and temporal distributions of the data to data adequacy guidelines. The assessment indicates the number of RCEU surface soil samples for each analyte group (except dioxins – see Section 1.2 for discussion) meet the data adequacy guideline; however, except for PMJM patch #2, the number of surface soil samples for each analyte group in each PMJM patch does not meet the data adequacy guideline. However, because the RCEU contains no historical IHSSs, and is hydraulically isolated from and generally upwind of potential historical source areas in and near the former Industrial Area, concentration gradients are not expected to be present in surface soil in the RCEU, and the data for PMJM patch #2 should be representative of all the PMJM patches. Although there is limited PCB data for surface water, available information on potential historical sources of contamination, migration pathways, and contaminant levels in other RCEU media show that PCBs are not likely to be of concern for the EU surface water. Therefore, it is possible to make risk management decisions without additional sampling surface soil or surface water sampling. Data used in the CRA must have detection limits to allow meaningful comparison to ESLs. When these detection limits exceed the respective ESLs, this is a source of uncertainty in the risk assessment. There are 16 analytes in surface soil that have detection limits that exceed the lowest ESLs, but these higher detection limits contribute only minimal uncertainty to the overall risk assessment process because either only a small fraction of the detection limits are greater than the lowest ESL, or professional judgment indicates they are not likely to be ECOPCs in RCEU surface soil even if detection limits had been lower.

10.3.2 Uncertainties Associated with the Lack of Toxicity Data for Ecological Contaminant of Interest Detected at the Rock Creek Drainage Exposure Unit

Several ECOIs detected in the RCEU do not have adequate toxicity data for the derivation of ESLs (CRA Methodology). These ECOIs are listed in Tables 7.1, 7.3, and 7.12 with a “UT” designation. Included as a subset of the ECOIs with a “UT” designation are the essential nutrients (calcium, iron, magnesium, potassium, and sodium). Although these nutrients may be potentially toxic to certain ecological receptors at high concentrations, the uncertainty associated with the toxicity of these nutrients is expected to be low. Appendix B of the CRA Methodology outlines a detailed search process that was intended to provide high quality toxicological information for a large proportion of the chemicals detected at RFETS. Although the toxicity is uncertain for those ECOIs that do not have ESLs calculated due to a lack of identified toxicity data, the overall effect on the risk assessment is small because the primary chemicals historically used at RFETS have adequate toxicity data for use in the CRA. Therefore, while the potential for risk from these ECOPCs is uncertain and will tend to underestimate the overall risk calculated, the magnitude of underestimation is likely to be low.

10.3.3 Uncertainties Associated With Eliminating Ecological Contaminants of Interest Based on Professional Judgment

Several analytes in surface soil and subsurface soil were eliminated as ECOIs based on professional judgment. The professional judgment evaluation is intended to identify those ECOIs that have a limited potential for contamination in the RCEU. The weight-of-evidence approach indicates that there is no identified source or pattern of release in the RCEU, and the slightly elevated values of the RCEU data for these ECOIs are most likely due to natural variation. The professional judgment evaluation is unlikely to have significant effect on the overall risk calculations because the ECOIs eliminated from further consideration are found at concentrations in RCEU that are at levels that are unlikely to result in risk concerns for ecological receptors and are well within regional background levels. In addition, these ECOIs are not related to site-activities in the RCEU and have very low potential to be transported from historical sources to the RCEU.

10.3.4 Summary of Significant Sources of Uncertainty

The preceding discussion outlined the significant sources of uncertainty in the CRA process for assessing ecological risk. While some of the sources of uncertainty discussed tend to either underestimate risk or overestimate risk, many result in an unknown effect on the potential risks. However, the CRA Methodology outlines a tiered process of risk evaluation that includes conservative assumptions for the ECOPC identification process and more realistic assumptions, as appropriate, for risk characterization.

11.0 SUMMARY AND CONCLUSIONS

A summary of the results of this CRA for human health and ecological receptors in the RCEU is presented below.

11.1 Data Adequacy

The adequacy of the RCEU data was assessed by comparing the number of samples for each analyte group in each medium as well as the spatial and temporal distributions of the data to data adequacy guidelines. The assessment indicates the total number of RCEU surface soil and sediment samples for each analyte group meet the data adequacy guideline; however, for individual PMJM patches, the data adequacy guideline for number of surface soil samples is met for only one patch (patch #2). Also, except for PCBs where there are limited data, the number of RCEU surface water samples for each analyte group meet the data adequacy guideline. Although there are data limitations for the RCEU, other lines of evidence (e.g., information on potential historical sources of contamination, migration pathways, and the concentration levels in the media) indicate that the data for PMJM patch #2 should be representative of the other PMJM patches, and PCBs are not likely to be present in RCEU surface water. Therefore, it is possible to render risk management decisions using the existing data. In addition, for analytes that are not detected or detected at a frequency less than 5 percent, there are several analytes in surface soil that have detection limits that exceed the lowest ESLs, but these higher detection limits contribute only minimal uncertainty to the overall risk assessment process because either only a small fraction of the detection limits are greater than the lowest ESL, or professional judgment indicates they are not likely to be ECOPCs in RCEU surface soil even if detection limits had been lower.

11.2 Human Health

In the COC screening analyses, MDCs and UCLs of analytes in RCEU media were compared to PRGs for the WRW receptor. Inorganic and radionuclide analytes with UCLs greater than the PRGs were statistically compared to the background data set. Inorganic and radionuclide analytes that were statistically greater than background at the 0.1 significance level, and organics with UCL concentrations greater than the PRG were carried forward to professional judgment evaluation. Based on the COC selection process, no COCs were identified for surface soil/surface sediment or subsurface soil/subsurface sediment. Only four analytes in surface soil/surface sediment, arsenic, cesium-137, manganese, and radium-228, had concentrations in the RCEU that were statistically greater than RFETS background. However, these analytes were subsequently eliminated as COCs in the professional judgment evaluation step of the COC selection process because the weight of evidence supports the conclusion that concentrations in the RCEU are not the result of RFETS activities, but rather are representative of naturally occurring concentrations. For comparative purposes, the cancer risks and noncancer HQs were estimated for the WRW in RCEU surface soil/surface sediment and in RFETS background surface soil/surface sediment. The estimated risks were similar for the RCEU and RFETS background: arsenic had an estimated cancer risk of 2E-06 in the RCEU and 2E-06 in background; cesium-137 had an estimated cancer risk of 7E-06 in the RCEU and 6E-06 in background; and radium-228 had an estimated cancer risk of 3E-05 in the RCEU and 2E-05 in background. The estimated HQ for arsenic in samples collected in the RCEU is 0.02 versus 0.01 in RFETS background samples. The estimated HQ for manganese in samples collected from the RCEU is 0.2 versus 0.1 in RFETS background samples. The estimated risks were also similar for the WRV for RCEU and RFETS background: arsenic had an estimated cancer risk of 2E-06 in the RCEU and 1E-06 in background; cesium-137 had an estimated cancer risk of 2E-06 in the RCEU and 2E-06 in background; and radium-228 had an estimated cancer risk of 8E-06 in the RCEU and 7E-06 in background. The estimated HQ for the WRV for arsenic in samples collected in the RCEU is 0.01 versus 0.007 in RFETS background samples. The estimated HQ for the

WRV for manganese in samples collected from the RCEU is 0.1 versus 0.04 in RFETS background samples. No analytes in subsurface soil/subsurface sediment were statistically greater than RFETS background. These results indicate that potential health risks for the WRW and WRV in the RCEU are expected to be similar to background risks, and there are no significant human health risks from RFETS-related operations at the RCEU.

11.3 Ecological Risk

The ECOPC identification process streamlines the ecological risk characterization by focusing the assessment on ECOIs that are present in the RCEU. The ECOPC identification process is described in the CRA Methodology (DOE 2005a) and additional details are provided in Appendix A, Volume 2 of the RI/FS Report. There are a number of PMJM patches within RCEU. Manganese and tin were identified as ECOPCs for PMJM receptors in surface soil. No ECOPCs were identified for non-PMJM receptors in surface soil. Although there are no dioxin data for surface soil, the evaluation of site-wide data indicate dioxins are not expected to be present in RCEU surface soil, however, there is some uncertainty in the overall risk estimates for the RCEU as a result of this data limitation. No ECOPCs were identified in subsurface soil for burrowing receptors.

ECOPCs for PMJM were evaluated in the risk characterization using conservative default exposure and risk assumptions as defined in the CRA Methodology. Tier 1 EPCs were used in the risk characterization: Tier 1 EPCs are based on the upper confidence limits of the arithmetic mean concentration for the EU data set. In addition, a refinement of the exposure and risk models based on chemical-specific uncertainties associated with the initial default exposure models were considered to provide a refined estimate of potential risk.

Using Tier 1 EPCs and default exposure and risk assumptions, NOAEL HQs ranged from 7 (manganese/PMJM in Patch #3B and tin/PMJM in Patch #3A and #3B) to less than 1 (tin and manganese in a number of PMJM patches) (Table 10.1).All of the patches within RCEU had LOAEL HQs less than 1 for both manganese and tin using the default risk model.

Based on default calculations, site-related risks are likely to be low for the ecological receptors evaluated in the RCEU (Table 11.1). In addition, data collected on wildlife abundance and diversity indicate that wildlife species richness remains high at RFETS. There are no significant risks to ecological receptors or high levels of uncertainty with the data, and therefore, there are no ecological contaminants of concern (ECOCs) for the RCEU.

12.0 REFERENCES

Audubon, 2005. The Missing Birds of Rock Creek Park. Online article under Issues and Actions. <http://www.audubon.org/campaign/population_habitat>. July.

CNHP, 1994. Natural Heritage Resources of the Rocky Flats Environmental Technology Site and Their Conservation. Phase 1: Lower Woman. Final Report. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Department of Energy (DOE), 1992. Final Historical Release Report for Rocky Flats Plant, Golden, Colorado. June.

DOE, 1995. Ecological Monitoring Program, 1995 Annual Report. Rocky Flats Field Office, Rocky Flats Environmental Technology Site. Golden Colorado.

DOE, 2004. Comprehensive Risk Assessment Sampling and Analysis Plan Addendum, #04-01, Rocky Flats Environmental Technology Site, Golden, Colorado. March.

DOE, 2005a. Final Comprehensive Risk Assessment Work Plan and Methodology, Rocky Flats Environmental Technology Site, Golden, Colorado. Revision 1. September.

DOE, 2005b. 2005 Annual Update to the Historical Release Report, Rocky Flats Environmental Technology Site, Golden, Colorado.

Ebasco Environmental Consultants Inc., 1992. Baseline Biological Characterization of the Terrestrial and Aquatic Habitats at Rocky Flats Plant. Prepared for U.S. DOE, Rocky Flats Field Office. Golden, Colorado.

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

EPA, 2003. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs). OSWER 9285.7-55. Office of Solid Waste and Emergency Response. December.

EPA, 2005. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs). Attachment 4-1 Update. Office of Solid Waste and Emergency Response, February.

Fitzgerald, J.P., C.A. Meaney, and D.M. Armstrong, 1994.Mammals of Colorado. University Press of Colorado and Denver Museum of Natural History.467pp.

Interagency Agreement (IAG), 1991. Federal Facility Agreement and Consent Order CERCLA VIII-91-03, RCRA (3008(h)) VIII-91-07 and State of Colorado Docket number 91-01-22-01.

K-H, 1997. 1996 Annual Wildlife Survey Report for the Rocky Flats Environmental Technology Site. Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, Colorado.

K-H, 1998. 1997 Annual Wildlife Survey Report for the Rocky Flats Environmental Technology Site. Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, Colorado.

K-H, 1999a, 1998. Annual Wildlife Report for the Rocky Flats Environmental Technology Site, Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, Colorado.

K-H, 1999b. 1998 Study of the Preble's Meadow Jumping Mouse at the Rocky Flats Environmental Technology Site. Appendix B, 1998 Annual Wildlife Survey Report for the Rocky Flats Environmental Technology Site, Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, Colorado.

K-H, 2000, 1999. Annual Wildlife Survey for the Rocky Flats Environmental Technology Site. Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, Colorado.

K-H, 2001. 2000 Annual Wildlife Survey Report for the Rocky Flats Environmental Technology Site. Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, Colorado.

K-H, 2002a. 2001 Annual Wildlife Survey Report for the Rocky Flats Environmental Technology Site. Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, Colorado.

K-H, 2002b. 2001 Annual Vegetation Report for the Rocky Flats Environmental Technology Site. Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, Colorado.

Nature Conservancy, 2005. Migratory Bird Program Online Article. Migratory Birds. <http://nature.org/initiatives/programs/birds/>.

PTI, 1997. 1997 Annual Vegetation Report for the Rocky Flats Environmental Technology Site. Prepared by PTI Environmental Services for Kaiser-Hill Company, L.L.C., Rocky Flats Environmental Technology Site, Golden, Colorado.

Rocky Flats Cleanup Agreement (RFCA), 1996. CERCLA Federal Facility Agreement and RCRA/CHWA Consent Order (CERCLA VIII-96-21; RCRA (3008(h)) VIII-96-01; State of Colorado Docket #96-07-19-0).

Todd, A., and M. Sattelberg, 2004. Actinides in Deer Tissue at the Rocky Flats Environmental Technology site. U.S. Fish and Wildlife Service Internal Report.

U.S. Fish and Wildlife Service (USFWS), 2005. Rocky Flats National Wildlife Refuge, Final Comprehensive Conservation Plan. U.S. Fish and Wildlife Service. April.

TABLES

Table 1.1
Number of Samples Collected in Each Medium by Analyte Suite

Analyte Suite	Surface Soil/Surface Sediment[a]	Subsurface Soil/Subsurface Sediment[a]	Surface Soil[b]	Surface Soil (PMJM)[b]	Subsurface Soil[b]
Inorganics	51	11	36	19	8
Organics	32	15	17	7	12
Radionuclides	64	11	50	29	8

[a] Used in the HHRA.

[b] Used in the ERA.

Note: The total number of results (samples) for the analytes listed in Tables 1.2 to 1.6 may differ from the number of samples presented in Table 1.1 because not all analyses are necessarily performed for each sample.

Table 1.2
Summary of Detected Analytes in Surface Soil/Surface Sediment

Analyte	Range of Reported Detection Limits[a]	Total Number of Results	Detection Frequency (%)	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Concentration[b]	Standard Deviation[b]
Inorganics (mg/kg)							
Aluminum	3.7 - 50	51	100	2,380	21,800	13,700	4,020
Ammonia	0.3 - 0.3	9	44.4	0.335	4.81	1.53	1.61
Arsenic	0.14 - 3	51	98.0	1.70	15	5.63	2.44
Barium	0.31 - 40	51	100	34.5	470	167	77
Beryllium	0.022 - 5	49	77.6	0.440	2.10	0.758	0.272
Boron	0.52 - 5	20	100	3.90	17	7.01	3.39
Cadmium	0.064 - 5	47	40.4	0.0750	1.80	0.523	0.442
Calcium	3.5 - 1,000	51	100	1,980	61,000	6,660	8,400
Cesium	93.2 - 749	29	37.9	1.70	3	54.6	72.2
Chromium	0.13 - 10	51	98.0	4.20	23.7	14.2	4.29
Cobalt	0.18 - 10	50	98	3.10	24	7.42	3.64
Copper	0.045 - 10	51	98.0	6.60	29.9	13.9	4.54
Iron	1.3 - 20	51	100	2,520	39,000	15,600	5,890
Lead	0.27 - 4.7	51	100	5.90	79.1	30.9	12.2
Lithium	0.066 - 20	51	100	1.80	17.7	10.5	2.94
Magnesium	2 - 1,000	51	100	444	6,380	2,720	982
Manganese	0.17 - 10	51	100	35.8	2,500	378	430
Mercury	0.0051 - 0.62	47	42.6	0.0210	0.0660	0.0544	0.0457
Molybdenum	0.29 - 40	50	42	0.690	9.60	1.58	1.66
Nickel	0.19 - 20	51	96.1	1.40	25	12.2	4.01
Nitrate / Nitrite	0.02 - 5.5	19	84.2	0.705	40	5.95	9.22
Potassium	22 - 1,170	51	100	342	5,310	2,590	932
Selenium	0.21 - 2.4	51	43.1	0.280	3.20	0.603	0.525
Silica	3.1 - 5.5	20	100	640	2,600	1,020	568
Silicon[c]	0 - 100	29	96.6	75.1	2,250	637	644
Silver	0.077 - 10	50	26	0.110	3.40	0.659	0.643
Sodium	8.9 - 1,000	51	47.1	56.9	413	121	72.8
Strontium	0.058 - 400	51	100	9.50	179	42.2	27.4
Thallium	0.14 - 2.8	49	16.3	0.200	0.410	0.369	0.200
Tin	0.83 - 100	49	34.7	1.20	41.9	12.2	13.1
Titanium[c]	0.086 - 0.73	20	100	86	360	180	81.9
Uranium[c]	1.4 - 3.5	20	10	5.10	7.80	1.33	1.81
Vanadium	0.46 - 10	51	100	6.40	57.1	31.7	9.10
Zinc	0.45 - 10	51	98.0	11.3	130	56.8	19.1
Organics (ug/kg)							
1,1,1-Trichloroethane	5 - 13	7	14.3	9	9	5.14	2.19
2-Butanone[c]	10 - 79	9	11.1	190	190	29.9	60.1
4,6-Dinitro-2-methylphenol	390 - 4,500	22	4.55	1,100	1,100	1,660	1,420
4-Methylphenol	130 - 910	25	12	640	1,500	433	385
4-Nitrophenol	600 - 4,500	23	4.35	1,300	1,300	1,530	1,300
Acetone[c]	10 - 79	9	44.4	46	520	119	178
Benzo(a)anthracene	58 - 910	30	3.33	62	62	325	291
Benzo(a)pyrene	94 - 910	29	3.45	130	130	330	294
Benzoic Acid	680 - 4,500	25	44	43	2,000	1,220	1,090
bis(2-ethylhexyl)phthalate	170 - 910	29	34.5	35	350	257	274
Chrysene	65 - 910	30	3.33	74	74	325	290
Di-n-butylphthalate	48 - 2,000	31	16.1	39	250	301	294
Fluoranthene	53 - 910	30	3.33	89	89	325	290
Methylene Chloride[c]	5 - 40	10	10	300	300	41.2	91.3
Pentachlorophenol	270 - 4,500	24	4.17	1,500	1,500	1,640	1,360
Phenanthrene	82 - 910	30	3.33	59	59	324	291
Phenol	82 - 910	24	4.17	120	120	425	410
Pyrene	310 - 910	30	3.33	130	130	327	289
Tetrachloroethene[c]	5 - 14	6	16.7	38	38	10.1	13.8
Toluene[c]	5 - 14	6	16.7	39	39	10.3	14.2

Table 1.2
Summary of Detected Analytes in Surface Soil/Surface Sediment

Analyte	Range of Reported Detection Limits[a]	Total Number of Results	Detection Frequency (%)	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Concentration[b]	Standard Deviation[b]
Trichloroethene[c]	5 - 14	7	14.3	48	48	10.7	16.5
Xylene[c, d]	5 - 14	6	16.7	14	14	6.08	4.16
Radionuclides (pCi/g)[e]							
Americium-241	0 - 0.192	49	N/A	-0.00738	0.950	0.0483	0.140
Cesium-134	0.071 - 0.33	13	N/A	0.00200	0.260	0.0899	0.0571
Cesium-137	0.03 - 0.5	22	N/A	0.103	2.50	0.891	0.688
Gross Alpha	1.6 - 30	23	N/A	-1.20	62	21.9	15.5
Gross Beta	2.2 - 20	33	N/A	5.58	54	30.2	9.36
Plutonium-239/240	0 - 0.225	64	N/A	-0.00602	7.25	0.179	0.904
Radium-226	0.16 - 1.1	16	N/A	0.750	1.40	1	0.189
Radium-228	0.07 - 2.5	16	N/A	0.810	2.90	1.93	0.611
Strontium-89/90	0.05 - 0.4	18	N/A	-0.0100	1	0.395	0.320
Uranium-233/234	0 - 0.632	51	N/A	0.343	2.20	1.14	0.413
Uranium-235	0 - 0.774	51	N/A	-0.109	0.466	0.0703	0.107
Uranium-238	0 - 0.556	51	N/A	0.417	1.83	1.11	0.314

[a] Values in this column are reported results for nondetects (i.e., U-qualified results).

[b] For inorganics and organics, statistics are computed using one-half the reported value for nondetects.

[c] All detections are "J" qualified, signifying that the reported result is below the detection limit, but above the instrument detection limit.

[d] The value for total xylene is used.

[e] All radionuclide values are considered detects.

N/A = Not applicable.

Table 1.3
Summary of Detected Analytes in Subsurface Soil/Subsurface Sediment

Analyte	Range of Reported Detection Limits[a]	Total Number of Results	Detection Frequency (%)	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Concentration[b]	Standard Deviation[b]
Inorganics (mg/kg)							
Aluminum	5.1 - 40	11	100	4,900	23,700	13,700	6,090
Antimony	0.69 - 12	10	10	8.80	8.80	2.90	2.31
Arsenic	0.68 - 2	11	100	2.50	13.1	6.80	4.06
Barium	0.18 - 40	11	100	49.5	187	92.7	43.4
Beryllium	0.03 - 1	10	100	0.320	1.30	0.871	0.311
Boron	1.8 - 1.9	2	100	3.40	5.80	4.60	1.70
Cadmium[c]	0.066 - 0.072	2	100	0.210	0.500	0.355	0.205
Calcium	12 - 1,000	11	100	1,440	54,300	19,000	17,500
Cesium[c]	200 - 200	9	100	1.50	3.40	2.54	0.644
Chromium	0.07 - 2	11	100	8.90	55.1	20	12.8
Cobalt	0.14 - 10	11	100	2.60	14.3	6.72	3.63
Copper	0.087 - 5	11	91	5.80	380	56.8	114
Iron	1.5 - 20	11	100	7,800	21,400	14,900	4,150
Lead	0.42 - 1	11	100	3.50	45.7	15.2	12.3
Lithium	0.34 - 20	10	100	4	38.2	10.9	9.80
Magnesium	6.8 - 1,000	11	100	1,000	4,090	2,520	885
Manganese	0.18 - 3	11	100	62.1	355	158	95.4
Mercury	0.0064 - 0.1	10	50	0.0130	0.160	0.0586	0.0502
Molybdenum	0.23 - 40	6	17	0.310	0.310	0.753	0.895
Nickel	0.23 - 8	10	100	6.30	33.4	16.3	7.38
Potassium	42 - 1,000	10	100	710	2,630	1,500	543
Selenium	0.84 - 1	11	18	0.300	1.50	0.313	0.416
Silica[c]	1.8 - 1.9	2	100	760	1,300	1,030	382
Silicon[c]	0 - 0	8	88	10.1	583	134	213
Silver[c]	0.085 - 2	7	29	0.890	3	0.765	1.02
Sodium	110 - 1,000	11	45	75.7	120	91.2	80.8
Strontium	0.11 - 40	11	100	12.8	88.1	40.6	22.5
Thallium	0.37 - 2	10	20	0.250	0.380	0.167	0.0906
Tin[c]	0.66 - 40	9	33	23.4	55.9	19.2	20.1
Titanium[c]	0.26 - 0.28	2	100	48	84	66	25.5
Vanadium	0.41 - 10	11	100	12	50.2	33.2	11.7
Zinc	0.58 - 4	11	100	17.2	59.2	31.2	12.7
Organics (ug/kg)							
2-Butanone	10 - 10	13	7.70	20	20	6.77	3.99
Acetone	5 - 10	12	17	10	68	14.4	19.8
Methylene Chloride	5 - 5	13	38	1	7	4.23	3.89
Toluene	5 - 5	12	100	3	70	19.1	19.9
Radionuclides (pCi/g)[d]							
Americium-241	0 - 0.167	5	N/A	9.71E-04	0.0230	0.0100	0.00958
Cesium-137	0.09 - 0.09	1	N/A	0.370	0.370	0.370	N/A
Gross Alpha	0.81 - 3.5	9	N/A	11.4	28.2	16.1	5.18
Gross Beta	2.4 - 4.8	9	N/A	18.5	49.7	26.4	9.80
Plutonium-239/240	0 - 0.168	11	N/A	-0.00155	0.0575	0.0116	0.0162
Strontium-89/90	0.04 - 0.04	1	N/A	0.0940	0.0940	0.0940	N/A
Uranium-233/234	0 - 0.267	9	N/A	0.425	1.47	0.811	0.347
Uranium-235	0 - 0.29	9	N/A	0.0120	0.0697	0.0449	0.0189
Uranium-238	0.021 - 0.159	9	N/A	0.526	1.19	0.895	0.203

[a] Values in this column are reported results for nondetects (i.e., U-qualified results).
[b] For inorganics and organics, statistics are computed using one-half the reported value for nondetects.
[c] All detections are "J" qualified, signifying that the reported result is below the detection limit, but above the instrument detection limit.
[d] All radionuclide values are considered detects.
N/A = Not applicable.

Table 1.4
Summary of Detected Analytes in Surface Soil

Analyte	Range of Reported Detection Limits[a]	Total Number of Results	Detection Frequency (%)	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Concentration[b]	Standard Deviation[b]
Inorganics (mg/kg)							
Aluminum	3.7 - 50	36	100	7,420	21,800	14,500	3,380
Ammonia	0.3 - 0.3	9	44.4	0.335	4.81	1.53	1.61
Arsenic	0.8 - 3	36	100	2.20	8.70	6.08	1.50
Barium	0.36 - 40	36	100	110	470	168	73.9
Beryllium	0.022 - 5	36	77.8	0.440	1.10	0.718	0.150
Boron	0.52 - 1.3	17	100	3.90	7.90	5.72	1
Cadmium	0.064 - 5	34	47.1	0.0750	1.80	0.456	0.427
Calcium	3.5 - 1,000	36	100	2,200	13,600	4,700	2,450
Cesium	200 - 500	19	57.9	1.70	3	26.6	29.6
Chromium	0.15 - 10	36	100	9	22	15.4	2.78
Cobalt	0.18 - 10	36	100	4.80	24	7.33	3.22
Copper	0.045 - 10	36	100	7.70	22.2	13.5	3.43
Iron	1.4 - 20	36	100	10,400	24,900	15,400	3,230
Lead	0.27 - 2	36	100	21	51	33.2	7.72
Lithium	0.066 - 20	36	100	6.80	17.7	11.5	2.33
Magnesium	2 - 1,000	36	100	1,440	6,380	2,810	976
Manganese	0.17 - 10	36	100	160	2,220	363	333
Mercury	0.0051 - 0.2	34	50	0.0210	0.0510	0.0376	0.0140
Molybdenum	0.29 - 40	36	50	0.690	2.70	1.25	0.708
Nickel	0.19 - 20	36	97.2	7.80	25	12.5	3.57
Nitrate / Nitrite	0.2 - 0.2	9	100	0.705	4.79	2.26	1.37
Potassium	22 - 1,000	36	100	1,950	5,310	3,010	663
Selenium	0.79 - 2	36	44.4	0.280	1.30	0.490	0.245
Silica	4.3 - 5.5	17	100	640	980	796	105
Silicon[c]	0 - 100	19	94.7	75.1	2,250	796	105
Silver	0.077 - 10	36	27.8	0.110	0.290	0.508	0.410
Sodium	100 - 1,000	36	36.1	56.9	249	101	44
Strontium	0.058 - 40	36	100	16	109	35.8	16.2
Thallium	0.9 - 2	36	16.7	0.280	0.410	0.349	0.140
Tin[c]	0.83 - 100	36	33.3	1.20	41.9	13.7	14
Titanium[c]	0.086 - 0.11	17	100	86	360	188	86.2
Vanadium	0.46 - 10	36	100	21.1	49	33.1	6.84
Zinc	0.45 - 10	36	100	36	130	56.4	16.7
Organics (ug/kg)							
Benzoic Acid	1,600 - 1,600	11	54.5	43	150	471	425
bis(2-ethylhexyl)phthalate	330 - 480	17	23.5	35	140	163	57.7
Di-n-butylphthalate	330 - 480	17	11.8	39	44	175	54.4
Radionuclides (pCi/g)[d]							
Americium-241	0 - 0.192	37	N/A	-0.00738	0.950	0.0613	0.160
Cesium-134	0.071 - 0.1	8	N/A	0.0710	0.100	0.0851	0.0124
Cesium-137	0.07 - 0.27	11	N/A	0.710	2.50	1.43	0.509
Gross Alpha	1.6 - 30	12	N/A	-1.20	44	18.6	11.4
Gross Beta	2.2 - 20	22	N/A	17.5	37.8	30.9	5.51
Plutonium-239/240	0 - 0.225	50	N/A	-0.00602	7.25	0.222	1.02
Radium-226	0.25 - 0.5	9	N/A	0.800	1.10	0.969	0.112
Radium-228	0.5 - 0.9	9	N/A	1.50	2.90	2.24	0.506
Strontium-89/90	0.22 - 0.34	8	N/A	0.0800	1	0.624	0.321
Uranium-233/234	0 - 0.632	39	N/A	0.343	2.17	1.07	0.362
Uranium-235	0 - 0.774	39	N/A	-0.109	0.466	0.0641	0.113
Uranium-238	0 - 0.556	39	N/A	0.417	1.83	1.11	0.311

[a] Values in this column are reported results for nondetects (i.e., U-qualified results).

[b] For inorganics and organics, statistics are computed using one-half the reported value for nondetects.

[c] All detections are "J" qualified, signifying that the reported result is below the detection limit, but above the instrument detection limit.

[d] All radionuclide values are considered detects.

N/A = Not applicable.

Table 1.5
Summary of Detected Analytes in Surface Soil (PMJM Habitat)

Analyte	Range of Reported Detection Limits[a]	Total Number of Results	Detection Frequency (%)	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Concentration[b]	Standard Deviation[b]
Inorganics (mg/kg)							
Aluminum	3.8 - 50	19	100	7,420	21,000	14,788	3,709
Ammonia	0.3 - 0.3	3	66.7	0.335	0.472	0.326	0.150
Arsenic	0.8 - 3	19	100	4.80	8.70	6.43	1.23
Barium	0.36 - 40	19	100	95	470	166	85.4
Beryllium	0.023 - 5	19	78.9	0.440	1.10	0.712	0.150
Boron	0.54 - 1.3	11	100	3.90	7.90	5.86	1.03
Cadmium	0.064 - 5	18	27.8	0.210	1	0.333	0.294
Calcium	3.7 - 1,000	19	100	2,260	10,700	4,713	2,208
Cesium	200 - 500	8	50	1.70	3	30.6	30.3
Chromium	0.15 - 10	19	100	9	21.6	15.2	2.93
Cobalt	0.18 - 10	19	100	5	24	7.85	4.20
Copper	0.045 - 10	19	100	9.50	22.2	13.7	3.17
Iron	1.4 - 20	19	100	10,400	24,000	15,189	3,430
Lead	0.27 - 2	19	100	24	50	31.6	7.08
Lithium	0.069 - 20	19	100	6.80	16.1	11.8	2.24
Magnesium	2.1 - 1,000	19	100	1,440	4,780	2,777	868
Manganese	0.17 - 10	19	100	160	2,220	405	447
Mercury	0.0052 - 0.2	18	61.1	0.0150	0.0510	0.0368	0.0140
Molybdenum	0.29 - 40	19	63.2	0.560	2.70	1.26	0.734
Nickel	0.19 - 20	19	94.7	8.20	25	12.8	4.15
Nitrate / Nitrite	0.2 - 0.2	3	100	1.89	4.17	2.78	1.22
Potassium	23 - 1,000	19	100	1,950	5,310	3,044	714
Selenium	0.79 - 2	19	31.6	0.370	1.30	0.465	0.244
Silica	4.3 - 5.5	11	100	640	980	791	107
Silicon[c]	0 - 100	8	100	119	1,600	738	660
Silver	0.077 - 10	19	42.1	0.110	0.290	0.466	0.404
Sodium	100 - 1,000	19	31.6	73.3	187	103	41.8
Strontium	0.058 - 40	19	100	20	59.1	35.8	11.3
Thallium	0.9 - 2	19	15.8	0.320	0.410	0.389	0.127
Tin[c]	0.84 - 100	19	36.8	1.20	33	10.1	12.3
Titanium[c]	0.087 - 0.11	11	100	86	300	181	74.8
Vanadium	0.46 - 10	19	100	21.1	49	33.5	7.83
Zinc	0.45 - 10	19	100	36	130	57.1	21.2
Organics (ug/kg)							
Benzoic Acid	1,600 - 1,600	6	33.3	73	110	647	436
bis(2-ethylhexyl)phthalate	330 - 350	7	14.3	49	49	171	55.4
Radionuclides (pCi/g)[d]							
Americium-241	0 - 0.192	19	N/A	-0.00738	0.329	0.0402	0.0718
Cesium-134	0.081 - 0.1	4	N/A	0.0810	0.100	0.0950	0.00935
Cesium-137	0.2 - 0.27	4	N/A	0.710	1.50	1.08	0.327
Gross Alpha	1.6 - 30	7	N/A	-1.20	44	21.0	13.6
Gross Beta	2.2 - 20	11	N/A	23	44	32.1	6.15
Plutonium-239/240	0 - 0.225	29	N/A	0.00823	0.334	0.0805	0.0668
Radium-226	0.28 - 0.47	4	N/A	0.850	1.10	1.01	0.120
Radium-228	0.62 - 0.9	4	N/A	1.70	2.90	2.43	0.525
Strontium-89/90	0.22 - 0.3	4	N/A	0.350	0.810	0.563	0.227
Uranium-233/234	0 - 0.584	20	N/A	0.343	2.17	1.03	0.386
Uranium-235	0.01 - 0.592	20	N/A	-0.0787	0.371	0.0715	0.0918
Uranium-238	0 - 0.493	20	N/A	0.569	1.60	1.10	0.309

[a] Values in this column are reported results for nondetects (i.e., U-qualified results).

[b] For inorganics and organics, statistics are computed using one-half the reported value for nondetects.

[c] All detections are "J" qualified, signifying that the reported result is below the detection limit, but above the instrument detection limit.

[d] All radionuclide values are considered detects.

N/A = Not applicable.

Table 1.6
Summary of Detected Analytes in Subsurface Soil

Analyte	Range of Reported Detection Limits[a]	Total Number of Results	Detection Frequency (%)	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Concentration[b]	Standard Deviation[b]
Inorganics (mg/kg)							
Aluminum	40 - 40	8	100	8,640	23,700	15,600	5,880
Antimony	12 - 12	8	12.5	8.80	8.80	3.54	2.13
Arsenic	2 - 2	8	100	2.50	13.1	8.08	4.07
Barium	40 - 40	8	100	49.5	187	90.2	44.1
Beryllium	1 - 1	8	100	0.590	1.30	0.958	0.264
Calcium	1,000 - 1,000	8	100	1,440	54,300	24,200	18,000
Cesium[c]	200 - 200	8	100	1.50	3.40	2.50	0.674
Chromium	2 - 2	8	100	11.4	55.1	21.3	14.1
Cobalt	10 - 10	8	100	4	12.8	6.41	2.81
Copper	5 - 5	8	100	6.70	380	74.9	131
Iron	20 - 20	8	100	10,100	21,400	15,800	4,060
Lead	1 - 1	8	100	3.50	45.7	14.5	13.1
Lithium[c]	20 - 20	8	100	5.50	38.2	12.1	10.7
Magnesium	1,000 - 1,000	8	100	1,700	4,090	2,720	860
Manganese	2 - 3	8	100	62.1	355	159	108
Mercury	0.1 - 0.1	8	37.5	0.0900	0.160	0.0669	0.0530
Nickel	8 - 8	8	100	12.5	33.4	18.2	6.89
Potassium	1,000 - 1,000	8	100	1,180	2,630	1,590	529
Selenium[c]	1 - 1	8	12.5	0.300	0.300	0.134	0.0673
Silicon[c]	N/A	8	87.5	10.1	583	134	213
Silver[c]	2 - 2	5	40	0.890	3	1.05	1.11
Sodium	1,000 - 1,000	8	50	75.7	107	63.7	27.8
Strontium[c]	40 - 40	8	100	12.8	88.1	42.5	25
Thallium	2 - 2	8	25	0.250	0.380	0.161	0.101
Tin[c]	40 - 40	7	42.9	23.4	55.9	24.5	19.7
Vanadium	10 - 10	8	100	16.2	50.2	36.6	10.6
Zinc	4 - 4	8	100	17.2	38.2	26.1	7.48
Organics (ug/kg)							
Acetone	5 - 10	11	18.2	10	68	11.9	18.7
Methylene Chloride	5 - 5	12	41.7	1	7	3.29	2.01
Toluene	5 - 5	12	100	3	70	19.1	19.9
Radionuclides (pCi/g)[d]							
Americium-241	0 - 0.008	2	N/A	9.71E-04	0.00355	0.00226	0.00182
Gross Alpha	0.81 - 3.5	8	N/A	11.4	28.2	16.1	5.53
Gross Beta	2.4 - 4.8	8	N/A	18.5	49.7	26.4	10.5
Plutonium-239/240	0 - 0.017	8	N/A	-0.00155	0.0166	0.00545	0.00525
Uranium-233/234	0 - 0.073	6	N/A	0.551	1.47	0.796	0.360
Uranium-235	0 - 0.052	6	N/A	0.0120	0.0697	0.0491	0.0220
Uranium-238	0.021 - 0.052	6	N/A	0.526	1.12	0.882	0.206

[a] Values in this column are reported results for nondetects (i.e., U-qualified results).
[b] For inorganics and organics, statistics are computed using one-half the reported value for nondetects.
[c] All detections are "J" qualified, signifying that the reported result is below the detection limit, but above the instrument detection limit.
[d] All radionuclide values are considered detects.
N/A = Not applicable.

Table 2.1
Essential Nutrient Screen for Surface Soil/Surface Sediment

Analyte	MDC (mg/kg)	Estimated Maximum Daily Intake[a] (mg/day)	RDA/RDI/AI[b] (mg/day)	UL[b] (mg/day)	Retain for PRG Screen?
Calcium	61,000	6.10	500-1,200	2,500	No
Magnesium	6,380	0.638	80-420	65-110	No
Potassium	5,310	0.531	2,000-3,500	N/A	No
Sodium	413	0.041	500-2,400	N/A	No

[a] Based on the MDC and a 100 mg/day soil ingestion rate for a WRW.

[b] RDA/RDI/AI/UL taken from NAS 2000, 2002.

N/A = Not available.

Table 2.2
PRG Screen for Surface Soil/Surface Sediment

Analyte	PRG[a]	MDC	MDC Exceeds PRG?	UCL[b]	UCL Exceeds PRG?	Retain for Detection Frequency Screen?
Inorganics (mg/kg)						
Aluminum	24,774	21,800	No	--	--	No
Ammonia	910,997	4.81	No	--	--	No
Arsenic	**2.41**	**15**	**Yes**	**6.20**	**Yes**	**Yes**
Barium	2,872	470	No	--	--	No
Beryllium	100	2.10	No	--	--	No
Boron	9,477	17	No	--	--	No
Cadmium	91.4	1.80	No	--	--	No
Chromium[c]	28.4	23.7	No	--	--	No
Cobalt	122	24	No	--	--	No
Copper	4,443	29.9	No	--	--	No
Iron	33,326	39,000	Yes	17,000	No	No
Lead	1,000	79.1	No	--	--	No
Lithium	2,222	17.7	No	--	--	No
Manganese	**419**	**2,500**	**Yes**	**641**	**Yes**	**Yes**
Mercury	32.9	0.0660	No	--	--	No
Molybdenum	555	9.60	No	--	--	No
Nickel	2,222	25	No	--	--	No
Nitrate / Nitrite[d]	177,739	40	No	--	--	No
Selenium	555	3.20	No	--	--	No
Silica	N/A	2,600	UT	--	--	UT
Silicon	N/A	2,250	UT	--	--	UT
Silver	555	3.40	No	--	--	No
Strontium	66,652	179	No	--	--	No
Thallium	7.78	0.410	No	--	--	No
Tin	66,652	41.9	No	--	--	No
Titanium	169,568	360	No	--	--	No
Uranium	333	7.80	No	--	--	No
Vanadium	111	57.1	No	--	--	No
Zinc	33,326	130	No	--	--	No
Organics (ug/kg)						
1,1,1-Trichloroethane	9.18E+06	9	No	--	--	No
2-Butanone	4.64E+07	190	No	--	--	No
4,6-Dinitro-2-methylphenol	8,014	1,100	No	--	--	No
4-Methylphenol	400,718	1,500	No	--	--	No
4-Nitrophenol	641,148	1,300	No	--	--	No
Acetone	1.00E+08	520	No	--	--	No
Benzo(a)anthracene	3,793	62	No	--	--	No
Benzo(a)pyrene	379	130	No	--	--	No
Benzoic Acid	3.21E+08	2,000	No	--	--	No
Bis(2-ethylhexyl)phthalate	213,750	350	No	--	--	No
Chrysene	379,269	74	No	--	--	No
Di-n-butylphthalate	8.01E+06	250	No	--	--	No
Fluoranthene	2.96E+06	89	No	--	--	No
Methylene Chloride	271,792	300	No	--	--	No
Pentachlorophenol	17,633	1,500	No	--	--	No
Phenol	2.40E+07	120	No	--	--	No
Pyrene	2.22E+06	130	No	--	--	No
Tetrachloroethene	6,705	38	No	--	--	No
Toluene	3.09E+06	39	No	--	--	No
Trichloroethene	1,770	48	No	--	--	No
Xylene[e]	1.06E+06	14	No	--	--	No
Radionuclides (pCi/g)						
Americium-241	7.69	0.950	No	--	--	No
Cesium-134	**8.00E-02**	**0.260**	**Yes**	**0.247**	**Yes**	**Yes**
Cesium-137	**0.221**	**2.50**	**Yes**	**1.14**	**Yes**	**Yes**
Gross Alpha	N/A	62	UT	--	--	UT
Gross Beta	N/A	54	UT	--	--	UT

Table 2.2
PRG Screen for Surface Soil/Surface Sediment

Analyte	PRG[a]	MDC	MDC Exceeds PRG?	UCL[b]	UCL Exceeds PRG?	Retain for Detection Frequency Screen?
Plutonium-239/240	9.80	7.25	No	--	--	No
Radium-226	2.69	1.40	No	--	--	No
Radium-228	**0.111**	**2.90**	**Yes**	**2.20**	**Yes**	**Yes**
Strontium-89/90	13.2	1	No	--	--	No
Uranium-233/234	25.3	2.20	No	--	--	No
Uranium-235	1.05	0.466	No	--	--	No
Uranium-238	29.3	1.83	No	--	--	No

[a] The value shown is equal to the most stringent of the PRGs based on a risk of 1E-06 or an HQ of 0.1.

[b] UCL = 95% upper confidence limit on the mean, unless the MDC < UCL, then the MDC is used as the UCL.

[c] The PRG for chromium (VI) is used in the PRG screen because it is more conservative than the PRG for chromium (III).

[d] The PRG for nitrate is used.

[e] The value for total xylene is used.

N/A - Not available.

UT = Uncertain toxicity; no PRG available (assessed in Section 6).

-- = Screen not performed because analyte was eliminated from further consideration in a previous step.

Bold = Analyte retained for further consideration in the next COC selection step.

Table 2.3

Statistical Distributions and Background Comparisons for Human Health PCOCs[a]

Analyte	Statistical Distribution Testing Results						Background Comparison Test Results		
	Background Data Set			RCEU Data Set					
	Total Samples	Distribution Recommended by ProUCL	Detects (%)	Total Samples	Distribution Recommended by ProUCL	Detects (%)	Test	1 - p	Retain as PCOC?
Surface Soil/Surface Sediment									
Arsenic	**73**	**GAMMA**	**91.8**	**46**	**NON-PARAMETRIC**	**100**	**WRS**	**2.29E-07**	**Yes**
Manganese	**73**	**GAMMA**	**100**	**46**	**NON-PARAMETRIC**	**100**	**WRS**	**6.23E-04**	**Yes**
Cesium-134	77	NON-PARAMETRIC	N/A	11	NORMAL	N/A	WRS	0.999	No
Cesium-137	**105**	**NON-PARAMETRIC**	**N/A**	**18**	**NORMAL**	**N/A**	**WRS**	**0.0239**	**Yes**
Radium-228	**40**	**GAMMA**	**N/A**	**14**	**NORMAL**	**N/A**	**WRS**	**0.0118**	**Yes**

[a] EU data used for background comparisons do not include data from background locations.

N/A = Not applicable; all radionuclide values are considered detect.

Bold = Analyte retained for further consideration in the next COC selection step.

Table 2.4
Essential Nutrient Screen for Subsurface Soil/Subsurface Sediment

Analyte	MDC (mg/kg)	Estimated Maximum Daily Intake[a] (mg/day)	RDA/RDI/AI[b] (mg/day)	UL[b] (mg/day)	Analyte Retained for PRG Screen?
Calcium	54,300	5.43	500-1,200	2,500	No
Magnesium	4,090	0.409	80-420	65-110	No
Potassium	2,630	0.263	2,000-3,500	N/A	No
Sodium	120	0.012	500-2,400	N/A	No

[a] Based on the MDC and a 100 mg/day soil ingestion rate for a WRW.
[b] RDA/RDI/AI/UL taken from NAS 2000, 2002.
N/A = Not available.

Table 2.5
PRG Screen for Subsurface Soil/Subsurface Sediment

Analyte	PRG[a]	MDC	MDC Exceeds PRG?	UCL[b]	UCL Exceeds PRG?	Retain for Detection Frequency Screen?
Inorganics (mg/kg)						
Aluminum	284,902	23,700	No	--	--	No
Antimony	511	8.80	No	--	--	No
Arsenic	27.7	13.1	No	--	--	No
Barium	33,033	187	No	--	--	No
Beryllium	1,151	1.30	No	--	--	No
Boron	108,980	5.80	No	--	--	No
Cadmium	1,051	0.500	No	--	--	No
Cesium	N/A	3.40	UT	--	--	UT
Chromium[c]	327	28.4	No	--	--	No
Cobalt	1,401	14.3	No	--	--	No
Copper	51,100	380	No	--	--	No
Iron	383,250	21,400	No	--	--	No
Lead	1,000	45.7	No	--	--	No
Lithium	25,550	38.2	No	--	--	No
Manganese	4,815	355	No	--	--	No
Mercury	379	0.160	No	--	--	No
Molybdenum	6,388	0.310	No	--	--	No
Nickel	25,550	33.4	No	--	--	No
Selenium	6,388	1.50	No	--	--	No
Silica	N/A	1,300	UT	--	--	UT
Silicon	N/A	583	UT	--	--	UT
Silver	6,388	3	No	--	--	No
Strontium	766,500	88.1	No	--	--	No
Thallium	89.4	0.380	No	--	--	No
Tin	766,500	55.9	No	--	--	No
Titanium	N/A	84	UT	--	--	UT
Vanadium	1,278	50.2	No	--	--	No
Zinc	383,250	59.2	No	--	--	No
Organics (ug/kg)						
2-Butanone	5.33E+08	20	No	--	--	No
Acetone	1.15E+09	68	No	--	--	No
Methylene Chloride	3.13E+06	7	No	--	--	No
Toluene	3.56E+07	70	No	--	--	No
Radionuclides (pCi/g)						
Americium-241	88.4	0.0230	No	--	--	No
Cesium-137	2.54	0.370	No	--	--	No
Gross Alpha	N/A	28.2	UT	--	--	UT
Gross Beta	N/A	49.7	UT	--	--	UT
Plutonium-239/240	112	0.0575	No	--	--	No
Strontium-89/90	152	0.0940	No	--	--	No
Uranium-233/234	291	1.47	No	--	--	No
Uranium-235	12.1	0.0697	No	--	--	No
Uranium-238	337	1.19	No	--	--	No

[a] The value shown is equal to the most stringent of the PRGs based on a risk of 1E-06 or an HQ of 0.1.

[b] UCL = 95% upper confidence limit on the mean, unless the MDC < UCL, then the MDC is used as the UCL.

[c] The PRG for chromium (VI) is used in the PRG screen because it is more conservative than the PRG for chromium (III).

N/A = Not available.

UT = Uncertain toxicity; no PRG available (assessed in Section 6).

-- = Screen not performed because analyte was eliminated from further consideration in a previous step.

Table 2.6
Summary of the COC Selection Process

Analyte	MDC Exceeds PRG?	UCL Exceeds PRG?	Detection Frequency > 5%?[a]	Exceeds 30X the PRG?	Exceeds Background?	Professional Judgment - Retain?	Retain as COC?
Surface Soil/Surface Sediment							
Arsenic	Yes	Yes	Yes	N/A	Yes	No	No
Manganese	Yes	Yes	Yes	N/A	Yes	No	No
Iron	Yes	No	--	--	--	--	No
Cesium-134	Yes	Yes	Yes	N/A	No	--	No
Cesium-137	Yes	Yes	Yes	N/A	Yes	No	No
Radium-228	Yes	Yes	Yes	N/A	Yes	No	No
Subsurface Soil/Subsurface Sediment							

No analytes in subsurface soil/surface sediment exceeded the PRG.

[a] All radionuclide values are considered detects.

N/A = Not applicable.

-- = Screen not performed because analyte was eliminated from further consideration in a previous step.

Table 6.1

Detected PCOCs without PRGs in each Medium by Analyte Suite[a]

Analyte	Surface Soil/Surface Sediment	Subsurface Soil/Subsurface Sediment
Inorganics		
Cesium	X	X[b]
Silica	X	X[b]
Silicon	X[b]	X[b]
Titanium	X	X
Radionuclides		
Gross Alpha	X	X
Gross Beta	X	X

[a] Does not include essential nutrients. Essential nutrients without PRGs were evaluated by comparing estimated intakes to recommended intakes.

[b] All detections are "J" qualified, signifying that the reported result is below the detection limit, but above the instrument detection limit.

N/A = Not applicable. Analyte not detected or not analyzed.

X = indicates PRG is unavailable.

Table 7.1
Comparison of MDCs in Surface Soil to NOAEL ESLs for Terrestrial Plants, Invertebrates, and Vertebrates in the RCEU

Analyte	MDC	Terrestrial Plants		Terrestrial Invertebrates		Mourning Dove Herbivore		Mourning Dove Insectivore		American Kestrel		Deer Mouse Herbivore		Deer Mouse Insectivore		Prairie Dog		Mule Deer		Coyote Carnivore		Coyote Generalist		Coyote Insectivore		Terrestrial Receptor[a]		Most Sensitive Receptor	Retain for Further Analysis?
		NOAEL	MDC > ESL?	NOAEL	MDC > ESL?	NOAEL	MDC > ESL?	NOAEL	MDC > ESL?	NOAEL	MDC > ESL?	NOAEL	MDC > ESL?	NOAEL	MDC > ESL?	NOAEL	MDC > ESL?	NOAEL	MDC > ESL?	NOAEL	MDC > ESL?	NOAEL	MDC > ESL?	NOAEL	MDC > ESL?	NOAEL	MDC > ESL?	Results	
Inorganics (mg/kg)																													
Aluminum	21,800	50	**Yes**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Terrestrial Plants	**Yes**
Ammonia	4.81	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7,320	No	586	No	26,700	No	37,000	No	2,250	No	2,310	No	2,540	No	N/A	N/A	Deer Mouse Insectivore	No
Arsenic	8.70	10	No	60	No	20	No	164	No	1,030	No	2.57	**Yes**	51.4	No	9.35	No	13	No	709	No	341	No	293	No	N/A	N/A	Deer Mouse Herbivore	**Yes**
Barium	470	500	No	330	**Yes**	159	**Yes**	357	**Yes**	1,320	No	930	No	4,430	No	3,220	No	4,770	No	24,900	No	19,800	No	18,400	No	N/A	N/A	Mourning Dove Herbivore	**Yes**
Beryllium	1.10	10	No	40	No	N/A	N/A	N/A	N/A	N/A	N/A	160	No	6.82	No	211	No	896	No	1,070	No	103	No	29.2	No	N/A	N/A	Deer Mouse Insectivore	No
Boron	7.90	0.500	**Yes**	N/A	N/A	30.3	No	115	No	167	No	62.1	No	422	No	237	No	314	No	929	No	6,070	No	1,820	No	N/A	N/A	Terrestrial Plants	**Yes**
Cadmium	1.80	32	No	140	No	28.1	No	0.705	**Yes**	15	No	59.9	No	1.56	**Yes**	198	No	723	No	1,360	No	51.2	No	9.75	No	N/A	N/A	Mourning Dove Insectivore	**Yes**
Calcium	13,600	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	UT
Cesium	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	UT
Chromium[b]	22	1	**Yes**	0.400	**Yes**	24.6	No	1.34	**Yes**	14	**Yes**	281	No	15.9	**Yes**	703	No	1,460	No	4,170	No	250	No	68.5	No	N/A	N/A	Terrestrial Invertebrates	**Yes**
Cobalt	24	13	**Yes**	N/A	N/A	278	No	87	No	440	No	1,480	No	363	No	2,460	No	7,900	No	3,780	No	2,490	No	1,520	No	N/A	N/A	Terrestrial Plants	**Yes**
Copper	22.2	100	No	50	No	28.9	No	8.25	**Yes**	164	No	295	No	605	No	838	No	4,120	No	5,460	No	3,000	No	4,640	No	N/A	N/A	Mourning Dove Insectivore	**Yes**
Iron	24,900	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	UT
Lead	51	110	No	1,700	No	49.9	**Yes**	12.1	**Yes**	95.8	No	1,340	No	242	No	1,850	No	9,800	No	8,930	No	3,070	No	1,390	No	N/A	N/A	Mourning Dove Insectivore	**Yes**
Lithium	17.7	2	**Yes**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1,880	No	610	No	3,180	No	10,200	No	18,400	No	5,610	No	2,560	No	N/A	N/A	Terrestrial Plants	**Yes**
Magnesium	6,380	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	UT
Manganese	2,220	500	**Yes**	N/A	N/A	1,030	**Yes**	2,630	No	9,920	No	486	**Yes**	4,080	No	1,519	**Yes**	2,510	No	14,100	No	10,900	No	19,100	No	N/A	N/A	Deer Mouse Herbivore	**Yes**
Mercury	0.0510	0.300	No	0.100	No	0.197	No	1.00E-04	**Yes**	1.57	No	0.439	No	0.179	No	3.15	No	7.56	No	8.18	No	8.49	No	37.3	No	N/A	N/A	Mourning Dove Insectivore	**Yes**
Molybdenum	2.70	2	**Yes**	N/A	N/A	44.4	No	6.97	No	76.7	No	8.68	No	1.90	**Yes**	27.1	No	44.3	No	275	No	28.9	No	8.18	No	N/A	N/A	Deer Mouse Insectivore	**Yes**
Nickel	25	30	No	200	No	44.1	No	1.24	**Yes**	13.1	**Yes**	16.4	**Yes**	0.431	**Yes**	38.3	No	124	No	90.9	No	6.02	**Yes**	1.86	**Yes**	N/A	N/A	Deer Mouse Insectivore	**Yes**
Nitrate / Nitrite	4.79	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4,480	No	7,650	No	16,200	No	22,700	No	32,900	No	32,200	No	32,900	No	N/A	N/A	Deer Mouse Herbivore	No
Potassium	5,310	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	UT
Selenium	1.30	1	**Yes**	70	No	1.61	No	1	**Yes**	8.48	No	0.872	**Yes**	0.754	**Yes**	2.80	No	3.82	No	32.5	No	12.2	No	5.39	No	N/A	N/A	Deer Mouse Insectivore	**Yes**
Silver	0.290	2	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Terrestrial Plants	No
Sodium	249	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	UT
Strontium	109	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	940	No	13,600	No	3,520	No	4,700	No	584,000	No	145,000	No	57,300	No	N/A	N/A	Deer Mouse Herbivore	No
Thallium	0.410	1	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	180	No	7.24	No	204	No	1,040	No	212	No	81.6	No	30.8	No	N/A	N/A	Terrestrial Plants	No
Tin	41.9	50	No	N/A	N/A	26.1	**Yes**	2.90	**Yes**	19	**Yes**	45	No	3.77	**Yes**	80.6	No	242	No	70	No	36.1	**Yes**	16.2	**Yes**	N/A	N/A	Mourning Dove Insectivore	**Yes**
Titanium	360	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	UT
Vanadium	49	2	**Yes**	N/A	N/A	503	No	274	No	1,510	No	63.7	No	29.9	**Yes**	83.5	No	358	No	341	No	164	No	121	No	N/A	N/A	Terrestrial Plants	**Yes**
Zinc	130	50	**Yes**	200	No	109	**Yes**	0.646	**Yes**	113	**Yes**	171	No	5.29	**Yes**	1,170	No	2,770	No	16,500	No	3,890	No	431	No	N/A	N/A	Mourning Dove Insectivore	**Yes**
Organics (ug/kg)																													
Benzoic acid	150	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	UT
Bis(2-ethylhexyl)phthalate	140	N/A	N/A	N/A	N/A	19,500	No	137	**Yes**	398	No	960,000	No	8,070	No	2.76E+06	No	4.93E+06	No	42,300	No	40,200	No	35,000	No	N/A	N/A	Mourning Dove Insectivore	**Yes**
Di-n-butylphthalate	44	200,000	No	N/A	N/A	989	No	15.9	**Yes**	41.5	**Yes**	1.21E+07	No	281,000	No	4.06E+07	No	6.13E+07	No	1.29E+06	No	1.27E+06	No	1.22E+06	No	N/A	N/A	Mourning Dove Insectivore	**Yes**
Radionuclides (pCi/g)																													
Americium-241	0.950	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3,890	No	N/A	No
Cesium-137	2.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	20.8	No	N/A	No
Gross Alpha	44	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	UT
Gross Beta	37.81	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	UT
Plutonium-239/240	7.25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6,110	No	N/A	No
Radium-226	1.10	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	50.6	No	N/A	No
Radium-228	2.90	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	43.9	No	N/A	No
Strontium-89/90	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	22.5	No	N/A	No
Uranium-233/234	2.17	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4,980	No	N/A	No
Uranium-235	0.370	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2,770	No	N/A	No
Uranium-238	1.83	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1,580	No	N/A	No

[a] Radionuclide ESLs are not receptor-specific. They are considered protective of all terrestrial ecological species.
[b] The ESLs for chromium were developed using available toxicity data based on chromium III (birds) and chromium VI (plants, invertebrates, and mammals).
N/A = No ESL was available for that ECOI/receptor pair.
UT = Uncertain toxicity; no ESL available (assessed in Section 10.0).
Bold = Analyte retained for further consideration in the next ECOPC selection step.

Table 7.2
Summary of Non-PMJM NOAEL ESL Screening Results for Surface Soil in the RCEU

Analyte	Terrestrial Plant Exceedance?	Terrestrial Invertebrate Exceedance?	Terrestrial Vertebrate Exceedance?
Inorganics			
Aluminum	**Yes**	UT	UT
Ammonia	UT	UT	No
Arsenic	No	No	**Yes**
Barium	No	**Yes**	**Yes**
Beryllium	No	No	No
Boron	**Yes**	UT	No
Cadmium	No	No	**Yes**
Calcium	UT	UT	UT
Cesium	UT	UT	UT
Chromium	**Yes**	**Yes**	**Yes**
Cobalt	**Yes**	UT	No
Copper	No	No	**Yes**
Iron	UT	UT	UT
Lead	No	No	**Yes**
Lithium	**Yes**	UT	No
Magnesium	UT	UT	UT
Manganese	**Yes**	UT	**Yes**
Mercury	No	No	**Yes**
Molybdenum	**Yes**	UT	**Yes**
Nickel	No	No	**Yes**
Nitrate / Nitrite	UT	UT	No
Potassium	UT	UT	UT
Selenium	**Yes**	No	**Yes**
Silver	No	UT	UT
Sodium	UT	UT	UT
Strontium	UT	UT	No
Thallium	No	UT	No
Tin	No	UT	**Yes**
Titanium	UT	UT	UT
Vanadium	**Yes**	UT	**Yes**
Zinc	**Yes**	No	**Yes**
Organics			
Benzoic acid	UT	UT	UT
Bis(2-ethylhexyl)phthalate	UT	UT	**Yes**
Di-n-butylphthalate	No	UT	**Yes**
Radionuclides			
Americium-241	UT	UT	No
Cesium-137	UT	UT	No
Gross Alpha	UT	UT	UT
Gross Beta	UT	UT	UT
Plutonium-239/240	UT	UT	No
Radium-226	UT	UT	No
Radium-228	UT	UT	No
Strontium-89/90	UT	UT	No
Uranium-233/234	UT	UT	No
Uranium-235	UT	UT	No
Uranium-238	UT	UT	No

UT = Uncertain toxicity; no ESL available (assessed in Section 10).

Bold = Analyte retained for further consideration in the next ECOPC selection step.

Table 7.3
Comparison of MDCs in Surface Soil with NOAEL ESLs for the PMJM in the RCEU

Analyte	MDC	PMJM NOAEL ESL	EPC> PMJM ESL?
Inorganics (mg/kg)			
Aluminum	21,000	N/A	UT
Ammonia	0.47	673	No
Antimony	0.48	1	No
Arsenic	**8.7**	**2.21**	**Yes**
Barium	470	743	No
Beryllium	1.1	8.16	No
Boron	7.9	52.7	No
Cadmium	1	1.75	No
Calcium	10,700	N/A	UT
Cesium	3	N/A	UT
Chromium[a]	**21.6**	**19.3**	**Yes**
Cobalt	24	340	No
Copper	22.2	95	No
Iron	24,000	N/A	UT
Lead	50	220	No
Lithium	16.1	519	No
Magnesium	4,780	N/A	UT
Manganese	**2,220**	**388**	**Yes**
Mercury	0.05	0.0521	No
Molybdenum	**2.7**	**1.84**	**Yes**
Nickel	**25**	**0.510**	**Yes**
Nitrate / Nitrite	4.17	2,910	No
Potassium	5,310	N/A	UT
Selenium	**1.3**	**0.421**	**Yes**
Silica	980	N/A	UT
Silicon	1,600	N/A	UT
Silver	0.29	N/A	UT
Sodium	187	N/A	UT
Strontium	59.1	833	No
Thallium	0.41	8.64	No
Tin	**33**	**4.22**	**Yes**
Titanium	300	N/A	UT
Vanadium	**49**	**21.6**	**Yes**
Zinc	**130**	**6.41**	**Yes**
Organics (µg/kg)			
Benzoic acid	110	N/A	UT
Bis(2-ethylhexyl)phthalate	49	10,166	No
Radionuclides (pCi/kg)			
Americium-241	0.33	3,890	No
Cesium-134	0.1	N/A	UT
Cesium-137	1.5	20.8	No
Gross alpha	44	N/A	UT
Gross beta	44	N/A	UT
Plutonium-239/240	0.33	6,110	No
Radium-226	1.1	50.6	No
Radium-228	2.90	43.9	No
Strontium-89/90	0.81	22.5	No
Uranium-233/234	2.17	4,980	No
Uranium-235	0.37	2,770	No
Uranium-238	1.6	1,580	No

[a] Chromium ESL is based on Chromium VI.
N/A = No ESL available for the ECOI/receptor pair.
UT = Uncertain toxicity; no ESL available (assessed in Section 10.0).
Bold = Analyte retained for further consideration in the next ECOPC selection step.

Table 7.4
Statistical Distribution and Comparison to Background for Surface Soil in the RCEU

Analyte	Statistical Distribution Testing Results						Background Comparison Test Results		
	Background Data Set			RCEU Data Set			Test	1 - p	Retain as ECOI?
	Total Samples	Distribution Recommended by ProUCL	Detects (%)	Total Samples	Distribution Recommended by ProUCL	Detects (%)			
Inorganics (mg/kg)									
Aluminum	20	NORMAL	100	36	NORMAL	100	t-Test_N	1.08E-05	**Yes**
Arsenic	20	NORMAL	100	36	NORMAL	100	t-Test_N	0.504	No
Barium	20	NORMAL	100	36	NON-PARAMETRIC	100	WRS	1.33E-08	**Yes**
Boron	N/A	N/A	N/A	17	NORMAL	100	N/A	N/A	**Yes**[a]
Cadmium	20	NON-PARAMETRIC	65	34	GAMMA	47.1	WRS	0.994	No
Chromium	20	NORMAL	100	36	NORMAL	100	t-Test_N	1.04E-06	**Yes**
Cobalt	20	NORMAL	100	36	NON-PARAMETRIC	100	WRS	0.854	No
Copper	20	NON-PARAMETRIC	100	36	NORMAL	100	WRS	0.369	No
Lead	20	NORMAL	100	36	NORMAL	100	t-Test_N	0.560	No
Lithium	20	NORMAL	100	36	NORMAL	100	t-Test_N	2.27E-08	**Yes**
Manganese	20	NORMAL	100	36	NON-PARAMETRIC	100	WRS	0.00100	**Yes**
Mercury	20	NON-PARAMETRIC	40	34	NON-PARAMETRIC	50	WRS	1	No
Molybdenum	20	NORMAL	0	36	NON-PARAMETRIC	50	N/A	N/A	**Yes**[a]
Nickel	20	NORMAL	100	36	GAMMA	97.2	WRS	0.00200	**Yes**
Selenium	20	NON-PARAMETRIC	60	36	NON-PARAMETRIC	44.4	WRS	0.930	No
Tin	20	NORMAL	0	36	NON-PARAMETRIC	33.3	N/A	N/A	**Yes**[a]
Vanadium	20	NORMAL	100	36	NORMAL	100	t-Test_N	0.00500	**Yes**
Zinc	20	NORMAL	100	36	NON-PARAMETRIC	100	WRS	0.0970	**Yes**

[a] Statistical comparisons to background cannot be performed. The analyte is retained as an ECOI for further evaluation.
N/A = Not applicable; background data not available or not detected.
Test: WRS = Wilcoxon Rank Sum, t-Test_N = Student's t-test using normal data.
Bold = Analyte retained for further consideration in the next ECOPC selection step.

Table 7.5
Statistical Distributions and Comparison to Background for Surface Soil in PMJM Habitat in the RCEU

Analyte	Statistical Distribution Testing Results						Background Comparison Test Results		
	Background			RCEU			Test	1 - p	Retain as ECOI?
	Total Samples	Distribution Recommended by ProUCL	Detects (%)	Total Samples	Distribution Recommended by ProUCL	Detects (%)			
Inorganics									
Arsenic	20	NORMAL	100	19	NORMAL	100	t-Test N	0.260	No
Chromium	**20**	**NORMAL**	**100**	**19**	**NORMAL**	**100**	**t-Test N**	**5.58E-05**	**Yes**
Manganese	**20**	**NORMAL**	**100**	**19**	**NON-PARAMETRIC**	**100**	**WRS**	**0.00500**	**Yes**
Molybdenum	**20**	**NORMAL**	**0**	**19**	**NON-PARAMETRIC**	**63.2**	**N/A**	**N/A**	**Yes[a]**
Nickel	**20**	**NORMAL**	**100**	**19**	**GAMMA**	**94.7**	**WRS**	**0.00800**	**Yes**
Selenium	20	NON-PARAMETRIC	60	19	NON-PARAMETRIC	31.6	WRS	0.916	No
Tin	**20**	**NORMAL**	**0**	**19**	**NON-PARAMETRIC**	**36.8**	**N/A**	**N/A**	**Yes[a]**
Vanadium	**20**	**NORMAL**	**100**	**19**	**NORMAL**	**100**	**t-Test N**	**0.0140**	**Yes**
Zinc	20	NORMAL	100	19	NON-PARAMETRIC	100	WRS	0.188	No

[a] Statistical comparisons to background cannot be performed. The analyte is retained as an ECOI for further evaluation.
N/A = Not applicable; background data not available or not detected.
Test: WRS = Wilcoxon Rank Sum, t-Test_N = Student's t-test using normal data.
Bold = Analyte retained for further consideration in the next ECOPC selection step.

Table 7.6
Statistical Concentrations in Surface Soil in the RCEU[a]

Analyte	Total Samples	UCL Recommended by ProUCL	Distribution Recommended by ProUCL	Mean	Median	75th Percentile	95th Percentile	UCL	UTL	MDC
Inorganics (mg/kg)										
Aluminum	36	95% Student's-t UCL	NORMAL	14,530	14,000	16,775	20,250	15,480	20,350	21,800
Barium	36	95% Student's-t UCL	NON-PARAMETRIC	168	139	173	296	189	324	470
Boron	17	95% Student's-t UCL	NORMAL	5.72	5.60	6.20	7.02	6.14	7.72	7.90
Chromium	36	95% Student's-t UCL	NORMAL	15.4	15	17	20.6	16.1	20.2	22
Lithium	36	95% Student's-t UCL	NORMAL	11.5	11.3	13.1	14.7	12.2	15.5	17.7
Manganese	36	95% Student's-t UCL	NON-PARAMETRIC	363	300	343	556	457	734	2,220
Molybdenum	36	95% Student's-t UCL	NON-PARAMETRIC	1.25	0.880	1.59	2.63	1.45	2.70	2.90
Nickel	36	95% Approximate Gamma UCL	GAMMA	12.5	11.6	14.7	18	13.5	18.7	25
Tin	36	95% Chebyshev (Mean, Sd) UCL	NON-PARAMETRIC	13.7	12.2	24.9	37.3	36.9	41.3	41.9
Vanadium	36	95% Student's-t UCL	NORMAL	33.1	31.7	36.3	45.8	35	44.9	49
Zinc	36	95% Student's-t UCL	NON-PARAMETRIC	56.4	53.3	59.3	81.1	61.1	90.2	130
Bis(2-ethylhexyl)phthalate	17	95% Chebyshev (Mean, Sd) UCL	NON-PARAMETRIC	163	185	190	220	224	240	240
Di-n-butylphthalate	17	95% Chebyshev (Mean, Sd) UCL	NON-PARAMETRIC	175	185	195	240	232	240	240

[a] For inorganics and organics, one-half the detection limit used as proxy value for nondetects in computation of the statistical concentrations.
MDC = Maximum detected concentration or in some cases, maximum proxy result.
UCL = 95% upper confidence limit on the mean, unless the MDC < UCL, then MDC is used as the UCL.
UTL = 95% upper confidence limit on the 90th percentile value, unless the MDC< UTL than the MDC is used as the UTL.

Table 7.7
Upper-Bound Exposure Point Concentration Comparison to Limiting ESLs in the RCEU Surface Soil

Analyte	Small Home Range Receptors			Large Home Range Receptors		
	EPC (UTL)	Limiting ESL[a]	EPC>ESL?	EPC (UCL)	Limiting ESL[b]	EPC>ESL?
Inorganics (mg/kg)						
Aluminum	20,350	50	**Yes**	15,480	N/A	N/A
Barium	324	159	**Yes**	189	4,770	No
Boron	7.70	0.500	**Yes**	6.10	314	No
Chromium[c]	20.2	0.400	**Yes**	16.1	68.5	No
Lithium	16	2	**Yes**	12.2	2,560	No
Manganese	734	486	**Yes**	457	2,510	No
Molybdenum	2.70	1.90	**Yes**	1.50	8.18	No
Nickel	18.7	0.431	**Yes**	13.5	1.86	**Yes**
Tin	41.3	2.90	**Yes**	36.9	16.2	**Yes**
Vanadium	44.9	2	**Yes**	35	121	No
Zinc	90.2	0.646	**Yes**	61.1	431	No
Bis(2-ethylhexyl)phthalate	240	137	**Yes**	224	35,000	No
Di-n-butylphthalate	240	15.9	**Yes**	232	1.22E+06	No

[a]Lowest ESL (threshold if available) for the plant, invertebrate, deer mouse, prairie dog, dove, or kestrel receptors.

[b]Lowest ESL (threshold if available) for the coyote and mule deer receptors.

[c] The ESL for chromium VI is used.

N/A = Not applicable; ESL not available.

Bold = Analyte retained for further consideration in the next ECOPC selection step.

Table 7.8
Upper-Bound Exposure Point Concentration Comparison to Receptor-Specific ESLs for Small Home-Range Receptors in the RCEU

Analyte	Small Home Range Receptor UTL	Receptor-Specific ESLs[a]							
		Terrestrial Plant	Terrestrial Invertebrate	American Kestrel	Mourning Dove (herbivore)	Mourning Dove (insectivore)	Deer Mouse (herbivore)	Deer Mouse (insectivore)	Prairie Dog
Inorganics (mg/kg)									
Aluminum	20,350	**50**	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Barium	324	500	330	1,320	**159**	357	930	4,430	3,220
Boron	7.70	**0.500**	N/A	167	30.3	115	62.1	422	237
Chromium	20.2	**1**	**0.400**	**14**	24.6	**1.34**	281	**15.9**	703
Lithium	16	**2**	N/A	N/A	N/A	N/A	1,880	610	3,180
Manganese	734	**500**	N/A	9,920	1,030	2,630	**486**	4,080	1,519
Molybdenum	2.70	**2**	N/A	76.1	44.1	6.97	8.68	**1.90**	27.1
Nickel	18.7	30	200	89.9	320	**7.84**	**16.4**	**0.431**	38.3
Tin	41.3	50	N/A	**19**	**26.1**	**2.90**	45	**3.77**	80.6
Vanadium	44.9	**2**	N/A	1,510	503	274	63.7	**29.9**	83.5
Zinc	90.2	**50**	200	113	109	**0.646**	171	**5.29**	1,170
Bis(2-ethylhexyl)phthalate	240	200,000	N/A	398	19,500	**137**	96,200	8,070	27,600
Di-n-butylphthalate	240	N/A	N/A	**41.5**	989	**15.9**	1.21E+06	281,000	4.06E+06

[a]Lowest ESL (threshold if available) for that receptor.

N/A = Not applicable; ESL not available (assessed in Section 10).

Bold = Analyte retained for further consideration in the next ECOPC selection step.

Table 7.9

Upper-Bound Exposure Point Concentration Comparison to Receptor-Specific ESLs for Large Home-Range Receptors in the RCEU

Analyte	Large Home Range Receptor UCL	Receptor-Specific ESLs[a]			
		Mule Deer	Coyote (carnivore)	Coyote (generalist)	Coyote (insectivore)
Inorganics (mg/kg)					
Nickel	13.5	124	91	**6**	**1.9**
Tin	36.9	242	70	**36.1**	**16.2**

[a]Lowest ESL (threshold if available) for that receptor.

Bold = Analyte retained for further consideration in the next ECOPC selection step.

Table 7.10
Summary of ECOPC Screening Steps for Surface Soil Non-PMJM Receptors in the RCEU

Analyte	Exceed Any NOAEL ESL?	Detection Frequency >5%?	Exceed Background?[a]	Upper-Bound EPC > Limiting ESL?	Professional Judgment - Retain?	ECOPC?	Receptor(s) of Potential Concern
Inorganics							
Aluminum	Yes	Yes	Yes	Yes	No	No	--
Ammonia	No	--	--	--	--	No	--
Arsenic	Yes	Yes	No	--	--	No	--
Barium	Yes	Yes	Yes	Yes	No	No	--
Beryllium	No	--	--	--	--	No	--
Boron	Yes	Yes	N/A	Yes	No	No	--
Cadmium	Yes	Yes	No	--	--	No	--
Calcium	UT	--	--	--	--	No	--
Cesium	UT	--	--	--	--	No	--
Chromium	Yes	Yes	Yes	Yes	No	No	--
Cobalt	Yes	Yes	No	--	--	No	--
Copper	Yes	Yes	No	--	--	No	--
Iron	UT	--	--	--	--	No	--
Lead	Yes	Yes	No	--	--	No	--
Lithium	Yes	Yes	Yes	Yes	No	No	--
Magnesium	UT	--	--	--	--	No	--
Manganese	Yes	Yes	Yes	Yes	No	No	--
Mercury	Yes	Yes	No	--	--	No	--
Molybdenum	Yes	Yes	N/A	Yes	No	No	--
Nickel	Yes	Yes	Yes	Yes	No	No	--
Nitrate / Nitrite	No	--	--	--	--	No	--
Potassium	UT	--	--	--	--	No	--
Selenium	Yes	Yes	No	--	--	No	--
Silver	No	--	--	--	--	No	--
Sodium	UT	--	--	--	--	No	--
Strontium	No	--	--	--	--	No	--
Thallium	No	--	--	--	--	No	--
Tin	Yes	Yes	N/A	Yes	No	No	--
Titanium	UT	--	--	--	--	No	--
Vanadium	Yes	Yes	Yes	Yes	No	No	--
Zinc	Yes	Yes	Yes	Yes	No	No	--
Organics							
Benzoic acid	UT	--	--	--	--	No	--
Bis(2-ethylhexyl)phthalate	Yes	Yes	N/A	Yes	No	No	--
Di-n-butylphthalate	Yes	Yes	N/A	Yes	No	No	--
Radionuclides							
Americium-241	No	--	--	--	--	No	--
Cesium-137	No	--	--	--	--	No	--
Gross Alpha	UT	--	--	--	--	No	--
Gross Beta	UT	--	--	--	--	No	--
Plutonium-239/240	No	--	--	--	--	No	--
Radium-226	No	--	--	--	--	No	--
Radium-228	No	--	--	--	--	No	--
Strontium-89/90	No	--	--	--	--	No	--
Uranium-233/234	No	--	--	--	--	No	--
Uranium-235	No	--	--	--	--	No	--
Uranium-238	No	--	--	--	--	No	--

[a] Based on results of statistical analysis at the 0.1 level of significance.
-- = Screen not performed because ECOI was eliminated from further consideration in a previous step.
N/A = Not applicable; background not available or not detected.
UT = Uncertain toxicity; no ESL available (assessed in Section 10).

Table 7.11
Summary of ECOPC Screening Steps for Surface Soil PMJM Receptors in the RCEU

Analyte	Exceed PMJM NOAEL ESL?	Exceeds Background?	Professional Judgment - Retain?	ECOPC?
Inorganics				
Aluminum	UT	--	--	No
Ammonia	No	--	--	No
Antimony	No	--	--	No
Arsenic	Yes	No	--	No
Barium	No	--	--	No
Beryllium	No	--	--	No
Boron	No	--	--	No
Cadmium	No	--	--	No
Calcium	UT	--	--	No
Cesium	UT	--	--	No
Chromium	Yes	Yes	No	No
Cobalt	No	--	--	No
Copper	No	--	--	No
Iron	UT	--	--	No
Lead	No	--	--	No
Lithium	No	--	--	No
Magnesium	UT	--	--	No
Manganese	**Yes**	**Yes**	**Yes**	**Yes**
Mercury	No	--	--	No
Molybdenum	Yes	N/A	No	No
Nickel	Yes	Yes	No	No
Nitrate / Nitrite	No	--	--	No
Potassium	UT	--	--	No
Selenium	Yes	No	--	No
Silica	UT	--	--	No
Silicon	UT	--	--	No
Silver	UT	--	--	No
Sodium	UT	--	--	No
Strontium	No	--	--	No
Thallium	No	--	--	No
Tin	**Yes**	**N/A**	**Yes**	**Yes**
Titanium	UT	--	--	No
Vanadium	Yes	Yes	No	No
Zinc	Yes	No	--	No
Organics				
Benzoic acid	UT	--	--	No
Bis(2-ethylhexyl)phthalate	No	--	--	No
Radionuclides				
Americium-241	No	--	--	No
Cesium-134	UT	--	--	No
Cesium-137	No	--	--	No
Gross alpha	UT	--	--	No
Gross beta	UT	--	--	No
Plutonium-239/240	No	--	--	No
Radium-226	No	--	--	No
Radium-228	No	--	--	No
Strontium-89/90	No	--	--	No
Uranium-233/234	No	--	--	No
Uranium-235	No	--	--	No
Uranium-238	No	--	--	No

-- = Screen not performed because ECOI was eliminated from further consideration in a previous step.
N/A = Not applicable; background not available or not detected.
UT = Uncertain toxicity; no ESL available (assessed in Section 10).
Bold = Analyte retained for further consideration.

Table 7.12

Comparison of MDCs in Subsurface Soil to NOAEL ESLs for Burrowing Receptors in the RCEU

Analyte	MDC	Prairie Dog NOAEL ESL	MDC > ESL?
Inorganics (mg/kg)			
Aluminum	23,700	N/A	UT
Antimony	8.8	18.7	No
Arsenic	**13.1**	**9.35**	**Yes**
Barium	187	3,220	No
Beryllium	1.3	211	No
Calcium	54,300	N/A	UT
Cesium	3.4	N/A	UT
Chromium[a]	55.1	703	No
Cobalt	12.8	2,460	No
Copper	380	838	No
Iron	21,400	N/A	UT
Lead	45.7	1,850	No
Lithium	38.2	3,180	No
Magnesium	4,090	N/A	UT
Manganese	355	1,519	No
Mercury	0.16	3.15	No
Nickel	33.4	38.3	No
Potassium	2,630	N/A	UT
Selenium	0.3	2.80	No
Silver	3	N/A	UT
Sodium	107	N/A	UT
Strontium	88.1	3,520	No
Thallium	0.38	204	No
Tin	55.9	80.6	No
Vanadium	50.2	83.5	No
Zinc	38.2	1,170	No
Organics (µg/kg)			
Acetone	68	248,000	No
Methylene Chloride	7	210,000	No
Toluene	70	1.22E+06	No
Radionuclides (pCi/g)			
Americium-241	0.0334	3,890	No
Gross Alpha	31.3	N/A	UT
Gross Beta	36.61	N/A	UT
Plutonium-239/240	0.69	6,110	No
Uranium-233/234	3.2	4,980	No
Uranium-235	0.1812	2,770	No
Uranium-238	3.1	1,580	No

[a] The ESL for chromium (VI) is used.

N/A = Indicates no ESL was available for that ECOI/receptor pair.

UT = Uncertain toxicity; no ESL available (assessed in Section 10).

Bold = Analyte retained for further consideration in the next ECOPC selection step.

Table 7.13
Statistical Distribution and Comparison to Background for Subsurface Soil in the RCEU

Analyte	Statistical Distribution Testing Results						Background Comparison Test Results		
	Background			RCEU					
	Total Samples	Distribution Recommended by ProUCL	Detects (%)	Total Samples	Distribution Recommended by ProUCL	Detects (%)	Test	1 - p	Retain as ECOI?
Inorganics (mg/kg)									
Arsenic	**45**	**NON-PARAMETRIC**	**93**	**8**	**NORMAL**	**100**	**WRS**	**0.0150**	**Yes**

WRS = Wilcoxon Rate Sum
Bold = Analyte retained for further consideration in the next ECOPC selection step.

Table 7.14

Statistical Concentrations in Subsurface Soil in the RCEU[a]

Analyte	Units	Total Samples	UCL Recommended by ProUCL	Distribution Recommended by ProUCL	Mean	Median	75th Percentile	95th Percentile	UCL	UTL	MDC
Arsenic	mg/kg	8	95% Student's-t UCL	NORMAL	8.08	8.15	11.5	13	10.8	13.1	13.1

[a] For inorganics and organics, one-half the detection limit used as proxy value for nondetects in computation of the statistical concentrations.

MDC = Maximum detected concentration or in some cases, maximum proxy result.

UCL = 95% upper confidence limit on the mean, unless the MDC < UCL, then MDC is used as the UCL.

UTL = 95% upper confidence limit on the 90th percentile value, unless the MDC< UTL than the MDC is used as the UTL.

Table 7.15

Upper-Bound Exposure Point Concentration Comparison to tESLs in the RCEU Subsurface Soil

Analyte	Burrowing Receptors		
	EPC (UTL)	tESL[a]	EPC>ESL?
Inorganics (mg/kg)			
Arsenic	**13.1[b]**	**9.35**	**Yes**

[a]Threshold ESL (if available) for the prairie dog receptor.

[b] The MDC was used as the EPC because the UTL was greater than the MDC (MDC = Maximum detected concentration or in some cases, maximum proxy result).

Bold = Analyte retained for further consideration in the next ECOPC selection step.

Table 7.16
Summary of ECOPC Screening Steps for Subsurface Soil in the RCEU

Analyte	Exceed Prairie Dog NOAEL ESL ?	Detection Frequency >5%?	Exceed Background?[a]	Upper-Bound EPC > Limiting ESL?	Professional Judgment - Retain?	Retain as ECOPC?
Inorganics						
Aluminum	UT	--	--	--	--	No
Antimony	No	--	--	--	--	No
Arsenic	Yes	Yes	Yes	Yes	No	No
Barium	No	--	--	--	--	No
Beryllium	No	--	--	--	--	No
Calcium	UT	--	--	--	--	No
Cesium	UT	--	--	--	--	No
Chromium	No	--	--	--	--	No
Cobalt	No	--	--	--	--	No
Copper	No	--	--	--	--	No
Iron	UT	--	--	--	--	No
Lead	No	--	--	--	--	No
Lithium	No	--	--	--	--	No
Magnesium	UT	--	--	--	--	No
Manganese	No	--	--	--	--	No
Mercury	No	--	--	--	--	No
Nickel	No	--	--	--	--	No
Potassium	UT	--	--	--	--	No
Selenium	No	--	--	--	--	No
Silver	UT	--	--	--	--	No
Sodium	UT	--	--	--	--	No
Strontium	No	--	--	--	--	No
Thallium	No	--	--	--	--	No
Tin	No	--	--	--	--	No
Vanadium	No	--	--	--	--	No
Zinc	No	--	--	--	--	No
Organics						
Acetone	No	--	--	--	--	No
Methylene Chloride	No	--	--	--	--	No
Toluene	No	--	--	--	--	No
Radionuclides						
Americium-241	No	--	--	--	--	No
Gross Alpha	UT	--	--	--	--	No
Gross Beta	UT	--	--	--	--	No
Plutonium-239/240	No	--	--	--	--	No
Uranium-233/234	No	--	--	--	--	No
Uranium-235	No	--	--	--	--	No
Uranium-238	No	--	--	--	--	No

[a] Based on results of statistical analysis at the 0.1 level of significance.
'-- = Screen not performed because analyte was eliminated from further consideration in a previous ECOPC selection step.
N/A = Not applicable; background comparison could not be conducted.
UT - Uncertain toxicity; no ESL available (assessed in Section 10).

Table 8.1
Summary of ECOPC/Receptor Pairs

ECOPC	Receptors of Potential Concern
Surface Soil	
None	None
Surface Soil - PMJM	
Manganese	PMJM
Tin	PMJM
Subsurface Soil	
None	None

Table 8.2
Surface Soil Exposure Point Concentrations in PMJM Patches

Analyte[a]	Number of Samples	UCL Recommended by ProUCL	Distribution Recommended by ProUCL	Mean	Median	75th Percentile	95th Percentile	UCL[b]	UTL[c]	Maximum[d]
Patch 1										
Manganese	2	Too Few Observations To Calculate UCL	N/A	305	305	308	310	N/A	N/A	310
Tin	2	Too Few Observations To Calculate UCL	N/A	0.510	0.510	0.555	0.591	N/A	N/A	0.600
Patch 2										
Manganese	7	95% Student's-t UCL	NORMAL	317	320	365	391	366	400	400
Tin	7	95% Student's-t UCL	NORMAL	13.8	10.8	25.0	31.2	23.9	33[e]	33.0
Patch 3A										
Manganese	2	Too Few Observations To Calculate UCL	N/A	325	325	373	411	N/A	N/A	420
Tin	2	Too Few Observations To Calculate UCL	N/A	14.5	14.5	21.3	26.7	N/A	N/A	28.1
Patch 3B										
Manganese	1	Too Few Observations To Calculate UCL	N/A	N/A	2,220	2,220	2,220	N/A	N/A	2,220
Tin	1	Too Few Observations To Calculate UCL	N/A	N/A	31.2	31.2	31.2	N/A	N/A	31.2
Patch 5										
Manganese	2	Too Few Observations To Calculate UCL	N/A	280	280	310	334	N/A	N/A	340
Tin	2	Too Few Observations To Calculate UCL	N/A	1.18	1.18	1.19	1.20	N/A	N/A	1.20
Patch 6										
Manganese	1	Too Few Observations To Calculate UCL	N/A	N/A	250	250	250	N/A	N/A	250
Tin	1	Too Few Observations To Calculate UCL	N/A	N/A	1.30	1.30	1.30	N/A	N/A	1.30
Patch 7										
Manganese	1	Too Few Observations To Calculate UCL	N/A	N/A	160	160	160	N/A	N/A	160
Tin	1	Too Few Observations To Calculate UCL	N/A	N/A	0.750	0.750	0.750	N/A	N/A	0.750
Patch 8										
Manganese	3	Too Few Observations To Calculate UCL	N/A	342	269	383	474	N/A	N/A	497
Tin	3	Too Few Observations To Calculate UCL	N/A	9.66	13.6	14.3	14.8	N/A	N/A	15.0

[a] ECOPCs shown on this table were detected at least once in a given patch and are only those that have patch-specific MDCs > ESL.

[b] UCL = 95% upper confidence limit on the mean

[c] UTL = 95% upper confidence limit on the 90th percentile value

[d] Maximum = maximum proxy result; may not be a detect.

[e] Value was greater than the maximum so maximum was used instead.

N/A = UCL, UTL, and/or Mean could not be calculated due to low number of samples.

Table 8.3
Surface Water Exposure Point Concentrations for Non-PMJM and PMJM Receptors

ECOPC	Mean	UCL[a]	UTL[b]	Maximum[c]
Inorganics (mg/L)				
Manganese	0.025	0.032	0.103	0.180
Tin	0.008	0.019	0.036	0.068

[a] UCL = 95% upper confidence limit on the mean

[b] UTL = 95% upper confidence limit on the 90th percentile value

[c] Maximum = maximum proxy result; may not be a detect.

Table 8.4
Receptor-Specific Exposure Parameters

Receptor	Body Weight (kg)	Body Weight Reference	Percentage of Diet				Food Ingestion Rate (kg/kg BW day^{-1})	Ingestion Rate Reference	Water Ingestion Rate (L/kg BW day^{-1})	Ingestion Rate Reference	Percentage of Diet as Soil	Soil Ingestion Reference
			Plant Tissue	Invertebrate Tissue	Bird or Mammal Tissue	Dietary Reference						
Vertebrate Receptors - Mammals												
Preble's Meadow Jumping Mouse	0.019	Morrison and Ryser (1962)	70	30	0	Estimated from Whitacker (1972)	0.17	EPA (1993) - Estimated- Nagy (1987) - Rodent Model	0.15	EPA (1993) - Estimated using model for all mammals - Calder and Braun (1983)	2.4	Beyer et al. (1994) - Meadow Vole used as a conservative surrogate

Receptor parameters for all receptors with the exception of the prairie dog and mourning dove were taken from the Watershed Risk Assessment (DOE 1996) and referenced to the original source.
All receptor parameters are estimates of central tendency except where noted.
All values are presented in a dry weight basis.
N/A = Not applicable.

Table 8.5
PMJM Intake Estimates

	Intake Estimates (mg/kg BW day)					
	Plant Tissue	**Invertebrate Tissue**	**Mammal Tissue**	**Soil**	**Surface Water**	**Total**
Default Exposure Estimates						
Manganese						
Patch 1						
UCL[a]	8.63	5.73	N/A	1.26	0.0270	15.7
Patch 2						
UCL	10.2	6.42	N/A	1.49	0.00480	18.1
Patch 3A						
UCL[a]	11.7	7.05	N/A	1.71	0.0270	20.5
Patch 3B						
UCL[a]	61.8	21.9	N/A	9.06	0.0270	92.8
Patch 5						
UCL[a]	9.47	6.10	N/A	1.39	0.0270	17.0
Patch 6						
UCL[a]	6.96	4.95	N/A	1.02	0.0270	13.0
Patch 7						
UCL[a]	4.46	3.65	N/A	0.653	0.0270	8.78
Patch 8						
UCL[a]	13.8	7.90	N/A	2.03	0.0270	23.8
Tin						
Patch 1						
UCL[a]	0.00214	0.0306	N/A	0.00245	0.0102	0.0454
Patch 2						
UCL	0.0853	1.22	N/A	0.0975	0.00285	1.40
Patch 3A						
UCL[a]	0.100	1.43	N/A	0.115	0.0102	1.66
Patch 3B						
UCL[a]	0.111	1.59	N/A	0.127	0.0102	1.84
Patch 5						
UCL[a]	0.00428	0.0612	N/A	0.00490	0.0102	0.0806
Patch 6						
UCL[a]	0.00464	0.0663	N/A	0.00530	0.0102	0.0864
Patch 7						
UCL[a]	0.00268	0.0383	N/A	0.00306	0.0102	0.0542
Patch 8						
UCL[a]	0.0536	0.765	N/A	0.0612	0.0102	0.890

[a] - Not enough samples were available to calculate a UCL. The MDC was used as a default.
N/A = Not applicable.

Table 9.1
TRVs for Terrestrial Vertebrate Receptors

ECOPC	NOAEL (mg/kg day)	NOAEL Endpoint	LOAEL (mg/kg day)	LOAEL Endpoint	TRV Source	Uncertainty Factor	Final NOAEL (mg/kg day)	Threshold (mg/kg day)	Rationale For Calculation	TRV Confidence
Mammals										
Manganese	13.7	No change in mouse testicle weight	159.1	Decrease in mouse testicle weight	PRC (1994)	1	13.7	NA	The original paper was not reviewed. Not enough information was available to calculate the threshold TRV.	High
Tin (Butyltins)	0.25	No systemic effects	15	Midrange of effects less than mortality	PRC (1994)	1	0.25	N/A	Threshold was not calculated.	High

<u>TRV Confidence:</u>
N/A = No TRV has been identified or the TRV has been deemed unacceptable for use in ECOPC selection.
Low = TRVs that have data for only one species looking at one endpoint (non-mortality) and from one primary literature source.
Moderate = TRVs that have multiple primary literature sources looking at one endpoint (non-mortality or mortality) but with only one species evaluated.
Good = For TRVs that have either multiple species with one endpoint from multiple studies or those TRVs with multiple species and multiple endpoints from only one study.
High = For TRVs that have multiple study sources looking at multiple endpoints and more than one species.
Very High = All EcoSSLs (EPA 2003a) will be assigned this level of confidence by default.

Table 10.1
Hazard Quotient Summary For PMJM Receptors

ECOPC	Receptor	BAF	EPC	Hazard Quotients (HQs)	
				Based on Default TRVs	Based on Refined Analysis
Manganese	Patch 1	Default	UCL[a]	NOAEL = 1 LOAEL = 0.1	Not Calculated
		Median	UCL[a]	Not Calculated	Not Calculated
	Patch 2	Default	UCL	NOAEL = 1 LOAEL = 0.1	Not Calculated
		Median	UCL	Not Calculated	Not Calculated
	Patch 3A	Default	UCL[a]	NOAEL = 2 LOAEL = 0.1	Not Calculated
		Median	UCL[a]	Not Calculated	Not Calculated
	Patch 3B	Default	UCL[a]	NOAEL = 7 LOAEL = 0.6	Not Calculated
		Median	UCL[a]	Not Calculated	Not Calculated
	Patch 5	Default	UCL[a]	NOAEL = 1 LOAEL = 0.1	Not Calculated
		Median	UCL[a]	Not Calculated	Not Calculated
	Patch 6	Default	UCL[a]	NOAEL = 0.97 LOAEL = 0.08	Not Calculated
		Median	UCL[a]	Not Calculated	Not Calculated
	Patch 7	Default	UCL[a]	NOAEL = 0.7 LOAEL = 0.06	Not Calculated
		Median	UCL[a]	Not Calculated	Not Calculated
	Patch 8	Default	UCL[a]	NOAEL = 2 LOAEL = 0.1	Not Calculated
		Median	UCL[a]	Not Calculated	Not Calculated
Tin	Patch 1	Default	UCL[a]	NOAEL = 0.2 LOAEL = 0.003	Not Calculated
		Median	UCL[a]	Not Calculated	Not Calculated
	Patch 2	Default	UCL	NOAEL = 6 LOAEL = 0.09	Not Calculated
		Median	UCL	Not Calculated	Not Calculated
	Patch 3A	Default	UCL[a]	NOAEL = 7 LOAEL = 0.1	Not Calculated
		Median	UCL[a]	Not Calculated	Not Calculated
	Patch 3B	Default	UCL[a]	NOAEL = 7 LOAEL = 0.1	Not Calculated
		Median	UCL[a]	Not Calculated	Not Calculated
	Patch 5	Default	UCL[a]	NOAEL = 0.3 LOAEL = 0.005	Not Calculated
		Median	UCL[a]	Not Calculated	Not Calculated
	Patch 6	Default	UCL[a]	NOAEL = 0.3 LOAEL = 0.006	Not Calculated
		Median	UCL[a]	Not Calculated	Not Calculated
	Patch 7	Default	UCL[a]	NOAEL = 0.2 LOAEL = 0.004	Not Calculated
		Median	UCL[a]	Not Calculated	Not Calculated
	Patch 8	Default	UCL[a]	NOAEL = 4 LOAEL = 0.06	Not Calculated
		Median	UCL[a]	Not Calculated	Not Calculated

[a] - Not enough samples were available to calculate a UCL. The MDC was used as a default.

Shaded cells represent default HQ calculations based on exposure and toxicity models specifically identified in the CRA Methodology

All HQ Calculations are provided in Attachment 4.

Discussion of the chemical-specific uncertainties are provided in Attachment 5.

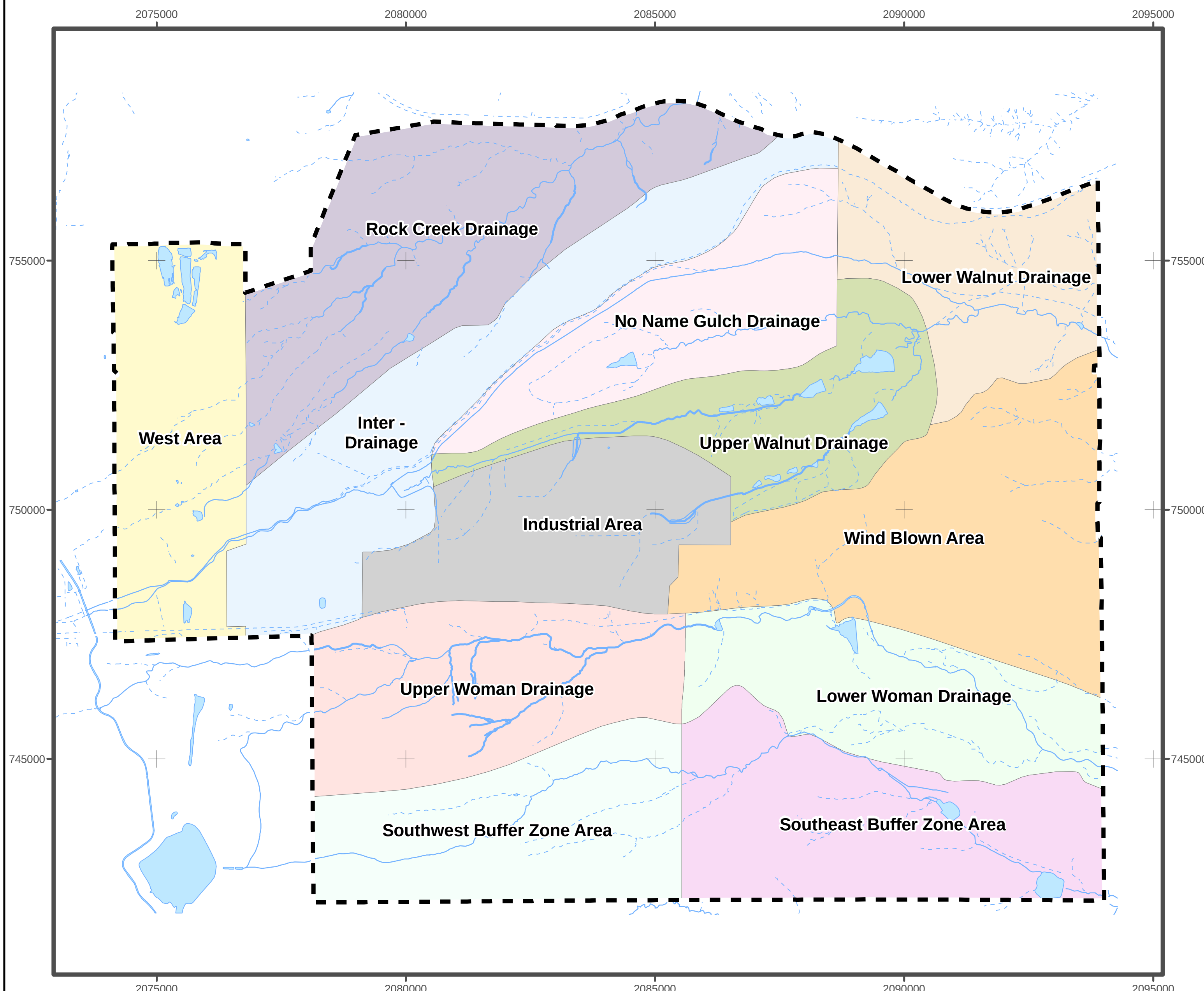
Table 11.1
Summary of Risk Characterization Results for the RCEU

Analyte	Ecological Receptors	Result of Risk Characterization	Risk Description Conclusion
Surface Soil Non-PMJM Receptors			
None	Terrestrial plants	No ECOPCs.	No ECOPCs
	Terrestrial invertebrate	No ECOPCs.	No ECOPCs
	American kestrel	No ECOPCs.	No ECOPCs
	Mourning dove (herbivore)	No ECOPCs.	No ECOPCs
	Mourning dove (insectivore)	No ECOPCs.	No ECOPCs
	Deer mouse (herbivore)	No ECOPCs.	No ECOPCs
	Deer mouse (Insectivore)	No ECOPCs.	No ECOPCs
	Prairie dog	No ECOPCs.	No ECOPCs
	Coyote (carnivore)	No ECOPCs.	No ECOPCs
	Coyote (generalist)	No ECOPCs.	No ECOPCs
	Coyote (insectivore)	No ECOPCs.	No ECOPCs
	Mule Deer	No ECOPCs.	No ECOPCs
Surface Soil - PMJM Receptors			
Manganese	Patch 1	NOAEL HQ =1 LOAEL HQ <1	Low Risk
	Patch 2	NOAEL HQ =1 LOAEL HQ <1	Low Risk
	Patch 3A	NOAEL HQ >1 using default exposure. LOAEL HQs <1 using default exposure.	Low Risk
	Patch 3B	NOAEL HQs >1 using default exposure. LOAEL HQs <1 using default exposure.	Low Risk
	Patch 5	NOAEL HQ =1 LOAEL HQ <1	Low Risk
	Patch 6	NOAEL and LOAEL HQ <1	Low Risk
	Patch 7	NOAEL and LOAEL HQ <1	Low Risk
	Patch 8	NOAEL HQ >1 using default exposure. LOAEL HQs <1 using default exposure.	Low Risk
Tin	Patch 1	NOAEL and LOAEL HQs <1 using default exposure and TRVs.	Low Risk
	Patch 2	NOAEL HQ >1 using default exposure and TRVs. LOAEL HQ <1 using default exposure and TRVs.	Low Risk
	Patch 3A	NOAEL HQ >1 using default exposure and TRVs. LOAEL HQ <1 using default exposure and TRVs.	Low Risk
	Patch 3B	NOAEL HQ >1 using default exposure and TRVs. LOAEL HQ <1 using default exposure and TRVs.	Low Risk
	Patch 5	NOAEL and LOAEL HQs <1 using default exposure and TRVs.	Low Risk
	Patch 6	NOAEL and LOAEL HQs <1 using default exposure and TRVs.	Low Risk
	Patch 7	NOAEL and LOAEL HQs <1 using default exposure and TRVs.	Low Risk
	Patch 8	NOAEL HQ >1 using default exposure and TRVs. LOAEL HQ <1 using default exposure and TRVs.	Low Risk
Subsurface Soil			
None	Prairie dog	No ECOPCs.	No ECOPCs

[a]ESL was not available. Analyte evaluated in Section 10.

FIGURES

Figure 1.1
Rocky Flats Environmental
Technology Site
Exposure Units



KEY

- Exposure unit boundary
- Pond
- Site boundary
- Perennial stream
- Intermittent stream
- Ephemeral stream

N
W E
S

0 1,500 3,000 Feet

Scale 1:36,000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental
Technology Site

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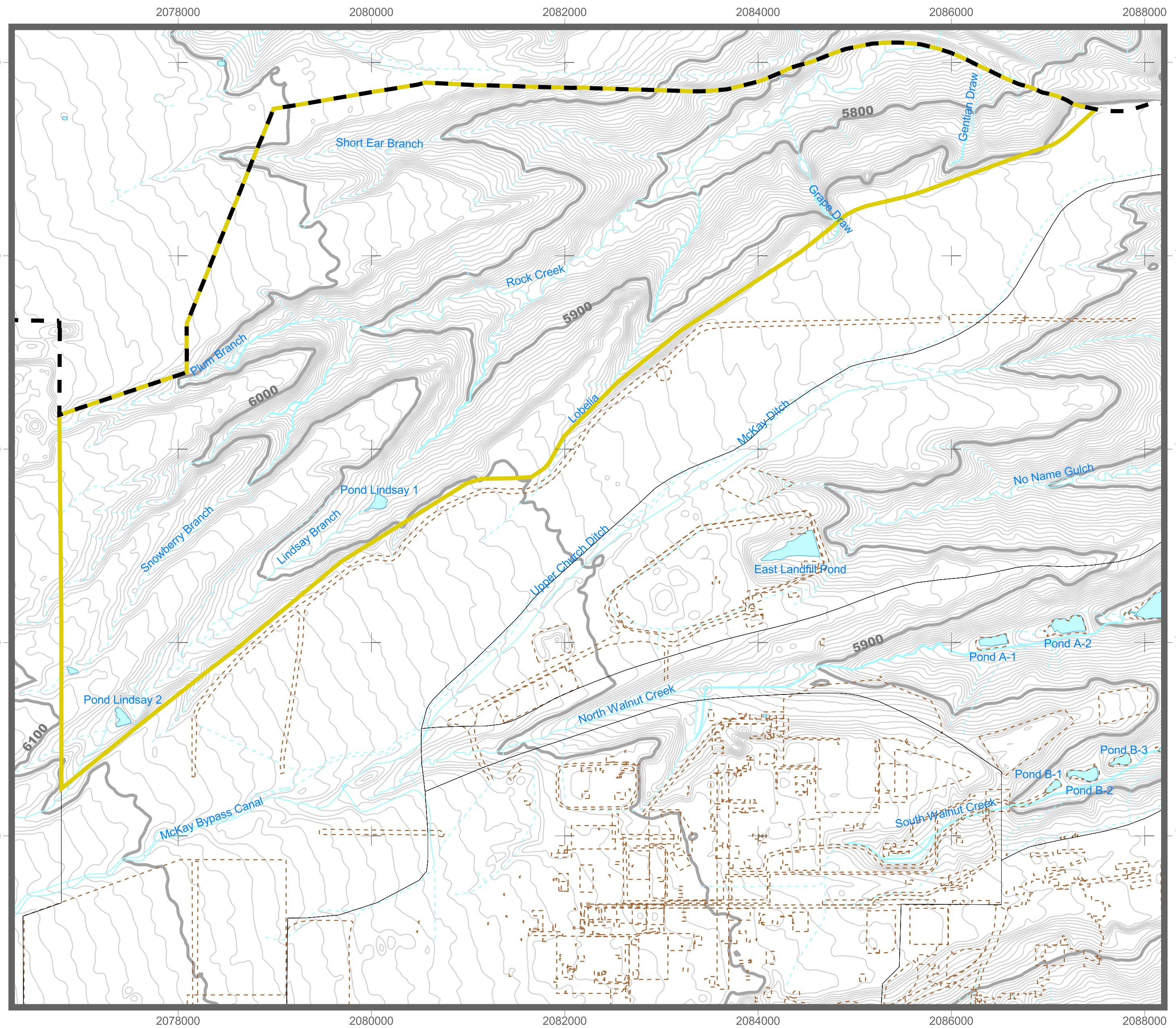


Figure 1.2
Topography and Historical IHSS Locations in the Rock Creek Drainage Exposure Unit

KEY

Rock Creek Drainage EU
Historical IHSS/PAC
Topographic contour interval = 5 ft.

Standard Map Features

Exposure unit boundary
Pond
Site boundary
Perennial stream
Intermittent stream
Ephemeral stream

N S W E

0 800 1600 Feet

Scale 1:19200

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

File: W:\Projects\Fy2005\CRA\GIS_Final\ArcView\Section1\RockCreekDrainage.apr

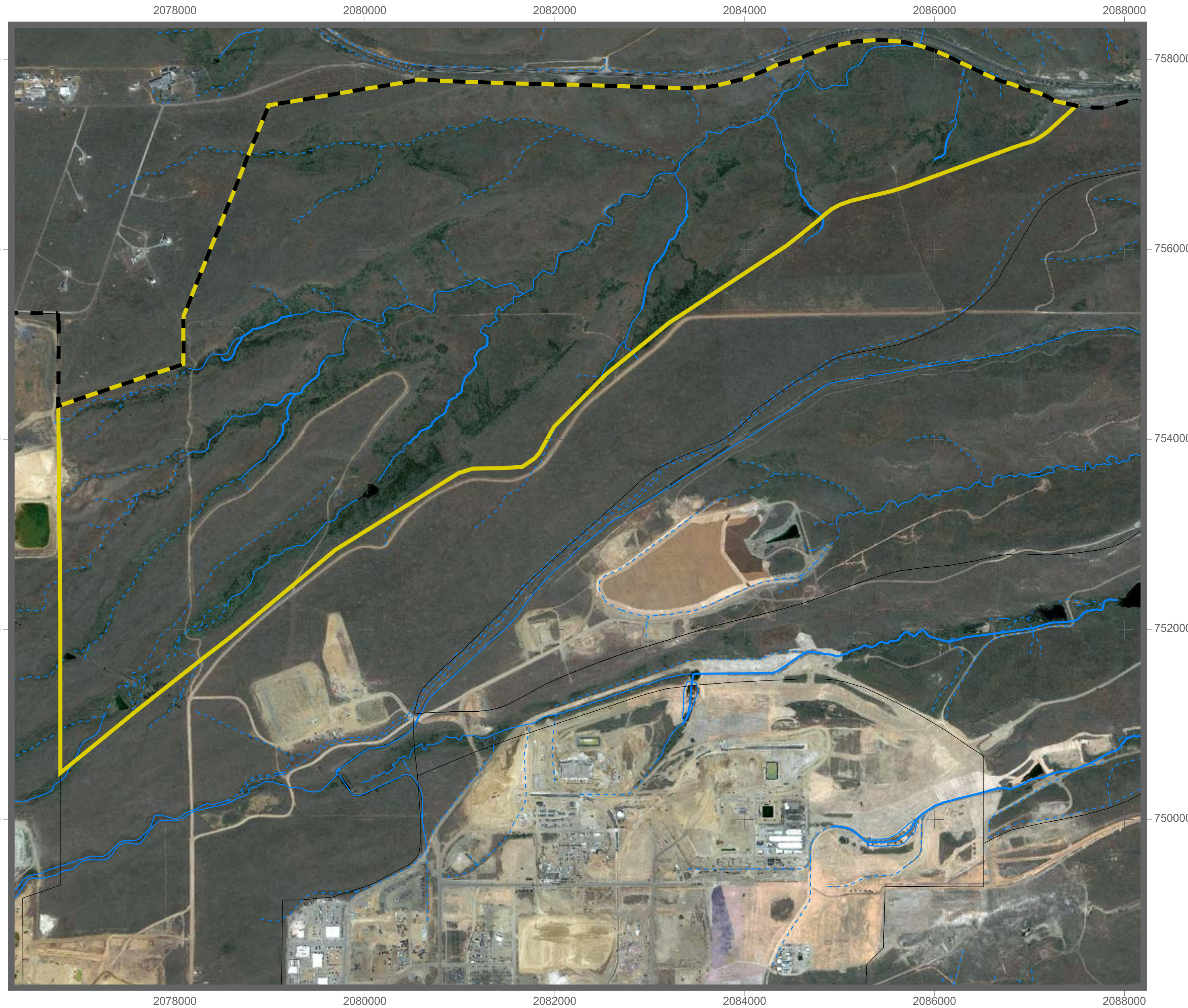


Figure 1.3
Aerial Photograph of the
Rock Creek Drainage Exposure Unit
July 2005

KEY

Rock Creek Drainage EU

Standard Map Features

Exposure unit boundary
Pond
Site boundary
Perennial stream
Intermittent stream
Ephemeral stream

N W E S

0 800 1600 Feet

Scale 1:19200

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental
Technology Site

File: W:\Projects\Fy2005\CRA\GIS_Final\ArcView\Section1\RockCreekDrainage.apr

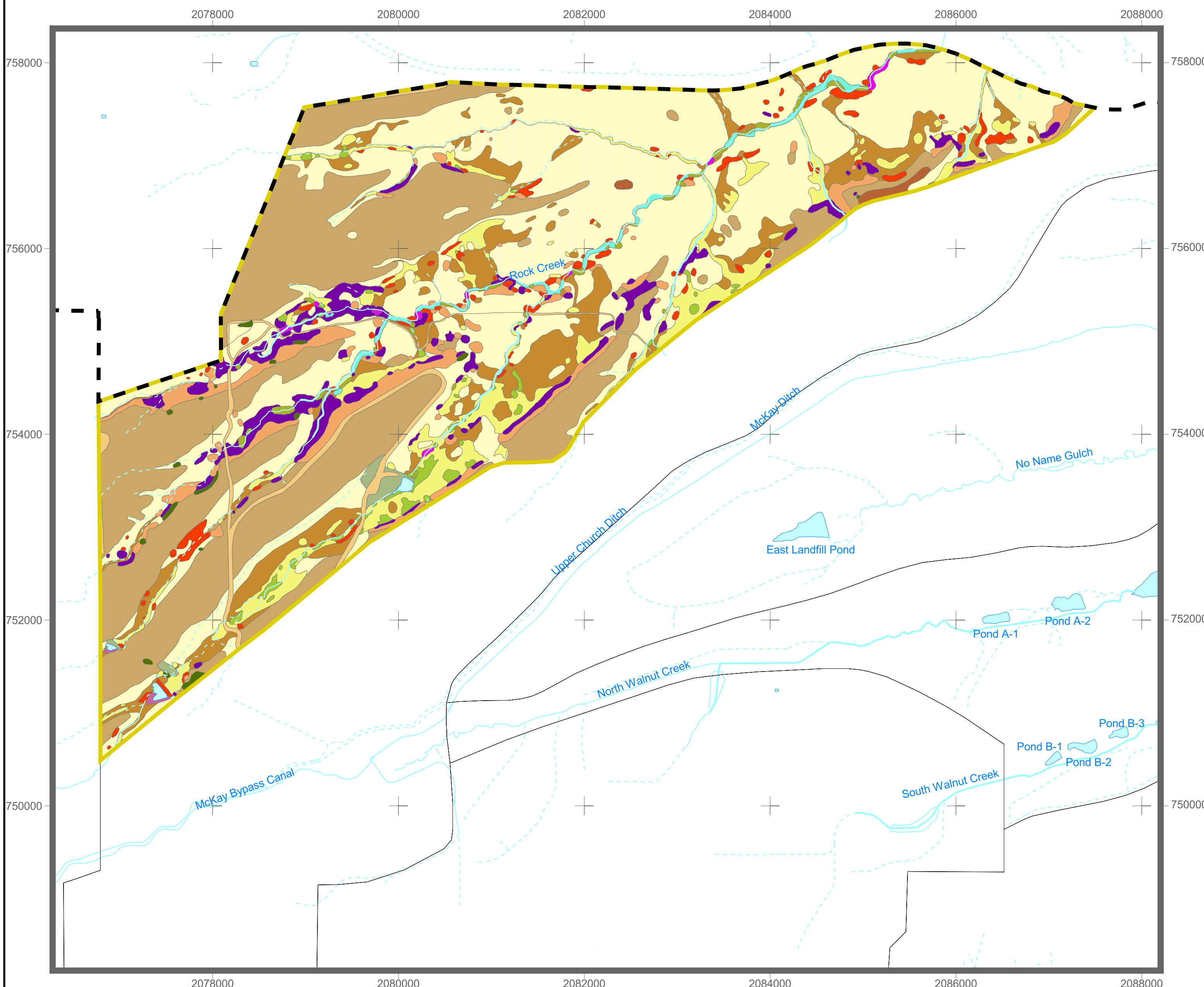


Figure 1.4
Vegetation in the Rock Creek Drainage Exposure Unit

KEY

Rock Creek Drainage EU

Vegetation, 2005

- Annual grass/forb community
- Disturbed areas
- Disturbed and revegetated areas
- Leadplant riparian shrubland
- Mesic mixed grassland
- Mudflats
- Open water
- Ponderosa woodland
- Reclaimed mixed grassland
- Riparian woodland
- Riprap, rock, and gravel piles
- Savannah shrubland
- Short grassland
- Short marsh
- Short upland shrubland
- Tall marsh
- Tall upland shrubland
- Tree plantings
- Wet meadow/marsh ecotone
- Willow riparian shrubland
- Xeric needle and thread grass prairie
- Xeric tallgrass prairie

Standard Map Features

- Exposure unit boundary
- Pond
- Site boundary
- Perennial stream
- Intermittent stream
- Ephemeral stream

N E S W

0 800 1600 Feet

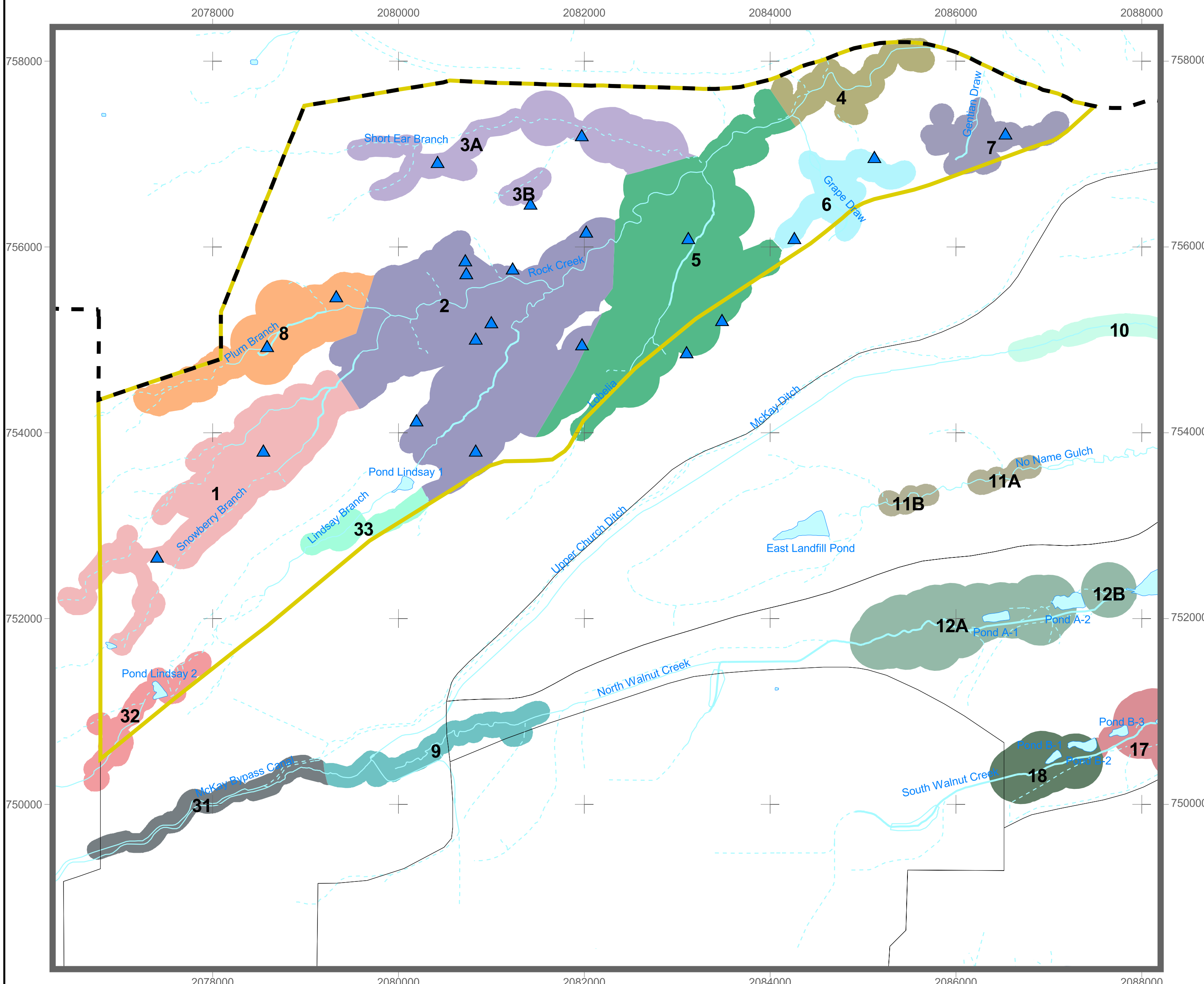
Scale 1:19200

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental
Technology Site

File: W:\Projects\Fy2005\CRA\GIS_Final\ArcView\Section1\RockCreekDrainage.apr

Figure 1.5
Preble's Meadow Jumping Mouse Habitat and Surface Soil Sample Locations in the Rock Creek Drainage Exposure Unit



KEY

- Surface soil sample location
- Rock Creek Drainage EU
- PMJM habitat patch
- 1 PMJM habitat patch ID

Note: Not all analyte groups were analyzed at every sample location.

Standard Map Features

- Exposure unit boundary
- Pond
- Site boundary
- Perennial stream
- Intermittent stream
- Ephemeral stream

N
W
E
S

0 800 1600 Feet

Scale 1:19200

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

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File: W:\Projects\Fy2005\CRA\GIS_Final\ArcView\Section1\RockCreekDrainage.apr

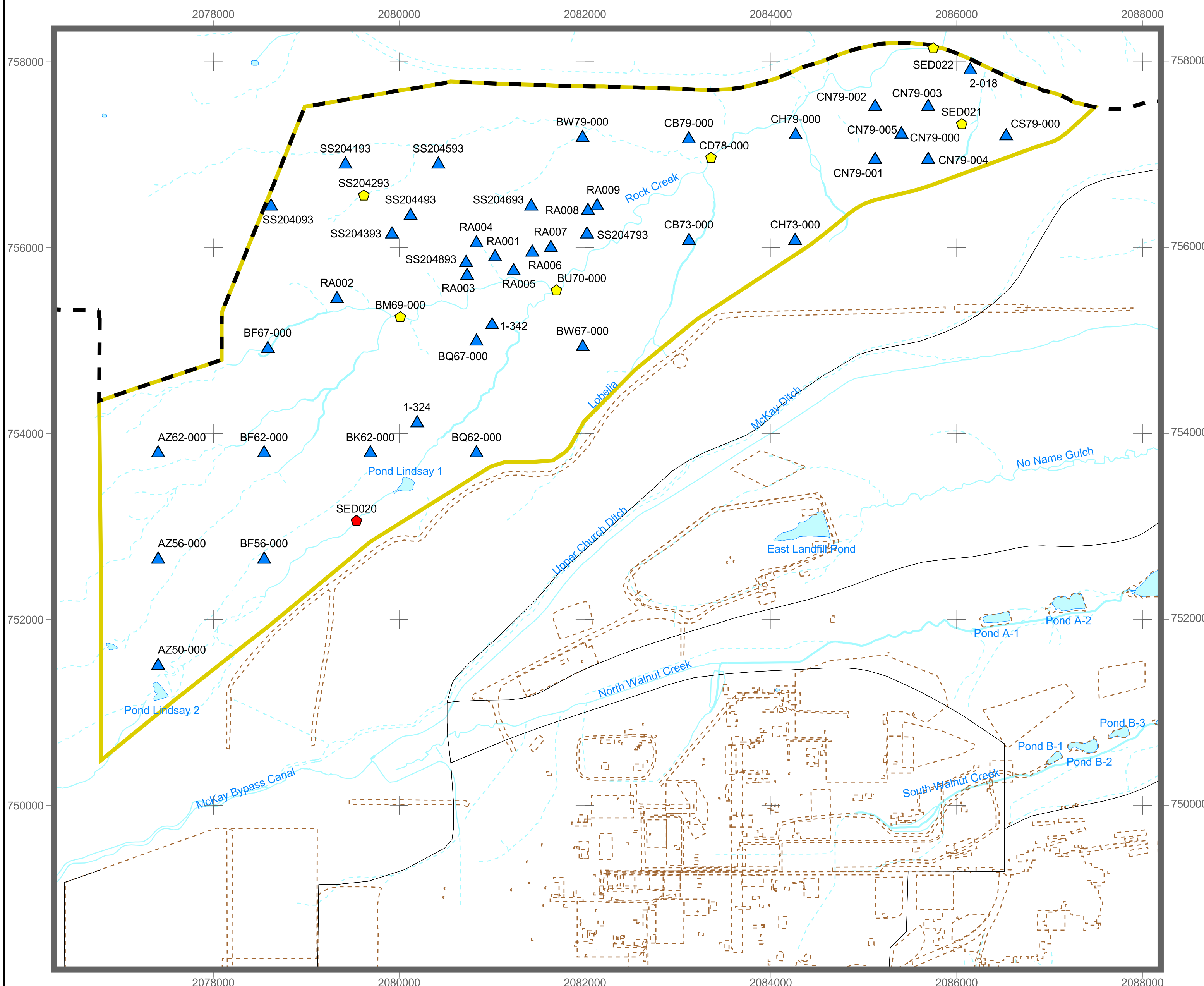


Figure 1.6
Rock Creek Drainage Exposure Unit Surface Soil and Surface Sediment Sample Locations

KEY

Sample location
- Surface sediment sample location
- Surface soil sample location

(Background locations shown in red)
- Surface sediment sample location
- Rock Creek Drainage EU
- Historical IHSS/PAC

Standard Map Features
- Exposure unit boundary
- Pond
- Site boundary
- Perennial stream
- Intermittent stream
- Ephemeral stream

N
W
E
S

0 800 1600 Feet

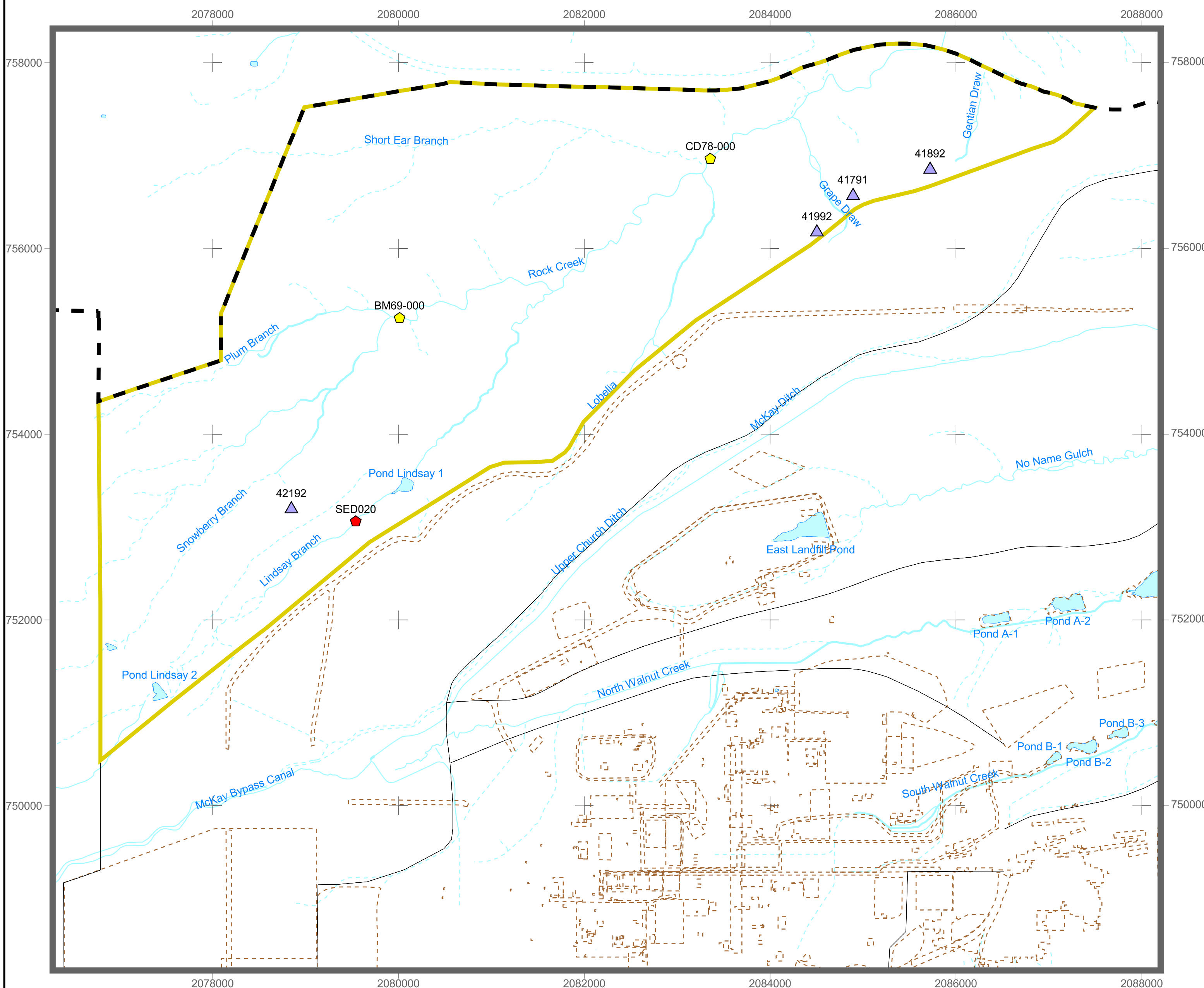
Scale 1:19200

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

File: W:\Projects\Fy2005\CRA\GIS_Final\ArcView\Section1\RockCreekDrainage.apr

Figure 1.7
Rock Creek Drainage Exposure Unit Subsurface Soil and Subsurface Sediment Sample Locations



KEY

Sample location

- Subsurface sediment sample location
- Subsurface soil sample location

(Background locations shown in red)

- Subsurface sediment sample location
- Rock Creek Drainage EU
- Historical IHSS/PAC

Standard Map Features

- Exposure unit boundary
- Pond
- Site boundary
- Perennial stream
- Intermittent stream
- Ephemeral stream

N E S W

0 800 1600 Feet

Scale 1:19200

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental
Technology Site

File: W:\Projects\Fy2005\CRA\GIS_Final\ArcView\Section1\RockCreekDrainage.apr

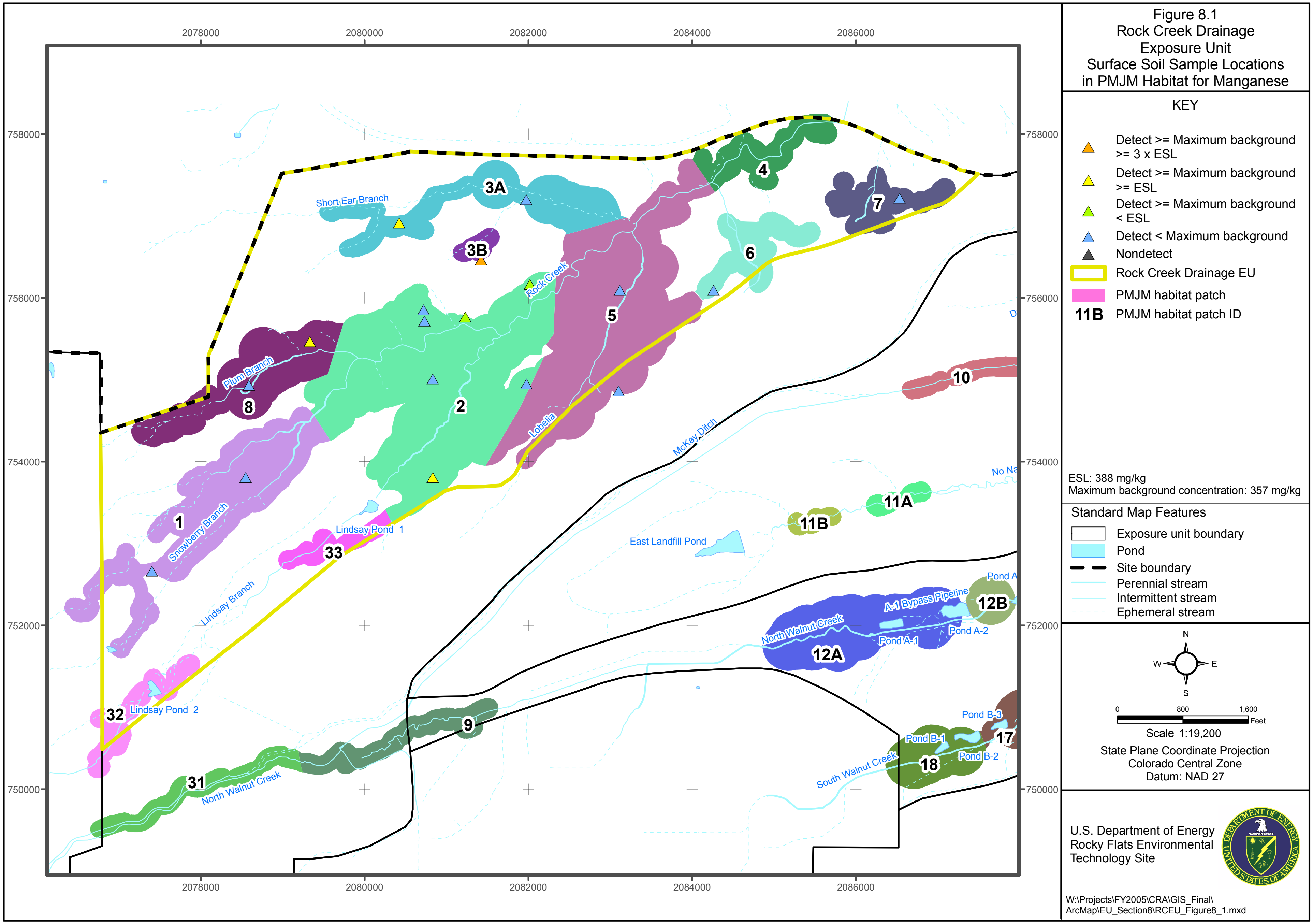


Figure 8.1
Rock Creek Drainage
Exposure Unit
Surface Soil Sample Locations
in PMJM Habitat for Manganese

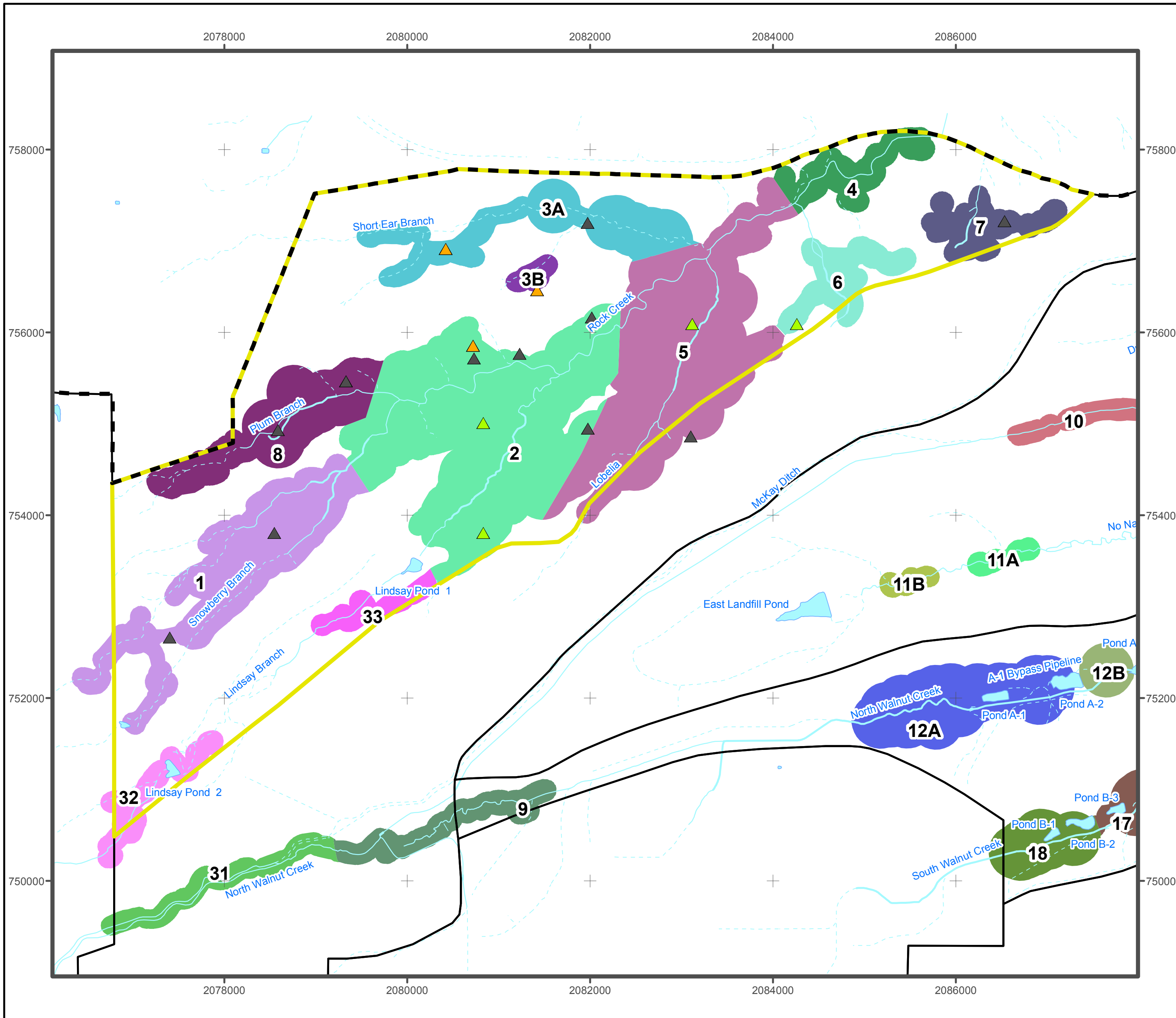


Figure 8.2
Rock Creek Drainage
Exposure Unit
Surface Soil Sample Locations
in PMJM Habitat for Tin

KEY

- Detect >= Maximum background >= 3 x ESL
- Detect >= Maximum background >= ESL
- Detect >= Maximum background < ESL
- Detect < Maximum background
- Nondetect
- Rock Creek Drainage EU
- PMJM habitat patch
- **11B** PMJM habitat patch ID

ESL: 4.22 mg/kg
Maximum background concentration: N/A

Standard Map Features

- Exposure unit boundary
- Pond
- Site boundary
- Perennial stream
- Intermittent stream
- Ephemeral stream

N
W E
S

0 800 1,600 Feet

Scale 1:19,200

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
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Technology Site

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COMPREHENSIVE RISK ASSESSMENT

ROCK CREEK DRAINAGE EXPOSURE UNIT

VOLUME 4: ATTACHMENT 1

Detection Limit Screen

TABLE OF CONTENTS

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

µg/kg	micrograms per kilogram
µg/L	micrograms per liter
CD	compact disc
CRA	Comprehensive Risk Assessment
ESL	ecological screening level
IHSS	Individual Hazardous Substance Site
mg/kg	milligrams per kilogram
N/A	not available or not applicable
NOAEL	no observed adverse effect level
PAC	Potential Area of Concern
pCi/g	picocuries per gram
PRG	preliminary remediation goal
RCEU	Rock Creek Drainage Exposure Unit
TIC	tentatively identified compound
VOC	volatile organic compound
WRW	wildlife refuge worker

1.0 EVALUATION OF ANALYTE DETECTION LIMITS FOR THE ROCK CREEK DRAINAGE EXPOSURE ZONE AREA EXPOSURE UNIT

For the Rock Creek Drainage Exposure Unit (EU) (RCEU), the detection limits for non-detected analytes as well as analytes detected in less than 5 percent of the samples are compared to human health preliminary remediation goals (PRGs) for the wildlife refuge worker (WRW) and the minimum ecological screening levels (ESLs). The comparisons are made in the tables to this attachment for potential contaminants of concern (PCOCs) in surface soil/surface sediment and subsurface soil/subsurface sediment, and ecological contaminants of interest (ECOIs) in surface soil and subsurface soil. The percent of the samples with detection limits that exceed the PRGs and ESLs are listed in these tables. When these detection limits exceed the respective PRGs and ESLs, this is a source of uncertainty in the risk assessment process, which is discussed herein.

Laboratory reported results for “U” qualified data (nondetects) are used to perform the detection limit screen rather than the detection limit identified in the detection limit field within the Soil Water Database (SWD). The basis for the detection limit is not always certain, i.e., Instrument Detection Limit (IDL), Method Detection Limit (MDL), Reporting Limit (RL), Sample Quantitation Limit (SQL), etc. Therefore, to be consistent in reporting, the “reported results” are presented in the tables to this attachment. Also, for statistical computations and risk estimations presented in the main text and tables to this volume, one-half the reported results are used as proxy values for nondetected data.

The term analyte as used in the following sections refers to analytes that are non-detected or detected in less than 5 percent of the samples. PRGs and ESLs do not exist for some of these analytes, which is also a source of uncertainty for the risk assessment. This uncertainty is discussed in Sections 6.2.1 and 10.3.2 of the main text of this volume.

1.1 Comparison of Reported Results to Preliminary Remediation Goals

1.1.1 Surface Soil/Surface Sediment

As shown in Table A1.1, there are only five analytes in surface soil/surface sediment where the reported results exceed the PRG: 4,6-dinitro-2-methylphenol (4.8%), benzo(a)pyrene (57.1%), dibenz(a,h)anthracene (58.6%), hexachlorobenzene (6.67%), and N-nitroso-di-n-propylamine (43.3%). For 4,6-dinitro-2-methylphenol and hexachlorobenzene, greater than 90% of the reported results are less than the PRGs, which represents only minimal uncertainty in the overall risk assessment process. For the other analytes, they are not likely to be present in the RCEU because there were no historical IHSSs located in this EU, and the RCEU is hydraulically isolated from the historical operations in the Industrial Area, and it is generally upwind. Therefore, there are no significant pathways for these analytes to migrate to the RCEU.

1.1.2 Subsurface Soil/Subsurface Sediment

All reported results are below the PRGs in subsurface soil/subsurface sediment (Table A1.2).

1.2 Comparison of Reported Results to Ecological Screening Levels

1.2.1 Surface Soil

As shown in Table A1.3, there are 16 analytes in surface soil where some percent of the reported results exceed the lowest ESL. For hexachlorobutadiene, nearly 90% of the reported results are less than the lowest ESL. Consequently, for this analyte, there is minimal uncertainty in the overall risk assessment process because of these higher reported results. Of the remaining 15 analytes, more than 50% of the reported results exceed the lowest ESL, and in some cases, the maximum reported results are more than an order of magnitude higher than the lowest ESL. This condition requires further analysis to determine the extent of uncertainty in the overall risk assessment process, i.e., ecological risks may be underestimated because these analytes may have been included as ECOPCs had they been detected more frequently using lower detection limits (lower reported results).

First, for these remaining 15 analytes, it is noted that the reported results are generally consistent with industry standards for laboratory detection limits. In all cases, the minimum reported results (see Table A1.3) are similar in magnitude to the Contract Required Quantitation Limits (CRQLs) for the Environmental Protection Agency's (EPA) Contract Laboratory Program (CLP) (330-830 ug/kg for semi-volatile organic compounds (SVOCs); 1.7-3.3 ug/kg for pesticides; and 33-67 ug/kg for PCBs depending on the compound). The CRQLs are minimum limits established by the CLP for identifying contaminants at Superfund sites.

Even though the lower limit of the range of reported results are generally consistent with industry standards for laboratory detection limits, the extent of uncertainty in the overall risk estimates was further assessed based on professional judgment and ecological risk potential.

Professional judgment indicates whether the analytes are likely to be ECOPCs in the RCEU surface soil based on 1) a listing of the analytes (or classes of analytes) as constituents in wastes potentially released at historical Individual Hazardous Substance Sites (IHSSs) in the RCEU (DOE 2005a), 2) the historical inventory for the chemical at RFETS (CDH 1991), and 3) a comparison of the maximum detected concentration and detection frequency in the EU and sitewide surface soil (see Table A1.4 for sitewide surface soil summary statistics). The comparison of the EU and sitewide maximum detected concentrations and detection frequencies in surface soil is performed to assess if the EU observations are much higher, which may potentially also indicate a source for the analyte within the EU. Using professional judgment, the analytes can be grouped into four categories that represent an ascending order of uncertainty. Category 1 is for analytes that were not listed as waste constituents for the EU historical IHSSs, and are not detected in the EU or sitewide surface soil. Category 2 is for analytes that may or may not be listed as waste constituents for the EU historical IHSSs, but nevertheless are not detected in the EU surface soil even though they were detected in other EU surface soil at RFETS at low maximum detected concentrations and low detection frequencies. Category 3 is for analytes that may or may not be listed as waste constituents for the EU historical IHSSs, and are detected in the EU (and therefore sitewide) surface soil, and the maximum detected concentrations in the EU surface soil are approximately the same order of magnitude as the ESL, and the detection frequencies are low. For these first three categories, the uncertainty with regard to the risk estimates because of the higher detection limits is considered small. Category 4 is for analytes that are detected in the EU (and therefore sitewide) surface soil at maximum concentrations that substantially exceed the ESLs and at detection frequencies generally higher than for Category 3, i.e., these analytes have the highest likelihood of being ECOPCs had they been detected more frequently using lower detection limits (lower reported results), and therefore, there is some uncertainty with regard to the risk estimates because of the higher detection limits.

The assessment of the ecological risk potential compares the maximum reported result to a Lowest Observed Adverse Effect Level (LOAEL)-based soil concentration. ESLs are based on No Observed Adverse Effect Levels (NOAELs) (DOE 2005b). The LOAEL-based soil concentration is estimated by multiplying the lowest ESL by the LOAEL/NOAEL ratio for the mammal or the bird depending on whether a mammal or bird is the most sensitive terrestrial vertebrate receptor for the chemical (see Appendix B, Table B-2 of the Final CRA Work Plan and Methodology, Revision 1 (DOE 2005b) for the Lowest Bounded LOAELs and Final NOAELs for mammals and birds). A maximum reported result/LOAEL-based soil concentration ratio greater than one indicates a potential for an adverse ecological effect if the analyte was detected at the highest reported result.

As shown in Table A1.5, all of the 15 analytes assessed using professional judgment are in categories 1 and 2, and thus are not likely to be ECOPCs in the RCEU surface soil based on professional judgment, which minimizes the uncertainty in the overall risk assessment process because of their higher reported results. Comparing the maximum reported results to the LOAEL-based soil concentrations indicates more than half of the above noted analytes would also not present a potential for adverse ecological effects if they were detected at the maximum reported results.

In conclusion, analytes in surface soil that have reported results that exceed the lowest ESLs contribute only minimal uncertainty to the overall risk assessment process because either only a small fraction of the reported results are greater than the lowest ESL, or professional judgment indicates they are not likely to be ECOPCs in RCEU surface soil even if detection limits (reported results) had been lower. Although some of the analytes would present a potential for adverse ecological effects if they were detected at their maximum reported results, because they are not expected to be ECOPCs in RCEU surface soil, uncertainty in the overall risk assessment process is low.

1.2.2 Subsurface Soil

All reported results are below the ESLs in subsurface soil (Table A1.6).

2.0 REFERENCES

CDH, 1991. Colorado Department of Health Project Task 1 Report (Revised 1), Identification of Chemicals and Radionuclides Used at Rocky Flats. Prepared by ChemRisk. March.

DOE, 2005a, 2005 Annual Update to the Historical Release Report, Rocky Flats Environmental Technology Site, October.

DOE, 2005b. Final Comprehensive Risk Assessment Work Plan and Methodology, Revision 1, Rocky Flats Environmental Technology Site, Golden, Colorado. Revision 1. September.

TABLES

Table A1.1
Evaluation of Reported Results for Nondetected Analytes and Analytes with a Detection Frequency Less than 5 Percent in Surface Soil/Surface Sediment in the RCEU

Analyte	Range of Nondetected Reported Results			Total Number of Nondetected Results	Lowest PRG	Number of Nondetected Results > PRG	Percent Nondetected Results > PRG	Analyte Detected?
Inorganics (mg/kg)								
Antimony	0.280	-	29.5	49	44.4	0	0	No
Chromium VI	0.860	-	0.960	2	28.4	0	0	No
Nitrite	0.500	-	0.500	1	11,109	0	0	No
Organics (ug/kg)		-						
4-Nitrophenol	1,700	-	13,000	22	641,148	0	0	Yes
PCB-1016	82	-	410	26	1,349	0	0	No
PCB-1221	82	-	410	26	1,349	0	0	No
PCB-1232	82	-	410	26	1,349	0	0	No
PCB-1242	82	-	410	26	1,349	0	0	No
PCB-1248	82	-	410	26	1,349	0	0	No
PCB-1254	160	-	820	26	1,349	0	0	No
PCB-1260	160	-	820	26	1,349	0	0	No
4,4'-DDD	16	-	82	26	15,528	0	0	No
4,4'-DDE	16	-	82	26	10,961	0	0	No
4,4'-DDT	16	-	82	26	10,927	0	0	No
Aldrin	8.20	-	41	26	176	0	0	No
alpha-BHC	8.20	-	41	26	570	0	0	No
alpha-Chlordane	82	-	410	26	10,261	0	0	No
beta-BHC	8.20	-	41	26	1,995	0	0	No
beta-Chlordane	86	-	400	13	10,261	0	0	No
delta-BHC	8.20	-	41	26	570	0	0	No
Dieldrin	16	-	82	26	187	0	0	No
Endosulfan I	8.20	-	41	26	480,861	0	0	No
Endosulfan II	16	-	82	26	480,861	0	0	No
Endosulfan sulfate	16	-	82	26	480,861	0	0	No
Endrin	16	-	82	26	24,043	0	0	No
Endrin ketone	16	-	82	26	33,326	0	0	No
gamma-BHC (Lindane)	8.20	-	41	26	2,771	0	0	No
gamma-Chlordane	82	-	410	13	10,261	0	0	No
Heptachlor	8.20	-	41	26	665	0	0	No
Heptachlor epoxide	8.20	-	41	26	329	0	0	No
Hexachlorocyclopentadiene	330	-	2,500	28	380,452	0	0	No
Methoxychlor	82	-	410	26	400,718	0	0	No
Toxaphene	160	-	820	26	2,720	0	0	No
1,2,4-Trichlorobenzene	330	-	2,500	30	151,360	0	0	No
2,4,5-Trichlorophenol	1,600	-	8,000	24	8.01E+06	0	0	No
2,4,6-Trichlorophenol	330	-	2,500	24	272,055	0	0	No
2,4-Dichlorophenol	330	-	2,500	24	240,431	0	0	No
2,4-Dimethylphenol	330	-	2,500	24	1.60E+06	0	0	No
2,4-Dinitrophenol	1,700	-	13,000	22	160,287	0	0	No
2,4-Dinitrotoluene	330	-	2,500	30	160,287	0	0	No
2,6-Dinitrotoluene	330	-	2,500	30	80,144	0	0	No
2-Chloronaphthalene	330	-	2,500	30	6.41E+06	0	0	No
2-Chlorophenol	330	-	2,500	24	555,435	0	0	No
2-Methylnaphthalene	330	-	2,500	28	320,574	0	0	No
2-Methylphenol	330	-	2,500	24	4.01E+06	0	0	No
2-Nitroaniline	1,700	-	13,000	30	192,137	0	0	No
2-Nitrophenol	330	-	2,500	24		0	0	No
3,3'-Dichlorobenzidine	660	-	5,000	29	6,667	0	0	No
3-Nitroaniline	1,700	-	13,000	29		0	0	No
4,6-Dinitro-2-methylphenol	1,700	-	13,000	21	8,014	1	4.76	Yes
4-Bromophenyl-phenylether	330	-	2,500	30		0	0	No
4-Chloro-3-methylphenol	330	-	5,000	24		0	0	No
4-Chloroaniline	330	-	5,000	29	320,574	0	0	No
4-Chlorophenyl-phenyl ether	330	-	2,500	30		0	0	No
4-Nitroaniline	1,700	-	13,000	29	207,917	0	0	No
Acenaphthene	330	-	1,600	30	4.44E+06	0	0	No
Acenaphthylene	330	-	1,600	30		0	0	No
Anthracene	330	-	1,600	30	2.22E+07	0	0	No
Benzo(a)anthracene	330	-	2,500	29	3,793	0	0	Yes

Table A1.1
Evaluation of Reported Results for Nondetected Analytes and Analytes with a Detection Frequency Less than 5 Percent in Surface Soil/Surface Sediment in the RCEU

Analyte	Range of Nondetected Reported Results			Total Number of Nondetected Results	Lowest PRG	Number of Nondetected Results > PRG	Percent Nondetected Results > PRG	Analyte Detected?
Benzo(a)pyrene	330	-	2,500	28	379	16	57.1	Yes
Benzo(b)fluoranthene	330	-	2,500	29	3,793	0	0	No
Benzo(g,h,i)perylene	330	-	2,500	23		0	0	No
Benzo(k)fluoranthene	330	-	2,500	29	37,927	0	0	No
Benzyl Alcohol	330	-	5,000	24	2.40E+07	0	0	No
bis(2-Chloroethoxy) methane	330	-	2,500	30		0	0	No
bis(2-Chloroethyl) ether	330	-	2,500	30	3,767	0	0	No
bis(2-Chloroisopropyl) ether	330	-	2,500	30	59,301	0	0	No
Butylbenzylphthalate	330	-	2,500	30	1.60E+07	0	0	No
Chrysene	330	-	2,500	29	379,269	0	0	Yes
Di-n-octylphthalate	330	-	2,500	29	3.21E+06	0	0	No
Dibenz(a,h)anthracene	330	-	2,500	29	379	17	58.6	No
Dibenzofuran	330	-	2,500	30	222,174	0	0	No
Diethylphthalate	330	-	2,500	30	6.41E+07	0	0	No
Dimethylphthalate	330	-	2,500	30	8.01E+08	0	0	No
Fluoranthene	330	-	2,500	29	2.96E+06	0	0	Yes
Fluorene	330	-	2,500	30	3.21E+06	0	0	No
Hexachlorobenzene	330	-	2,500	30	1,870	2	6.67	No
Hexachlorobutadiene	330	-	2,500	30	22,217	0	0	No
Indeno(1,2,3-cd)pyrene	330	-	2,500	28	3,793	0	0	No
Isophorone	330	-	2,500	30	3.16E+06	0	0	No
N-Nitroso-di-n-propylamine	330	-	2,500	30	429	13	43.3	No
N-nitrosodiphenylamine	330	-	2,500	30	612,250	0	0	No
Naphthalene	330	-	2,500	30	1.40E+06	0	0	No
Nitrobenzene	330	-	2,500	24	43,246	0	0	No
Pentachlorophenol	1,700	-	13,000	23	17,633	0	0	Yes
Phenanthrene	330	-	2,500	29		0	0	Yes
Phenol	340	-	3,350	23	2.40E+07	0	0	Yes
Pyrene	330	-	2,500	29	2.22E+06	0	0	Yes
1,1,2,2-Tetrachloroethane	5	-	14	6	10,483	0	0	No
1,1,2-Trichloroethane	5	-	14	7	28,022	0	0	No
1,1-Dichloroethane	5	-	14	8	2.72E+06	0	0	No
1,1-Dichloroethene	5	-	14	8	17,366	0	0	No
1,2-Dichlorobenzene	330	-	1,600	27	2.89E+06	0	0	No
1,2-Dichloroethane	5	-	14	8	13,270	0	0	No
1,2-Dichloroethene	5	-	14	8	999,783	0	0	No
1,2-Dichloropropane	5	-	14	7	38,427	0	0	No
1,3-Dichlorobenzene	330	-	2,500	30	3.33E+06	0	0	No
1,4-Dichlorobenzene	330	-	1,600	27	91,315	0	0	No
2-Hexanone	10	-	28	6		0	0	No
4-Methyl-2-pentanone	10	-	28	6	8.32E+07	0	0	No
Benzene	5	-	14	7	23,563	0	0	No
Bromodichloromethane	5	-	14	7	67,070	0	0	No
Bromoform	5	-	14	7	419,858	0	0	No
Bromomethane	10	-	28	8	20,959	0	0	No
Carbon Disulfide	5	-	14	8	1.64E+06	0	0	No
Carbon Tetrachloride	5	-	14	7	8,446	0	0	No
Chlorobenzene	5	-	14	6	666,523	0	0	No
Chloroethane	10	-	28	8	1.43E+06	0	0	No
Chloroform	5	-	14	8	7,850	0	0	No
Chloromethane	10	-	28	8	115,077	0	0	No
cis-1,3-Dichloropropene	5	-	14	7	19,432	0	0	No
Dibromochloromethane	5	-	14	7	49,504	0	0	No
Ethylbenzene	5	-	14	6	5.39E+06	0	0	No
Hexachloroethane	330	-	2,500	30	111,087	0	0	No
Pyridine	1,600	-	2,500	3		0	0	No
Styrene	5	-	14	6	1.38E+07	0	0	No
trans-1,3-Dichloropropene	5	-	14	7	20,820	0	0	No
Vinyl acetate	10	-	28	7	2.65E+06	0	0	No
Vinyl Chloride	10	-	28	8	2,169	0	0	No

Table A1.2
Evaluation of Reported Results for Nondetected Analytes and Analytes with a Detection Frequency Less than 5 Percent in Suburface Soil/Subsurface Sediment in the RCEU

Analyte	Range of Nondetected Reported Results			Total Number of Nondetected Results	Lowest PRG	Number of Nondetected Results > PRG	Percent Nondetected Results > PRG	Analyte Detected?
Inorganic (mg/kg)								
Nitrate / Nitrite	22.8	-	22.8	1	2.04E+06	0	0	No
Uranium	1.20	-	1.30	2	3,833	0	0	No
Organic (ug/kg)								
1,1,1-Trichloroethane	5	-	6	12	1.06E+08	0	0	No
1,1,2,2-Tetrachloroethane	5	-	6	12	120,551	0	0	No
1,1,2-Trichloroethane	5	-	6	12	322,253	0	0	No
1,1-Dichloroethane	5	-	6	12	3.12E+07	0	0	No
1,1-Dichloroethene	5	-	6	12	199,706	0	0	No
1,2,4-Trichlorobenzene	890	-	970	2	1.74E+06	0	0	No
1,2-Dichloroethane	5	-	6	12	152,603	0	0	No
1,2-Dichloroethene	5	-	6	12	1.15E+07	0	0	No
1,2-Dichloropropane	5	-	6	12	441,907	0	0	No
1,3-Dichlorobenzene	890	-	970	2	3.83E+07	0	0	No
2,4,5-Trichlorophenol	890	-	970	2	9.22E+07	0	0	No
2,4,6-Trichlorophenol	890	-	970	2	3.13E+06	0	0	No
2,4-Dichlorophenol	890	-	970	2	2.76E+06	0	0	No
2,4-Dimethylphenol	890	-	970	2	1.84E+07	0	0	No
2,4-Dinitrophenol	4,500	-	4,900	2	1.84E+06	0	0	No
2,4-Dinitrotoluene	890	-	970	2	1.84E+06	0	0	No
2,6-Dinitrotoluene	890	-	970	2	921,651	0	0	No
2-Chloronaphthalene	890	-	970	2	7.37E+07	0	0	No
2-Chlorophenol	890	-	970	2	6.39E+06	0	0	No
2-Hexanone	11	-	13	12		0	0	No
2-Methylnaphthalene	890	-	970	2	3.69E+06	0	0	No
2-Methylphenol	890	-	970	2	4.61E+07	0	0	No
2-Nitroaniline	4,500	-	4,900	2	2.21E+06	0	0	No
2-Nitrophenol	890	-	970	2		0	0	No
3,3'-Dichlorobenzidine	1,800	-	1,900	2	76,667	0	0	No
3-Nitroaniline	4,500	-	4,900	2		0	0	No
4,6-Dinitro-2-methylphenol	4,500	-	4,900	2	92,165	0	0	No
4-Bromophenyl-phenylether	890	-	970	2		0	0	No
4-Chloro-3-methylphenol	1,800	-	1,900	2		0	0	No
4-Chloroaniline	1,800	-	1,900	2	3.69E+06	0	0	No
4-Chlorophenyl-phenyl ether	890	-	970	2		0	0	No
4-Methyl-2-pentanone	11	-	13	12	9.57E+08	0	0	No
4-Methylphenol	890	-	970	2	4.61E+06	0	0	No
4-Nitroaniline	4,500	-	4,900	2	2.39E+06	0	0	No
4-Nitrophenol	4,500	-	4,900	2	7.37E+06	0	0	No
Acenaphthene	450	-	490	2	5.10E+07	0	0	No
Acenaphthylene	450	-	490	2		0	0	No
Anthracene	450	-	490	2	2.55E+08	0	0	No
Benzene	5	-	6	12	270,977	0	0	No
Benzo(a)anthracene	890	-	970	2	43,616	0	0	No
Benzo(a)pyrene	890	-	970	2	4,357	0	0	No
Benzo(b)fluoranthene	890	-	970	2	43,616	0	0	No
Benzo(g,h,i)perylene	890	-	970	2		0	0	No
Benzo(k)fluoranthene	890	-	970	2	436,159	0	0	No
Benzoic Acid	4,500	-	4,900	2	3.69E+09	0	0	No
Benzyl Alcohol	1,800	-	1,900	2	2.76E+08	0	0	No
bis(2-Chloroethoxy) methane	890	-	970	2		0	0	No
bis(2-Chloroethyl) ether	890	-	970	2	43,315	0	0	No
bis(2-Chloroisopropyl) ether	890	-	970	2	681,967	0	0	No
bis(2-ethylhexyl)phthalate	890	-	970	2	2.46E+06	0	0	No
Bromodichloromethane	5	-	6	12	771,304	0	0	No
Bromoform	5	-	6	12	4.83E+06	0	0	No
Bromomethane	11	-	13	12	241,033	0	0	No

Table A1.2
Evaluation of Reported Results for Nondetected Analytes and Analytes with a Detection Frequency Less than 5 Percent in Suburface Soil/Subsurface Sediment in the RCEU

Analyte	Range of Nondetected Reported Results			Total Number of Nondetected Results	Lowest PRG	Number of Nondetected Results > PRG	Percent Nondetected Results > PRG	Analyte Detected?
Butylbenzylphthalate	890	-	970	2	1.84E+08	0	0	No
Carbon Disulfide	5	-	6	12	1.88E+07	0	0	No
Carbon Tetrachloride	5	-	6	12	97,124	0	0	No
Chlorobenzene	5	-	6	12	7.67E+06	0	0	No
Chloroethane	11	-	13	12	1.65E+07	0	0	No
Chloroform	5	-	6	12	90,270	0	0	No
Chloromethane	11	-	13	12	1.32E+06	0	0	No
Chrysene	890	-	970	2	4.36E+06	0	0	No
cis-1,3-Dichloropropene	5	-	6	12	223,462	0	0	No
Dibenz(a,h)anthracene	890	-	970	2	4,362	0	0	No
Dibenzofuran	890	-	970	2	2.56E+06	0	0	No
Dibromochloromethane	5	-	6	12	569,296	0	0	No
Diethylphthalate	890	-	970	2	7.37E+08	0	0	No
Dimethylphthalate	890	-	970	2	9.22E+09	0	0	No
Di-n-butylphthalate	890	-	970	2	9.22E+07	0	0	No
Di-n-octylphthalate	890	-	970	2	3.69E+07	0	0	No
Ethylbenzene	5	-	6	12	6.19E+07	0	0	No
Fluoranthene	890	-	970	2	3.40E+07	0	0	No
Fluorene	890	-	970	2	3.69E+07	0	0	No
Hexachlorobenzene	890	-	970	2	21,508	0	0	No
Hexachlorobutadiene	890	-	970	2	255,500	0	0	No
Hexachlorocyclopentadiene	890	-	970	2	4.38E+06	0	0	No
Hexachloroethane	890	-	970	2	1.28E+06	0	0	No
Indeno(1,2,3-cd)pyrene	890	-	970	2	43,616	0	0	No
Isophorone	890	-	970	2	3.63E+07	0	0	No
Naphthalene	890	-	970	2	1.61E+07	0	0	No
Nitrobenzene	890	-	970	2	497,333	0	0	No
N-Nitroso-di-n-propylamine	890	-	970	2	4,929	0	0	No
N-nitrosodiphenylamine	890	-	970	2	7.04E+06	0	0	No
Pentachlorophenol	4,500	-	4,900	2	202,777	0	0	No
Phenanthrene	890	-	970	2		0	0	No
Phenol	890	-	970	2	2.76E+08	0	0	No
Pyrene	890	-	970	2	2.55E+07	0	0	No
Pyridine	890	-	970	2		0	0	No
Styrene	5	-	6	12	1.59E+08	0	0	No
Tetrachloroethene	5	-	6	12	77,111	0	0	No
trans-1,3-Dichloropropene	5	-	6	12	239,434	0	0	No
Trichloroethene	5	-	6	12	20,354	0	0	No
Vinyl acetate	11	-	13	12	3.04E+07	0	0	No
Vinyl Chloride	11	-	13	12	24,948	0	0	No
Xylene	5	-	6	12	1.22E+07	0	0	No

Table A1.3
Evaluation of Reported Results for Nondetected Analytes and Analytes with a Detection Frequency Less than 5 Percent in Surface Soil in the RCEU

Analyte	Range of Nondetected Reported Results			Total Number of Nondetected Results	Lowest ESL	Number of Nondetected Results > ESL	Percent Nondetected Results > ESL	Analyte Detected?
Inorganic (mg/kg)								
Antimony	0.280	-	14.6	36	0.905	19	52.8	No
Chromium (VI)	0.860	-	0.960	2	1.34	0	0	No
Uranium	1.40	-	1.80	17	5	0	0	No
Organic (ug/kg)								
1,2,4-Trichlorobenzene	340	-	480	17	777	0	0	No
1,2-Dichlorobenzene	340	-	480	17		0	0	No
1,3-Dichlorobenzene	340	-	480	17		0	0	No
1,4-Dichlorobenzene	340	-	480	17	20,000	0	0	No
2,4,5-Trichlorophenol	1,700	-	2,300	11	4,000	0	0	No
2,4,6-Trichlorophenol	350	-	480	11	161	11	100	No
2,4-Dichlorophenol	350	-	480	11	2,744	0	0	No
2,4-Dimethylphenol	350	-	480	11		0	0	No
2,4-Dinitrophenol	1,700	-	2,300	11	20,000	0	0	No
2,4-Dinitrotoluene	340	-	480	17	32.1	17	100	No
2,6-Dinitrotoluene	340	-	480	17	6,186	0	0	No
2-Chloronaphthalene	340	-	480	17		0	0	No
2-Chlorophenol	350	-	480	11	281	11	100	No
2-Methylnaphthalene	340	-	480	15	2,769	0	0	No
2-Methylphenol	350	-	480	11	123,842	0	0	No
2-Nitroaniline	1,700	-	2,400	17	5,659	0	0	No
2-Nitrophenol	350	-	480	11		0	0	No
3,3'-Dichlorobenzidine	680	-	960	17		0	0	No
3-Nitroaniline	1,700	-	2,400	17		0	0	No
4,4'-DDD	16	-	23	17	13,726	0	0	No
4,4'-DDE	16	-	23	17	7.95	17	100	No
4,4'-DDT	16	-	23	17	1.20	17	100	No
4,6-Dinitro-2-methylphenol	1,700	-	2,300	11	560	11	100	No
4-Bromophenyl-phenylether	340	-	480	17		0	0	No
4-Chloro-3-methylphenol	350	-	480	11		0	0	No
4-Chloroaniline	340	-	480	17	716	0	0	No
4-Chlorophenyl-phenyl ether	340	-	480	17		0	0	No
4-Methylphenol	350	-	480	11		0	0	No
4-Nitroaniline	1,700	-	2,400	17	41,050	0	0	No
4-Nitrophenol	1,700	-	2,300	11	7,000	0	0	No
Acenaphthene	340	-	480	17	20,000	0	0	No
Acenaphthylene	340	-	480	17		0	0	No
Aldrin	8.20	-	12	17	47.0	0	0	No
alpha-BHC	8.20	-	12	17	18,662	0	0	No
alpha-Chlordane	82	-	120	17	289	0	0	No
Anthracene	340	-	480	17		0	0	No
Benzo(a)anthracene	340	-	480	17		0	0	No
Benzo(a)pyrene	340	-	480	17	631	0	0	No
Benzo(b)fluoranthene	340	-	480	17		0	0	No
Benzo(g,h,i)perylene	350	-	480	13		0	0	No
Benzo(k)fluoranthene	340	-	480	17		0	0	No
Benzyl Alcohol	350	-	480	11	4,403	0	0	No
beta-BHC	8.20	-	12	17	207	0	0	No
beta-Chlordane	86	-	120	11	289	0	0	No
bis(2-Chloroethoxy) methane	340	-	480	17		0	0	No
bis(2-Chloroethyl) ether	340	-	480	17		0	0	No
bis(2-Chloroisopropyl) ether	340	-	480	17		0	0	No
Butylbenzylphthalate	340	-	480	17	24,155	0	0	No
Chrysene	340	-	480	17		0	0	No
delta-BHC	8.20	-	12	17	25.9	0	0	No
Dibenz(a,h)anthracene	340	-	480	17		0	0	No
Dibenzofuran	340	-	480	17	21,200	0	0	No
Dieldrin	16	-	23	17	7.40	17	100	No

Table A1.3
Evaluation of Reported Results for Nondetected Analytes and Analytes with a Detection Frequency Less than 5 Percent in Surface Soil in the RCEU

Analyte	Range of Nondetected Reported Results			Total Number of Nondetected Results	Lowest ESL	Number of Nondetected Results > ESL	Percent Nondetected Results > ESL	Analyte Detected?
Diethylphthalate	340	-	480	17	100,000	0	0	No
Dimethylphthalate	340	-	480	17	200,000	0	0	No
Di-n-octylphthalate	340	-	480	17	731,367	0	0	No
Endosulfan I	8.20	-	12	17	80.1	0	0	No
Endosulfan II	16	-	23	17	80.1	0	0	No
Endosulfan sulfate	16	-	23	17	80.1	0	0	No
Endrin	16	-	23	17	1.40	17	100	No
Endrin ketone	16	-	23	17	1.40	17	100	No
Fluoranthene	340	-	480	17		0	0	No
Fluorene	340	-	480	17	30,000	0	0	No
gamma-BHC (Lindane)	8.20	-	12	17	25.9	0	0	No
gamma-Chlordane	82	-	110	6	289	0	0	No
Heptachlor	8.20	-	12	17	63.3	0	0	No
Heptachlor epoxide	8.20	-	12	17	64.0	0	0	No
Hexachlorobenzene	340	-	480	17	7.73	17	100	No
Hexachlorobutadiene	340	-	480	17	431	2	11.8	No
Hexachlorocyclopentadiene	340	-	480	17	5,518	0	0	No
Hexachloroethane	340	-	480	17	366	10	58.8	No
Indeno(1,2,3-cd)pyrene	340	-	480	17		0	0	No
Isophorone	340	-	480	17		0	0	No
Methoxychlor	82	-	120	17	1,226	0	0	No
Naphthalene	340	-	480	17	27,048	0	0	No
Nitrobenzene	350	-	480	11	40,000	0	0	No
N-Nitroso-di-n-propylamine	340	-	480	17		0	0	No
N-nitrosodiphenylamine	340	-	480	17	20,000	0	0	No
PCB-1016	82	-	120	17	172	0	0	No
PCB-1221	82	-	120	17	172	0	0	No
PCB-1232	82	-	120	17	172	0	0	No
PCB-1242	82	-	120	17	172	0	0	No
PCB-1248	82	-	120	17	172	0	0	No
PCB-1254	160	-	230	17	172	10	58.8	No
PCB-1260	160	-	230	17	172	10	58.8	No
Pentachlorophenol	1,700	-	2,300	11	122	11	100	No
Phenanthrene	340	-	480	17		0	0	No
Phenol	350	-	3,350	11	23,090	0	0	No
Pyrene	340	-	480	17		0	0	No
Toxaphene	160	-	230	17	3,756	0	0	No

Table A1.4
Sitewide Summary Statistics for Analytes in Surface Soil with an Ecological Screening Level

Analyte	Total Number of Results	Detection Frequency (%)	Number of Detects	Minimum Detected Conc.	Maximum Detected Conc.	Minimum Nondetected Result	Maximum Nondetected Result	Minimum ESL
Inorganics (mg/kg)								
Aluminum	2,622	99.9	2,620	1,450	61,000	10.9	70	50
Ammonia	32	78.1	25	0.335	4.81	0.338	6.12	586
Antimony	2,482	20.0	497	0.270	348	0.0360	19.3	0.905
Arsenic	2,613	99.0	2,586	0.290	56.2	0.400	6.20	2.57
Barium	2,624	99.9	2,622	0.640	1,500	2.20	95	159
Beryllium	2,623	81.7	2,142	0.0710	26.8	0.0620	1.90	6.82
Boron	1,303	85.7	1,117	0.350	28	0.340	7	0.500
Cadmium	2,603	36.1	940	0.0600	270	0.0300	2.80	0.705
Chromium	2,624	99.2	2,604	1.20	210	2.20	19.8	0.400
Chromium VI	17	5.88	1.000	0.850	0.850	0.530	1.20	1.34
Cobalt	2,622	98.1	2,573	1.10	137	2.10	10.4	13
Copper	2,621	98.2	2,575	1.70	1,860	2.20	22.8	8.25
Cyanide	245	2.45	6.00	0.170	0.290	0.180	4.70	607
Fluoride	9	100	9	1.87	3.61	NA	NA	1.33
Lead	2,618	100	2,618	0.870	814	NA	NA	12.1
Lithium	2,433	94.5	2,300	0.990	50	1.60	20.6	2
Manganese	2,617	99.9	2,615	15	2,220	2.20	130	486
Mercury	2,541	48.8	1,239	0.00140	48	0.00120	0.190	1.00E-04
Molybdenum	2,421	47.0	1,138	0.140	19.1	0.0990	7.50	1.84
Nickel	2,620	97.5	2,554	1.90	280	1.60	19.1	0.431
Nitrate / Nitrite	450	83.3	375	0.216	765	0.200	5.60	4,478
Selenium	2,590	13.3	345	0.220	2.20	0.0540	4.50	0.754
Silver	2,589	28.4	735	0.0580	364	0.0490	7	2
Strontium	2,423	100.0	2,422	2.40	413	1.10	1.10	940
Thallium	2,597	14.1	366	0.100	5.80	0.0160	2.50	1
Tin	2,423	10.0	243	0.289	161	0.0780	58.5	2.90
Uranium	1,296	8.80	114	0.430	370	0.130	16.8	5
Vanadium	2,622	100.0	2,621	4.40	5,300	2.20	2.20	2
Zinc	2,622	99.8	2,617	4.20	11,900	2.20	99.8	0.646
Organics (ug/kg)								
1,1,1-Trichloroethane	633	1.58	10.00	1.10	47.7	0.587	680	551,453
1,1,2,2-Tetrachloroethane	632	0.158	1.000	1.39	1.39	0.527	680	60,701
1,1-Dichloroethane	633	0	0	NA	NA	0.512	680	3,121
1,1-Dichloroethene	633	0.158	1.000	7.90	7.90	0.610	680	16,909
1,2,3-Trichloropropane	517	0.193	1.000	1.47	1.47	0.525	129	13,883

Table A1.4
Sitewide Summary Statistics for Analytes in Surface Soil with an Ecological Screening Level

Analyte	Total Number of Results	Detection Frequency (%)	Number of Detects	Minimum Detected Conc.	Maximum Detected Conc.	Minimum Nondetected Result	Maximum Nondetected Result	Minimum ESL
1,2,4-Trichlorobenzene	1,549	0.323	5.00	0.870	150	0.621	7,000	777
1,2-Dichloroethane	629	0	0	NA	NA	0.522	680	2,764
1,2-Dichloroethene	101	0.990	1.000	16	16	5	680	25,617
1,2-Dichloropropane	633	0.316	2.00	18	140	0.413	680	49,910
1,3,5-Trimethylbenzene	515	6.60	34.0	0.610	490	0.535	65.2	7,598
1,4-Dichlorobenzene	1,329	0.677	9.00	0.450	110	0.649	6,900	20,000
2,4,5-T	9	11.1	1.000	1.80	1.80	21	100	162
2,4,5-Trichlorophenol	1,180	0.0847	1.000	1,100	1,100	330	34,000	4,000
2,4,6-Trichlorophenol	1,180	0.0847	1.000	950	950	330	7,000	161
2,4,6-Trinitrotoluene	8	12.5	1	56	56	0.220	250	283
2,4-DB	9	0	0	NA	NA	83	100	426
2,4-Dichlorophenol	1,180	0	0	NA	NA	330	7,000	2,744
2,4-Dinitrophenol	1,173	0	0	NA	NA	850	35,000	20,000
2,4-Dinitrotoluene	1,232	0	0	NA	NA	250	7,000	32.1
2,6-Dinitrotoluene	1,232	0	0	NA	NA	250	7,000	6,186
2378-TCDD	22	68.2	15.0	2.59E-05	0.00680	2.20E-04	0.00106	0.00425
2-Butanone	631	2.54	16.0	3	155	2.72	1,400	1.07E+06
2-Chlorophenol	1,180	0	0	NA	NA	330	7,000	281
2-Methylnaphthalene	1,223	6.95	85.0	34	12,000	330	7,000	2,769
2-Methylphenol	1,180	0	0	NA	NA	330	7,000	123,842
2-Nitroaniline	1,224	0	0	NA	NA	370	35,000	5,659
4,4'-DDD	468	0.427	2.00	3.50	10	1.80	190	13,726
4,4'-DDE	468	1.50	7.00	0.600	7.20	1.80	190	7.95
4,4'-DDT	468	0.855	4.00	9.10	26	1.80	190	1.20
4,6-Dinitro-2-methylphenol	1,176	0.0850	1.000	390	390	850	35,000	560
4-Chloroaniline	1,217	0	0	NA	NA	330	14,000	716
4-Methyl-2-pentanone	630	2.38	15.0	4	73	1.94	2,960	14,630
4-Nitroaniline	1,218	0.328	4.00	62	820	850	55,000	41,050
4-Nitrophenol	1,169	0.171	2.00	53	320	850	35,000	7,000
4-Nitrotoluene	5	0	0	NA	NA	250	250	61,422
Acenaphthene	1,239	22.3	276	21	44,000	330	6,900	20,000
Acetone	632	19.3	122	1.70	1,280	2.65	2,960	6,182
Aldrin	468	0.855	4.00	0.590	17	1.80	95	47.0
alpha-BHC	468	0.214	1.000	7.90	7.90	1.80	95	18,662
alpha-Chlordane	433	0	0	NA	NA	1.80	950	289
Benzene	633	0.948	6.00	1	11	0.502	680	500

Table A1.4
Sitewide Summary Statistics for Analytes in Surface Soil with an Ecological Screening Level

Analyte	Total Number of Results	Detection Frequency (%)	Number of Detects	Minimum Detected Conc.	Maximum Detected Conc.	Minimum Nondetected Result	Maximum Nondetected Result	Minimum ESL
Benzo(a)pyrene	1,235	41.2	509	36	43,000	19	7,000	631
Benzyl Alcohol	1,114	0.718	8.00	140	2,800	330	14,000	4,403
beta-BHC	467	0.428	2.00	11	11	1.80	95	207
beta-Chlordane	411	0.243	1.000	2.60	2.60	1.80	950	289
bis(2-ethylhexyl)phthalate	1,227	29.7	365	29	75,000	330	7,000	137
Bromodichloromethane	633	0	0	NA	NA	0.502	680	5,750
Bromoform	633	0	0	NA	NA	0.525	680	2,855
Butylbenzylphthalate	1,226	9.79	120	35	7,100	330	7,000	24,155
Carbon Disulfide	633	0.158	1.000	4	4	0.535	680	5,676
Carbon Tetrachloride	633	3.32	21.0	0.340	103	0.575	680	8,906
Chlordane	34	0	0	NA	NA	18	220	289
Chlorobenzene	633	0.316	2.00	2	2.03	0.484	680	4,750
Chloroform	633	1.11	7.00	1.30	7	0.543	680	8,655
cis-1,2-Dichloroethene	517	1.74	9.00	1.10	15	0.502	590	1,814
cis-1,3-Dichloropropene	633	0	0	NA	NA	0.502	680	2,800
delta-BHC	468	0.214	1.000	23	23	1.80	95	25.9
Dibenzofuran	1,227	10.9	134	36	20,000	330	7,000	21,200
Dibromochloromethane	633	0	0	NA	NA	0.502	680	5,730
Dicamba	9	55.6	5.00	2.30	150	42	100	1,690
Dichlorodifluoromethane	499	0	0	NA	NA	1.73	398	855
Dieldrin	468	2.35	11.0	1.80	92	1.80	190	7.40
Diethylphthalate	1,224	0.654	8.00	33	420	330	7,000	100,000
Dimethoate	7	0	0	NA	NA	18	180	13.7
Dimethylphthalate	1,227	1.47	18.0	69	460	330	7,000	200,000
Di-n-butylphthalate	1,227	7.99	98.0	35	10,000	330	7,000	15.9
Di-n-octylphthalate	1,225	3.92	48.0	38	11,000	330	7,000	731,367
Endosulfan I	468	0.427	2.00	3.90	7.40	1.80	95	80.1
Endosulfan II	461	0.651	3.00	0.700	9.90	1.80	170	80.1
Endosulfan sulfate	468	0.641	3.00	5.50	24	1.80	190	80.1
Endrin	468	1.28	6.00	2.40	17	1.80	200	1.40
Endrin aldehyde	66	3.03	2.00	8.70	9.20	1.80	38	1.40
Endrin ketone	437	0.229	1.000	36	36	1.80	190	1.40
Fluorene	1,244	18.8	234	27	39,000	140	7,000	30,000
gamma-BHC (Lindane)	468	0.214	1.000	8.30	8.30	1.80	95	25.9
gamma-Chlordane	23	0	0	NA	NA	2	260	289
Heptachlor	468	0	0	NA	NA	1.80	95	63.3

Table A1.4
Sitewide Summary Statistics for Analytes in Surface Soil with an Ecological Screening Level

Analyte	Total Number of Results	Detection Frequency (%)	Number of Detects	Minimum Detected Conc.	Maximum Detected Conc.	Minimum Nondetected Result	Maximum Nondetected Result	Minimum ESL
Heptachlor epoxide	467	0.642	3.00	7.20	23	1.80	95	64.0
Hexachlorobenzene	1,224	0.327	4.00	110	380	330	7,000	7.73
Hexachlorobutadiene	1,550	0.0645	1.000	2.20	2.20	0.508	7,000	431
Hexachlorocyclopentadiene	1,208	0	0	NA	NA	330	7,000	5,518
Hexachloroethane	1,227	0	0	NA	NA	330	7,000	366
HMX	5	20	1	230	230	250	250	16,012
Methoxychlor	468	1.71	8.00	0.280	450	3.50	950	1,226
Methylene Chloride	631	12.0	76.0	0.790	45	0.502	2,200	3,399
Naphthalene	1,567	14.1	221	0.850	41,000	0.751	7,000	27,048
Nitrobenzene	1,218	0	0	NA	NA	250	7,000	40,000
N-nitrosodiphenylamine	1,227	0	0	NA	NA	330	7,000	20,000
PCB-1016	795	0.755	6.00	13	95	33	4,500	172
PCB-1221	845	0	0	NA	NA	33	4,500	172
PCB-1232	845	0	0	NA	NA	33	4,500	172
PCB-1242	845	0.237	2.00	23	350	33	4,500	172
PCB-1248	845	0.710	6.00	17	840	33	4,500	172
PCB-1254	842	17.9	151	6.80	8,900	33	9,000	172
PCB-1260	838	17.2	144	6.20	7,800	33	4,300	172
Pentachlorophenol	1,180	1.02	12.0	39	39,000	850	35,000	122
Phenol	1,180	0.424	5.00	33	130	330	7,000	23,090
Styrene	633	0.158	1.000	7.80	7.80	0.550	680	16,408
Tetrachloroethene	633	8.53	54.0	0.380	29,000	0.641	680	763
Toluene	633	9.00	57.0	0.0990	990	0.528	60.8	14,416
Toxaphene	468	0	0	NA	NA	86	2,200	3,756
trans-1,2-Dichloroethene	532	0	0	NA	NA	0.738	93.3	25,617
trans-1,3-Dichloropropene	633	0	0	NA	NA	0.502	680	2,800
Trichloroethene	633	4.11	26.0	0.170	200	0.500	680	389
Vinyl acetate	78	0	0	NA	NA	10	1,400	13,986
Vinyl Chloride	633	0	0	NA	NA	0.748	1,400	97.7
Xylene	633	10.4	66.0	0.600	933	0.502	680	1,140

NA = Not applicable.

Table A1.5
Summary of Professional Judgment and Ecological Risk Potential

ANALYTE	SUMMARY OF PROFESSIONAL JUDGMENT								ECOLOGICAL RISK POTENTIAL						
	Listed as Waste Constituent for RCEU Historical IHSSs ?[1]	Historical RFETS Inventory [2] (1974/1988) (kg)	Maximum Conc. in Soil Sitewide (ug/kg)	Detection Frequency in Sitewide Soil (%)	Maximum Conc. in RCEU Soil (ug/kg)	Detection Frequency in RCEU Soil (%)	Potential to be an ECOPC?	Uncertainty Category[3]	Lowest ESL (ug/kg)	Most Sensitive Receptor[4]	LOAEL/ NOAEL [5]	LOAEL-Based Soil Conc. (ug/kg)	Maximum Reported Result for Non-detects in RCEU (ug/kg)	Maximum Reported Result/ LOAEL-Based Soil Conc.[6]	Potential for Adverse Effects if Detected at Reported Results Levels?
Antimony	No	2.627/8.547	348	20.0	NA	0	No	2	0.91	Deer Mouse Insectivore	9.8	8.9	14.6	2	Yes
2,4,6-Trichlorophenol	No	0/.01	950	0.1	NA	0	No	2	161	Deer Mouse Insectivore	100	16100	480	0.03	No
2,4-Dinitrotoluene	No	0/0	N/A	0	NA	0	No	2	32.1	Deer Mouse Insectivore	10	321	480	2	Yes
2-Chlorophenol	No	0.12/0.02	N/A	0	NA	0	No	1	281	Deer Mouse Insectivore	100	28100	480	0.02	No
4,4'-DDE	No	0/0.001	7.2	1.5	NA	0	No	2	7.95	Mourning Dove Insectivore	10	79.5	23	0.3	No
4,4'-DDT	No	0/0.001	26	0.9	NA	0	No	2	1.20	Mourning Dove Insectivore	167	200.4	23	0.1	No
4,6-Dinitro-2-methylphenol	No	0/0	390	0.1	NA	0	No	2	560	Deer Mouse Insectivore	20	11200	2,300	0.2	No
Dieldrin	No	0/0.003	92	2.4	NA	0	No	2	7.40	Deer Mouse Insectivore	2	14.8	23	2	Yes
Endrin	No	0/0.004	17	1.3	NA	0	No	2	1.40	Mourning Dove Insectivore	10	14	23	2	Yes
Endrin ketone	No	0/0	36	0.2	NA	0	No	2	1.40	Mourning Dove Insectivore	10	14	23	2	Yes
Hexachlorobenzene	No	1.000/1.005	380	0.3	NA	0	No	2	7.73	Mourning Dove Insectivore	40	309	480	2	Yes
Hexachloroethane	No	0.02/0.02	N/A	0	NA	0	No	1	366	Deer Mouse Insectivore	20	7320	480	0.1	No
PCB-1254	No	0/0.017	8900	0/0.017	NA	0	No	2	172	Mourning Dove Insectivore	14.1	2425	230	0.1	No
PCB-1260	No	0/0.018	7800	0/0.018	NA	0	No	2	172	Mourning Dove Insectivore	14.1	2425	230	0.1	No
Pentachlorophenol	No	0.02/0.02	39000	0.02/0.02	NA	0	No	2	122	Deer Mouse Insectivore	10	1220	2,300	2	Yes

[1] Includes listing of the class of compound, e.g., herbicides, pesticides, chlorinated solvents, polynuclear aromatic hydrocarbons, etc. Ref. DOE, 2005a.
[2] CDH, 1991.
[3] See text for explanation.
[4] Basis for the lowest ESL.
[5] LOAELs and NOAELs from Appendix B, Table B-2, "TRVs for Terrestrial Vertebrate Receptors", Ref. DOE 2005b.
[6] Ratios are rounded to one significant figure.
CDH – Colorado Department of Health
DDE – dichlorodiphenyldichloroethylene
DDT – dichlorodiphenyltrichloroethane
DOE – Department of Energy
ECOPC – Ecological Contaminant of Potential Concern
ESL – Ecological Screening Level
IHSS – Individual Hazardous Substance Site
LOAEL – Lowest Bounded Lowest Observed Adverse Effect Level
NOAEL - Final No Observed Adverse Effect Level
RFETS – Rocky Flats Environmental Technology Site
RCEU – Rock Creek Drainage Exposure Unit
NA – Not applicable
NVA – No Value Available
I- Inconclusive

Table A1.6
Evaluation of Reported Results for Nondetected Analytes and Analytes with a Detection Frequency Less than 5 Percent in Subsurface Soil in the RCEU

Analyte	Range of Nondetected Reported Results			Total Number of Nondetected Results	Lowest ESL	Number of Nondetected Results > ESL	Percent Nondetected Results > ESL	Analyte Detected?
Inorganic (mg/kg)								
Molybdenum	0.990	-	5.10	4	27.1	0	0	No
Organic (ug/kg)								
1,1,1-Trichloroethane	5	-	6	12	4.85E+07	0	0	No
1,1,2,2-Tetrachloroethane	5	-	6	12	4.70E+06	0	0	No
1,1,2-Trichloroethane	5	-	6	12		0	0	No
1,1-Dichloroethane	5	-	6	12	215,360	0	0	No
1,1-Dichloroethene	5	-	6	12	1.28E+06	0	0	No
1,2-Dichloroethane	5	-	6	12	2.00E+06	0	0	No
1,2-Dichloroethene	5	-	6	12	1.87E+06	0	0	No
1,2-Dichloropropane	5	-	6	12	3.92E+06	0	0	No
2-Butanone	11	-	13	12	4.94E+07	0	0	No
2-Hexanone	11	-	13	12		0	0	No
4-Methyl-2-pentanone	11	-	13	12	859,131	0	0	No
Benzene	5	-	6	12	1.10E+06	0	0	No
Bromodichloromethane	5	-	6	12	381,135	0	0	No
Bromoform	5	-	6	12	198,571	0	0	No
Bromomethane	11	-	13	12		0	0	No
Carbon Disulfide	5	-	6	12	410,941	0	0	No
Carbon Tetrachloride	5	-	6	12	736,154	0	0	No
Chlorobenzene	5	-	6	12	413,812	0	0	No
Chloroethane	11	-	13	12		0	0	No
Chloroform	5	-	6	12	560,030	0	0	No
Chloromethane	11	-	13	12		0	0	No
cis-1,3-Dichloropropene	5	-	6	12	222,413	0	0	No
Dibromochloromethane	5	-	6	12	389,064	0	0	No
Ethylbenzene	5	-	6	12		0	0	No
Styrene	5	-	6	12	1.53E+06	0	0	No
Tetrachloroethene	5	-	6	12	72,494	0	0	No
trans-1,3-Dichloropropene	5	-	6	12	222,413	0	0	No
Trichloroethene	5	-	6	12	32,424	0	0	No
Vinyl acetate	11	-	13	12	730,903	0	0	No
Vinyl Chloride	11	-	13	12	6,494	0	0	No
Xylene	5	-	6	12	111,663	0	0	No

COMPREHENSIVE RISK ASSESSMENT

ROCK CREEK EXPOSURE UNIT

VOLUME 4: ATTACHMENT 2

Data Quality Assessment

TABLE OF CONTENTS

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ACRONYMS AND ABBREVIATIONS

AA	atomic absorption
ASD	Analytical Services Division
COC	contaminant of concern
CRA	Comprehensive Risk Assessment
CRDL	contract required detection limit
DAR	data adequacy report
DER	duplicate error ratio
DOE	U.S. Department of Energy
DQA	Data Quality Assessment
DQO	data quality objective
DRC	data review checklist
ECOPC	ecological contaminant of potential concern
EDD	electronic data deliverable
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ESL	ecological screening level
EU	exposure unit
FD	field duplicate
HQ	hazard quotient
IAG	Interagency Agreement
ICP	inductively couple plasma
IDL	instrument detection limit
LCS	laboratory control sample
LOAEL	lowest observable adverse effect level

MDA	minimum detectable activity
MDL	method detection limit
MS	matrix spike
MSA	method of standard additions
MSD	matrix spike duplicate
N/A	not applicable
PARCC	precision, accuracy, representativeness, completeness, and comparability
PPT	Pipette
PRG	preliminary remediation goal
PCB	polychlorinated biphenyl
QC	quality control
RCEU	Rock Creek Drainage Exposure Unit
RDL	required detection limit
RFETS	Rocky Flats Environmental Technology Site
RI/FS	Remedial Investigation/Feasibility Study
RL	reporting limit
RPD	relative percent difference
SDP	standard data package
SOW	Statement of Work
SVOC	semi-volatile organic compound
SWD	Soil Water Database
TCLP	Toxicity Characteristic Leaching Procedure
TIC	tentatively identified compound
V&V	verification and validation
VOC	volatile organic compound

1.0 INTRODUCTION

This document provides an assessment of the quality of the data used in the human health and ecological risk assessments for the Rock Creek Drainage Exposure Unit (RCEU). The data quality was evaluated against standard precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters by the data validator under the multiple work plans that guided the data collection over the past 15 years, as well as the requirements for the PARCC parameters provided in the Comprehensive Risk Assessment (CRA) Methodology (DOE 2005). The details of this data quality assessment (DQA) process are presented in the Sitewide DQA contained in Appendix A, Volume 2, Attachment 2 of the Remedial Investigation/Feasibility Study (RI/FS).

Of the 34,017 environmental sampling records in the RFETS database associated with the RCEU, 16,531 were used in the RCEU risk assessment based on the data processing rules described in Section 2.0 of the Sitewide DQA. Of the 16,531 analytical records existing in the RCEU CRA data set, 89 percent (14,639 records) have undergone verification or validation (V&V) (Table A2.1). The V&V review involved applying observation notes and qualifiers flags or observation notes without qualifier flags to the data.

PARCC parameter analysis was used to determine if the data quality could affect the risk assessment decisions (i.e., have significant impact on risk calculations or selection of contaminants of concern [COCs] for human health or ecological contaminants of potential concern [ECOPCs]). In consultation with the data users and project team, the primary ways in which the PARCC parameters could impact the risk assessment decisions were identified and these include the following:

- Detect results are falsely identified as nondetects;
- Nondetect results are falsely identified as detects;
- Issues that cause detection limit uncertainty;
- Issues that cause significant overestimation of detect results; and
- Issues that cause significant underestimation of detect results.

2.0 SUMMARY OF FINDINGS

2.1 PARCC Findings

A summary of V&V observations and the associated, affected PARCC parameter is presented in Table A2.2 by analyte group and matrix (i.e., "soil" includes soil and sediment, and "water" includes surface water and groundwater). Table A2.3 presents the percentage of the RCEU V&V data that were qualified as estimated or undetected by analyte group and matrix. Overall, approximately 17 percent of the RCEU CRA data were qualified as estimated or undetected. Less than 3 percent of the data reported as detected by the laboratory were qualified as undetected by the validator due to blank contamination (Table A2.4). In general, data qualified as estimated or undetected are marked as such because of various laboratory noncompliance issues that are not serious enough to render the data unusable. The precision between field duplicate (FD)/target sample analyte pairs is summarized in Table A2.5.

Of the 89 percent of the RCEU data set that underwent V&V, 79 percent were qualified as having no QC issues, and approximately 17 percent were qualified as estimated or undetected (Table A2.3). The remaining 4 percent of the V&V data are made up of records qualified with additional flags indicating acceptable and non-estimated data such as “A”, “C”, or “E”.

Approximately 7 percent of the entire data set was rejected during the V&V process (Table A2.6). Rejected data were removed from the RCEU CRA data set during the data processing as defined in Section 2.0 of the Sitewide DQA.

The general discussion below summarizes the data quality as presented by the data validator’s observations. The relationship between these observations and the PARCC parameters can be found in the Sitewide DQA. Several observations have no impact on data quality because they represent issues that were noted but corrected, or represent other, general observations such as missing documentation that was not required for data assessment. Approximately 15 percent of the RCEU V&V data were marked with these V&V observations that have no affect on any of the PARCC parameters.

Of the V&V data, approximately 3 percent were noted for observations related to precision. Of that 3 percent, 97 percent contained issues related to sample matrices. Result confirmation and instrument sensitivity observations make up the other 3 percent.

Of the V&V data, 37 percent were noted for accuracy-related observations. Of that 37 percent, 74 percent was noted for laboratory practice-related observations, while sample-specific accuracy observations make up the other 26 percent. It is important to note that not all accuracy-related observations resulted in data qualification. Only 17 percent of the RCEU CRA data set was qualified as estimated or undetected (Table A2.3).

The data were determined to meet the representativeness parameter because sampling locations are spatially distributed such that contaminant randomness and bias considerations are addressed based on the site-specific history (see the Data Adequacy Report [DAR] in Appendix A, Volume 2, Attachment 3). Samples were also analyzed by the SW-846 or alpha-spectroscopy methods and results were documented as quality records according to approved procedures and guidelines (V&V).

Of the V&V data, approximately 43 percent were noted for observations related to representativeness. Of that 43 percent, 74 percent was marked for blank observations, 17 percent for failure to observe allowed holding times, 3 percent for documentation issues, and 2 percent for instrument sensitivity issues. Matrix, LCS, instrument set-up, sample preparation, and other observations make up the other 4 percent of the data noted for observations related to sample representativeness. Reportable levels of target analytes were not routinely detected in the laboratory blanks greater than the laboratory RLs and samples were generally stored and preserved properly.

The CRA Methodology specifies completeness criteria based on data adequacy and these criteria and the findings are discussed in the DAR in Appendix A, Volume 2, Attachment 3 of the RI/FS. Additionally, it should be noted that approximately 7 percent of all V&V data associated with the RCEU were rejected.

Comparability of the RCEU CRA data set is ensured as all analytical results have been converted into common units. Comparability is addressed more specifically in Appendix A, Volume 2, Attachment 2 of the RI/FS.

2.2 PARCC Findings Potential Impact on Data Usability

PARCC parameter influence on data usability is discussed below with an emphasis on the risk assessment decisions as described in the Introduction to this document.

Table A2.3 summarizes the overall percentage of qualified data, independent of validation observation. The table is used for overall guidance in selecting analyte group and matrix combinations of interest in the analysis of the risk assessment decisions, the impact on data usability is better analyzed using Tables A2.5 through A2.7, as these can be more directly related to the 5 key risk assessment decision factors described in the introduction.

A summary of FD/target sample precision information can be found in Table A2.5. Where there are analyte group and matrix combinations failures that have the potential to impact risk assessment decisions, the data quality is discussed in further detail in the bulleted list below.

Table A2.7 lists V&V observations where the number of observations by analyte group and matrix exceeds 5 percent of the associated records (see column “Percent Observed”) with the exception of those observations that were determined to have no impact on any of the PARCC parameters. Such observations are identified in Table A2.2 by an “Affected PARCC Parameter” of not applicable (N/A). Additionally the analyte group and matrix is broken down further in the columns “Percent Qualified U” and “Percent Qualified J”. Data qualifications that are considered to have potential impact on risk assessment decisions were reviewed and are discussed in detail in the bulleted list below. Other issues are not considered to have the potential for significant impacts on the results of the risk assessments because the uncertainty associated with these data quality issues is assumed to be less than the overall uncertainty in the risk assessment process (e.g., uncertainties such as exposure assumptions, toxicity values, and statistical methods for calculating exposure point concentrations).

Data qualifications associated with the water matrix are not discussed below. Surface water data are used in the ecological risk assessment for an EU only for those analytes identified as ECOPCs, and the surface water component of exposure contributes only minimally to the overall risk estimates. As described in the Sitewide DQA (Attachment 2 of Volume 2 of Appendix A of the RI/FS Report), groundwater data are not used in the ecological risk assessment and the groundwater evaluations for the human health portion of the risk assessment are performed on a sitewide basis. In addition, surface water is evaluated for the human health risk assessment on a sitewide basis. Therefore, data quality evaluations for groundwater and surface water are presented in the Sitewide DQA.

Issues that have the potential to impact the risk assessment decisions include the following:

- Twelve percent of the herbicide/soil data associated with the RCEU were qualified as estimated and noted with the V&V observation that the allowed sample holding time was exceeded. This V&V observation has the potential to affect the representativeness of associated data. Data representativeness related to sample holding times is important as false nondetect results have the potential to impact the ECOPC and/or COC selection processes. As all records associated with this V&V observation that were qualified as estimated data are nondetect results, the potential impact on risk assessment decisions was reviewed. The impact to both the human health and ecological portions of the risk assessment is determined to be minimal as all of the nondetect herbicide results associated with the RCEU were well below human health preliminary remediation goals (PRGs) and the lowest associated ecological screening level (ESL).

- Notable percentages of the polychlorinated biphenyl (PCB), pesticide and semi-volatile organic compound (SVOC)/soil nondetect results were qualified because the allowed sample holding times were exceeded. Similar to the herbicide/soil discussion above, all noted results were nondetects, so the impact to the ECOPC and COC selection processes was reviewed.

  The impact on the risk assessment decisions made concerning PCBs and pesticides is determined to be minimal. All nondetect results were reported well below human health PRGs, and although some nondetect results exceeded the lowest associated ESL, neither PCBs nor pesticides were ever detected in the RCEU. Additionally, it is important to note that PCBs and pesticides are not expected to be present in the RCEU as no sources or contaminant migration pathways are present. Refer to Attachment 1 of this volume for further details regarding nondetected analytes.

  The nondetected SVOC/soil that were noted for holding time observations in the RCEU are also determined to have minimal impact on risk assessment calculations and decisions. Although several associated detection limits were reported at concentrations that exceed PRGs and ESLs, all detected results reported for these analytes were well below the associated screening levels. Additionally, those SVOCs associated with nondetected results that exceeded ESLs were generally not detected in RCEU surface and subsurface soils.

Bis(2-ethylhexyl)phthalate and di-n-butyl phthalate were the only SVOCs detected in RCEU surface soils, and the detection frequency for these analytes is very low (24 and 12 percent respectively). Furthermore, professional judgment indicates that if the associated detection limits had been lower, SVOCs would still not have been selected as ECOPCs in the RCEU. Refer to Attachment 1 of this volume for more detailed discussions of nondetected analytes.

- Approximately 13 percent of the metal/soil detected data set was qualified as estimated and noted with V&V observations related to laboratory control sample (LCS) analyses that did not meet recovery criteria. This V&V observation has the potential to affect the accuracy of associated data. Data accuracy is important at or near the contract required detection limit (CRDL) as false detect results have the potential to impact the ECOPC and/or COC selection processes. As all records associated with this V&V observation that were qualified as estimated were detected results that were generally reported well above the detection limit, the impact on ECOPC and COC selection processes is determined to be minimal.

  Manganese and tin were selected as ECOPCs in the RCEU. The noted LCS data quality issue was determined to have little impact on the risk assessment decisions related to these two metals as the risk characterization determined that the hazard quotients (HQs) calculated using the lowest observable adverse effect level (LOAEL) for manganese and zinc are all well below 1 (0.003 **–** 0.6). As a result, it has been determined that any data inaccuracies are not likely to impact the magnitude of the associated analytical results by a large enough margin to raise the HQs to a value above one. The ecological HQs for the RCEU are discussed in further detail in Section 10.1 of the main text of this volume**.**

- Thirteen percent of the volatile organic compound (VOC)/soil data set was qualified as estimated and noted with the V&V observation that internal standards did not meet control criteria. All affected records are nondetect results. While this data quality issue does have the potential to impact the accuracy of the associated data, it is important to note that no VOCs were selected either as COCs or as ECOPCs in the RCEU risk assessment. The impact on the selection of the COCs and ECOPCs is also determined to be minimal as all nondetected VOC results reported in RCEU soils are well below associated PRGs and ESLs.

- Several V&V observations related to the wet chemistry/soil analyte group and matrix combination resulted in data qualifications in notable percentages of the data set (Table A2.7). It is important to note, that this analyte group contains general chemistry parameters such as ions/anions and alkalinity that are not directly related to site characterization. Therefore, the impact of these qualifications on risk assessment results is determined to be minimal.

3.0 CONCLUSIONS

This review concludes that the quality of the RCEU data is acceptable and the CRA objectives for PARCC performance have generally been met. Where either CRA Methodology or V&V guidance have not been met, the data are either flagged by the V&V process, or for those instances where the frequency of issues may influence the risk assessment decisions, the data quality issues were reviewed for potential impact on risk assessment results.

Those elements of data quality that could affect risk assessment decisions in the RCEU have been analyzed and it was concluded that the noted deviations from the PARCC parameter criteria have minimal impact on risk assessment results related to the RCEU.

4.0 REFERENCES

DOE, 2002, Final Work Plan for the Development of the Remedial Investigation and Feasibility Study Report, Rocky Flats Environmental Technology Site, Golden, Colorado, March.

DOE, 2005. Final Comprehensive Risk Assessment Work Plan and Methodology, Environmental Restoration, Rocky Flats Environmental Technology Site, Golden, Colorado. Revision 1, September 2005.

TABLES

Table A2.1
CRA Data V&V Summary

Analyte Group	Matrix	Total No. of CRA V&V Records	Total No. of CRA Records	Percent V&V (%)
Herbicide	Soil	25	25	100.00
Herbicide	Water	2	2	100.00
Metal	Soil	1,707	1,771	96.39
Metal	Water	4,652	5,301	87.76
PCB	Soil	175	182	96.15
PCB	Water	14	14	100.00
Pesticide	Soil	529	550	96.18
Pesticide	Water	42	42	100.00
Radionuclide	Soil	441	470	93.83
Radionuclide	Water	701	813	86.22
SVOC	Soil	1,760	1,770	99.44
SVOC	Water	148	187	79.14
VOC	Soil	769	779	98.72
VOC	Water	3,023	3,905	77.41
Wet Chem	Soil	52	52	100.00
Wet Chem	Water	599	668	89.67
	Total	**14,639**	**16,531**	**88.55%**

Table A2.2
Summary of V&V Observations

Analyte Group	Matrix	QC Category	V&V Observation	Detect	No. of Records w/ Noted Observation	Total No. of V&V Records	Percent Observed (%)	PARCC Parameter Affected
Herbicide	Soil	Holding Times	Holding times were exceeded	No	3	25	12.00	Representativeness
Metal	Soil	Blanks	Calibration verification blank contamination	No	37	1,707	2.17	Representativeness
Metal	Soil	Blanks	Calibration verification blank contamination	Yes	23	1,707	1.35	Representativeness
Metal	Soil	Blanks	Method, preparation, or reagent blank contamination	No	22	1,707	1.29	Representativeness
Metal	Soil	Blanks	Method, preparation, or reagent blank contamination	Yes	22	1,707	1.29	Representativeness
Metal	Soil	Blanks	Negative bias indicated in the blanks	No	6	1,707	0.35	Representativeness
Metal	Soil	Blanks	Negative bias indicated in the blanks	Yes	14	1,707	0.82	Representativeness
Metal	Soil	Calibration	Calibration correlation coefficient did not meet requirements	Yes	1	1,707	0.06	Accuracy
Metal	Soil	Documentation Issues	Key data fields incorrect	No	7	1,707	0.41	N/A
Metal	Soil	Documentation Issues	Key data fields incorrect	Yes	4	1,707	0.23	N/A
Metal	Soil	Documentation Issues	Transcription error	Yes	13	1,707	0.76	N/A
Metal	Soil	Instrument Set-up	Interference was indicated in the interference check sample	No	5	1,707	0.29	Accuracy
Metal	Soil	Instrument Set-up	Interference was indicated in the interference check sample	Yes	8	1,707	0.47	Accuracy
Metal	Soil	LCS	CRDL check sample recovery criteria were not met	No	17	1,707	1.00	Accuracy
Metal	Soil	LCS	CRDL check sample recovery criteria were not met	Yes	28	1,707	1.64	Accuracy
Metal	Soil	LCS	LCS recovery criteria were not met	No	67	1,707	3.93	Accuracy
Metal	Soil	LCS	LCS recovery criteria were not met	Yes	215	1,707	12.60	Accuracy
Metal	Soil	LCS	Low level check sample recovery criteria were not met	No	42	1,707	2.46	Accuracy
Metal	Soil	LCS	Low level check sample recovery criteria were not met	Yes	27	1,707	1.58	Accuracy
Metal	Soil	Matrices	Duplicate sample precision criteria were not met	No	6	1,707	0.35	Precision

Table A2.2
Summary of V&V Observations

Analyte Group	Matrix	QC Category	V&V Observation	Detect	No. of Records w/ Noted Observation	Total No. of V&V Records	Percent Observed (%)	PARCC Parameter Affected
Metal	Soil	Matrices	Duplicate sample precision criteria were not met	Yes	65	1,707	3.81	Precision
Metal	Soil	Matrices	LCS/LCSD precision criteria were not met	Yes	17	1,707	1.00	Precision
Metal	Soil	Matrices	MSA calibration correlation coefficient < 0.995	Yes	1	1,707	0.06	Accuracy
Metal	Soil	Matrices	Percent solids < 30 percent	Yes	48	1,707	2.81	Representativeness
Metal	Soil	Matrices	Post-digestion MS did not meet control criteria	No	11	1,707	0.64	Accuracy
Metal	Soil	Matrices	Post-digestion MS did not meet control criteria	Yes	10	1,707	0.59	Accuracy
Metal	Soil	Matrices	Predigestion MS recovery criteria were not met	No	85	1,707	4.98	Accuracy
Metal	Soil	Matrices	Predigestion MS recovery criteria were not met	Yes	138	1,707	8.08	Accuracy
Metal	Soil	Matrices	Predigestion MS recovery was < 30 percent	Yes	13	1,707	0.76	Accuracy
Metal	Soil	Matrices	Serial dilution criteria were not met	Yes	51	1,707	2.99	Accuracy
Metal	Soil	Other	IDL is older than 3 months from date of analysis	No	93	1,707	5.45	Accuracy
Metal	Soil	Other	IDL is older than 3 months from date of analysis	Yes	351	1,707	20.56	Accuracy
Metal	Soil	Other	Result obtained through dilution	Yes	1	1,707	0.06	N/A
Metal	Soil	Other	See hard copy for further explanation	No	15	1,707	0.88	N/A
Metal	Soil	Other	See hard copy for further explanation	Yes	72	1,707	4.22	N/A
Metal	Water	Blanks	Calibration verification blank contamination	No	99	4,652	2.13	Representativeness
Metal	Water	Blanks	Calibration verification blank contamination	Yes	15	4,652	0.32	Representativeness
Metal	Water	Blanks	Method, preparation, or reagent blank contamination	No	257	4,652	5.52	Representativeness
Metal	Water	Blanks	Method, preparation, or reagent blank contamination	Yes	132	4,652	2.84	Representativeness
Metal	Water	Blanks	Negative bias indicated in the blanks	No	100	4,652	2.15	Representativeness
Metal	Water	Blanks	Negative bias indicated in the blanks	Yes	40	4,652	0.86	Representativeness

Table A2.2
Summary of V&V Observations

Analyte Group	Matrix	QC Category	V&V Observation	Detect	No. of Records w/ Noted Observation	Total No. of V&V Records	Percent Observed (%)	PARCC Parameter Affected
Metal	Water	Calculation Errors	Control limits not assigned correctly	Yes	1	4,652	0.02	N/A
Metal	Water	Calibration	Calibration correlation coefficient did not meet requirements	No	10	4,652	0.21	Accuracy
Metal	Water	Calibration	Calibration correlation coefficient did not meet requirements	Yes	4	4,652	0.09	Accuracy
Metal	Water	Calibration	Continuing calibration verification criteria were not met	Yes	5	4,652	0.11	Accuracy
Metal	Water	Calibration	Frequency or sequencing verification criteria not met	No	12	4,652	0.26	Accuracy
Metal	Water	Calibration	Frequency or sequencing verification criteria not met	Yes	15	4,652	0.32	Accuracy
Metal	Water	Documentation Issues	Key data fields incorrect	No	20	4,652	0.43	N/A
Metal	Water	Documentation Issues	Key data fields incorrect	Yes	36	4,652	0.77	N/A
Metal	Water	Documentation Issues	Missing deliverables (not required for validation)	No	23	4,652	0.49	N/A
Metal	Water	Documentation Issues	Missing deliverables (not required for validation)	Yes	33	4,652	0.71	N/A
Metal	Water	Documentation Issues	Omissions or errors in data package (not required for validation)	No	24	4,652	0.52	N/A
Metal	Water	Documentation Issues	Omissions or errors in data package (not required for validation)	Yes	57	4,652	1.23	N/A
Metal	Water	Documentation Issues	Record added by the validator	Yes	1	4,652	0.02	N/A
Metal	Water	Documentation Issues	Transcription error	No	337	4,652	7.24	N/A
Metal	Water	Documentation Issues	Transcription error	Yes	28	4,652	0.60	N/A
Metal	Water	Holding Times	Holding times were exceeded	No	3	4,652	0.06	Representativeness
Metal	Water	Instrument Set-up	Interference was indicated in the interference check sample	No	2	4,652	0.04	Accuracy
Metal	Water	Instrument Set-up	Interference was indicated in the interference check sample	Yes	5	4,652	0.11	Accuracy

Table A2.2
Summary of V&V Observations

Analyte Group	Matrix	QC Category	V&V Observation	Detect	No. of Records w/ Noted Observation	Total No. of V&V Records	Percent Observed (%)	PARCC Parameter Affected
Metal	Water	LCS	CRDL check sample recovery criteria were not met	No	35	4,652	0.75	Accuracy
Metal	Water	LCS	CRDL check sample recovery criteria were not met	Yes	33	4,652	0.71	Accuracy
Metal	Water	LCS	LCS recovery criteria were not met	No	2	4,652	0.04	Accuracy
Metal	Water	LCS	LCS recovery criteria were not met	Yes	7	4,652	0.15	Accuracy
Metal	Water	LCS	Low level check sample recovery criteria were not met	No	26	4,652	0.56	Accuracy
Metal	Water	LCS	Low level check sample recovery criteria were not met	Yes	18	4,652	0.39	Accuracy
Metal	Water	LCS	QC sample/analyte (e.g. spike, duplicate, LCS) was not analyzed	No	11	4,652	0.24	Representativeness
Metal	Water	LCS	QC sample/analyte (e.g. spike, duplicate, LCS) was not analyzed	Yes	15	4,652	0.32	Representativeness
Metal	Water	Matrices	Duplicate sample precision criteria were not met	No	7	4,652	0.15	Precision
Metal	Water	Matrices	Duplicate sample precision criteria were not met	Yes	32	4,652	0.69	Precision
Metal	Water	Matrices	LCS/LCSD precision criteria were not met	No	4	4,652	0.09	Precision
Metal	Water	Matrices	LCS/LCSD precision criteria were not met	Yes	3	4,652	0.06	Precision
Metal	Water	Matrices	Post-digestion MS did not meet control criteria	No	35	4,652	0.75	Accuracy
Metal	Water	Matrices	Post-digestion MS did not meet control criteria	Yes	9	4,652	0.19	Accuracy
Metal	Water	Matrices	Predigestion MS recovery criteria were not met	No	56	4,652	1.20	Accuracy
Metal	Water	Matrices	Predigestion MS recovery criteria were not met	Yes	68	4,652	1.46	Accuracy
Metal	Water	Matrices	Predigestion MS recovery was < 30 percent	No	1	4,652	0.02	Accuracy
Metal	Water	Matrices	Serial dilution criteria were not met	No	1	4,652	0.02	Accuracy
Metal	Water	Matrices	Serial dilution criteria were not met	Yes	76	4,652	1.63	Accuracy

Table A2.2
Summary of V&V Observations

Analyte Group	Matrix	QC Category	V&V Observation	Detect	No. of Records w/ Noted Observation	Total No. of V&V Records	Percent Observed (%)	PARCC Parameter Affected
Metal	Water	Other	IDL is older than 3 months from date of analysis	No	78	4,652	1.68	Accuracy
Metal	Water	Other	IDL is older than 3 months from date of analysis	Yes	58	4,652	1.25	Accuracy
Metal	Water	Other	See hard copy for further explanation	Yes	1	4,652	0.02	N/A
Metal	Water	Sample Preparation	Samples were not properly preserved in the field	No	24	4,652	0.52	Representativeness
Metal	Water	Sample Preparation	Samples were not properly preserved in the field	Yes	31	4,652	0.67	Representativeness
Metal	Water	Sensitivity	IDL changed due to a significant figure discrepancy	No	25	4,652	0.54	Representativeness
PCB	Soil	Documentation Issues	Transcription error	No	63	175	36.00	N/A
PCB	Soil	Holding Times	Holding times were exceeded	No	21	175	12.00	Representativeness
PCB	Soil	Other	See hard copy for further explanation	No	7	175	4.00	N/A
PCB	Soil	Surrogates	Surrogate recovery criteria were not met	No	14	175	8.00	Accuracy
Pesticide	Soil	Documentation Issues	Transcription error	No	8	529	1.51	N/A
Pesticide	Soil	Holding Times	Holding times were exceeded	No	63	529	11.91	Representativeness
Pesticide	Soil	Other	See hard copy for further explanation	No	20	529	3.78	N/A
Pesticide	Soil	Surrogates	Surrogate recovery criteria were not met	No	40	529	7.56	Accuracy
Radionuclide	Soil	Blanks	Blank recovery criteria were not met	Yes	2	441	0.45	Representativeness
Radionuclide	Soil	Blanks	Method, preparation, or reagent blank contamination	No	2	441	0.45	Representativeness
Radionuclide	Soil	Blanks	Method, preparation, or reagent blank contamination	Yes	35	441	7.94	Representativeness
Radionuclide	Soil	Calculation Errors	Calculation error	Yes	4	441	0.91	N/A
Radionuclide	Soil	Calibration	Continuing calibration verification criteria were not met	Yes	48	441	10.88	Accuracy
Radionuclide	Soil	Documentation Issues	Record added by the validator	Yes	3	441	0.68	N/A
Radionuclide	Soil	Documentation Issues	Results were not included on Data Summary Table	Yes	1	441	0.23	N/A
Radionuclide	Soil	Documentation Issues	Sufficient documentation not provided by the laboratory	No	2	441	0.45	Representativeness

Table A2.2
Summary of V&V Observations

Analyte Group	Matrix	QC Category	V&V Observation	Detect	No. of Records w/ Noted Observation	Total No. of V&V Records	Percent Observed (%)	PARCC Parameter Affected
Radionuclide	Soil	Documentation Issues	Sufficient documentation not provided by the laboratory	Yes	52	441	11.79	Representativeness
Radionuclide	Soil	Documentation Issues	Transcription error	No	2	441	0.45	N/A
Radionuclide	Soil	Documentation Issues	Transcription error	Yes	55	441	12.47	N/A
Radionuclide	Soil	Holding Times	Holding times were grossly exceeded	Yes	6	441	1.36	Representativeness
Radionuclide	Soil	Instrument Set-up	Detector efficiency did not meet requirements	Yes	8	441	1.81	Accuracy
Radionuclide	Soil	Instrument Set-up	Resolution criteria were not met	Yes	4	441	0.91	Representativeness
Radionuclide	Soil	LCS	LCS recovery > +/- 3 sigma	Yes	18	441	4.08	Accuracy
Radionuclide	Soil	LCS	LCS recovery criteria were not met	Yes	4	441	0.91	Accuracy
Radionuclide	Soil	LCS	LCS relative percent error criteria not met	No	1	441	0.23	Accuracy
Radionuclide	Soil	LCS	LCS relative percent error criteria not met	Yes	11	441	2.49	Accuracy
Radionuclide	Soil	Matrices	Recovery criteria were not met	Yes	1	441	0.23	Accuracy
Radionuclide	Soil	Matrices	Replicate analysis was not performed	Yes	1	441	0.23	Precision
Radionuclide	Soil	Matrices	Replicate precision criteria were not met	Yes	5	441	1.13	Precision
Radionuclide	Soil	Other	Lab results not verified due to unsubmitted data	Yes	6	441	1.36	Representativeness
Radionuclide	Soil	Other	QC sample does not meet method requirements	No	22	441	4.99	Representativeness
Radionuclide	Soil	Other	QC sample does not meet method requirements	Yes	18	441	4.08	Representativeness
Radionuclide	Soil	Other	Sample exceeded efficiency curve weight limit	Yes	9	441	2.04	Accuracy
Radionuclide	Soil	Other	See hard copy for further explanation	No	1	441	0.23	N/A
Radionuclide	Soil	Other	See hard copy for further explanation	Yes	25	441	5.67	N/A
Radionuclide	Soil	Sensitivity	Incorrect reported activity or MDA	No	1	441	0.23	N/A
Radionuclide	Soil	Sensitivity	MDA exceeded the RDL	No	3	441	0.68	Representativeness
Radionuclide	Soil	Sensitivity	MDA exceeded the RDL	Yes	4	441	0.91	Representativeness
Radionuclide	Soil	Sensitivity	MDA was calculated by reviewer	Yes	149	441	33.79	N/A
Radionuclide	Soil	Sensitivity	Results considered qualitative not quantitative	Yes	3	441	0.68	Accuracy

Table A2.2
Summary of V&V Observations

Analyte Group	Matrix	QC Category	V&V Observation	Detect	No. of Records w/ Noted Observation	Total No. of V&V Records	Percent Observed (%)	PARCC Parameter Affected
Radionuclide	Water	Blanks	Blank recovery criteria were not met	No	3	701	0.43	Representativeness
Radionuclide	Water	Blanks	Method, preparation, or reagent blank contamination	No	8	701	1.14	Representativeness
Radionuclide	Water	Blanks	Method, preparation, or reagent blank contamination	Yes	58	701	8.27	Representativeness
Radionuclide	Water	Calculation Errors	Calculation error	Yes	1	701	0.14	N/A
Radionuclide	Water	Calibration	Calibration counting statistics did not meet criteria	No	2	701	0.29	Accuracy
Radionuclide	Water	Calibration	Continuing calibration verification criteria were not met	No	20	701	2.85	Accuracy
Radionuclide	Water	Calibration	Continuing calibration verification criteria were not met	Yes	121	701	17.26	Accuracy
Radionuclide	Water	Documentation Issues	Missing deliverables (required for validation)	No	1	701	0.14	Representativeness
Radionuclide	Water	Documentation Issues	Missing deliverables (required for validation)	Yes	1	701	0.14	Representativeness
Radionuclide	Water	Documentation Issues	No raw data submitted by the laboratory	Yes	1	701	0.14	Representativeness
Radionuclide	Water	Documentation Issues	Omissions or errors in data package (not required for validation)	Yes	3	701	0.43	N/A
Radionuclide	Water	Documentation Issues	Record added by the validator	Yes	18	701	2.57	N/A
Radionuclide	Water	Documentation Issues	Sufficient documentation not provided by the laboratory	Yes	128	701	18.26	Representativeness
Radionuclide	Water	Documentation Issues	Transcription error	No	72	701	10.27	N/A
Radionuclide	Water	Documentation Issues	Transcription error	Yes	52	701	7.42	N/A
Radionuclide	Water	Holding Times	Holding times were exceeded	No	7	701	1.00	Representativeness
Radionuclide	Water	Holding Times	Holding times were exceeded	Yes	9	701	1.28	Representativeness
Radionuclide	Water	Holding Times	Holding times were grossly exceeded	No	2	701	0.29	Representativeness
Radionuclide	Water	Instrument Set-up	Resolution criteria were not met	No	1	701	0.14	Representativeness
Radionuclide	Water	Instrument Set-up	Resolution criteria were not met	Yes	4	701	0.57	Representativeness
Radionuclide	Water	Instrument Set-up	Transformed spectral index external site criteria were not met	No	6	701	0.86	Representativeness

Table A2.2
Summary of V&V Observations

Analyte Group	Matrix	QC Category	V&V Observation	Detect	No. of Records w/ Noted Observation	Total No. of V&V Records	Percent Observed (%)	PARCC Parameter Affected
Radionuclide	Water	LCS	Expected LCS value not submitted/verifiable	No	5	701	0.71	Representativeness
Radionuclide	Water	LCS	Expected LCS value not submitted/verifiable	Yes	12	701	1.71	Representativeness
Radionuclide	Water	LCS	LCS recovery > +/- 3 sigma	No	26	701	3.71	Accuracy
Radionuclide	Water	LCS	LCS recovery > +/- 3 sigma	Yes	39	701	5.56	Accuracy
Radionuclide	Water	LCS	LCS recovery criteria were not met	No	3	701	0.43	Accuracy
Radionuclide	Water	LCS	LCS recovery criteria were not met	Yes	3	701	0.43	Accuracy
Radionuclide	Water	LCS	LCS relative percent error criteria not met	No	12	701	1.71	Accuracy
Radionuclide	Water	LCS	LCS relative percent error criteria not met	Yes	46	701	6.56	Accuracy
Radionuclide	Water	Matrices	Recovery criteria were not met	No	1	701	0.14	Accuracy
Radionuclide	Water	Matrices	Recovery criteria were not met	Yes	14	701	2.00	Accuracy
Radionuclide	Water	Matrices	Replicate analysis was not performed	No	7	701	1.00	Precision
Radionuclide	Water	Matrices	Replicate analysis was not performed	Yes	17	701	2.43	Precision
Radionuclide	Water	Matrices	Replicate precision criteria were not met	No	15	701	2.14	Precision
Radionuclide	Water	Matrices	Replicate precision criteria were not met	Yes	52	701	7.42	Precision
Radionuclide	Water	Matrices	Replicate recovery criteria were not met	No	2	701	0.29	Accuracy
Radionuclide	Water	Matrices	Replicate recovery criteria were not met	Yes	7	701	1.00	Accuracy
Radionuclide	Water	Other	Lab results not verified due to unsubmitted data	No	1	701	0.14	Representativeness
Radionuclide	Water	Other	Lab results not verified due to unsubmitted data	Yes	9	701	1.28	Representativeness
Radionuclide	Water	Other	Sample exceeded efficiency curve weight limit	Yes	4	701	0.57	Accuracy
Radionuclide	Water	Other	Sample results were not validated due to re-analysis	No	1	701	0.14	N/A
Radionuclide	Water	Other	Sample results were not validated due to re-analysis	Yes	2	701	0.29	N/A
Radionuclide	Water	Other	See hard copy for further explanation	No	9	701	1.28	N/A
Radionuclide	Water	Other	See hard copy for further explanation	Yes	65	701	9.27	N/A
Radionuclide	Water	Sample Preparation	Improper aliquot size	Yes	1	701	0.14	Accuracy
Radionuclide	Water	Sensitivity	Incorrect reported activity or MDA	Yes	2	701	0.29	N/A
Radionuclide	Water	Sensitivity	MDA exceeded the RDL	No	10	701	1.43	Representativeness

Table A2.2
Summary of V&V Observations

Analyte Group	Matrix	QC Category	V&V Observation	Detect	No. of Records w/ Noted Observation	Total No. of V&V Records	Percent Observed (%)	PARCC Parameter Affected
Radionuclide	Water	Sensitivity	MDA exceeded the RDL	Yes	33	701	4.71	Representativeness
Radionuclide	Water	Sensitivity	MDA was calculated by reviewer	Yes	297	701	42.37	N/A
Radionuclide	Water	Sensitivity	Repeat count outside of 3 sigma counting error	Yes	1	701	0.14	Precision
SVOC	Soil	Blanks	Method, preparation, or reagent blank contamination	No	4	1,760	0.23	Representativeness
SVOC	Soil	Calibration	Continuing calibration verification criteria were not met	No	10	1,760	0.57	Accuracy
SVOC	Soil	Calibration	Continuing calibration verification criteria were not met	Yes	2	1,760	0.11	Accuracy
SVOC	Soil	Holding Times	Holding times were exceeded	No	177	1,760	10.06	Representativeness
SVOC	Soil	Internal Standards	Internal standards did not meet criteria	No	15	1,760	0.85	Accuracy
SVOC	Soil	Internal Standards	Internal standards did not meet criteria	Yes	5	1,760	0.28	Accuracy
SVOC	Soil	Matrices	Percent solids < 30 percent	Yes	3	1,760	0.17	Representativeness
SVOC	Water	Blanks	Method, preparation, or reagent blank contamination	Yes	1	148	0.68	Representativeness
SVOC	Water	Calibration	Continuing calibration verification criteria were not met	No	2	148	1.35	Accuracy
VOC	Soil	Blanks	Method, preparation, or reagent blank contamination	No	16	769	2.08	Representativeness
VOC	Soil	Calibration	Continuing calibration verification criteria were not met	Yes	11	769	1.43	Accuracy
VOC	Soil	Documentation Issues	Transcription error	No	12	769	1.56	N/A
VOC	Soil	Documentation Issues	Transcription error	Yes	1	769	0.13	N/A
VOC	Soil	Holding Times	Holding times were exceeded	No	12	769	1.56	Representativeness
VOC	Soil	Internal Standards	Internal standards did not meet criteria	No	100	769	13.00	Accuracy
VOC	Soil	Internal Standards	Internal standards did not meet criteria	Yes	8	769	1.04	Accuracy
VOC	Soil	Matrices	Percent solids < 30 percent	No	1	769	0.13	Representativeness
VOC	Soil	Matrices	Percent solids < 30 percent	Yes	4	769	0.52	Representativeness
VOC	Soil	Surrogates	Surrogate recovery criteria were not met	No	1	769	0.13	Accuracy
VOC	Soil	Surrogates	Surrogate recovery criteria were not met	Yes	2	769	0.26	Accuracy
VOC	Water	Blanks	Method, preparation, or reagent blank contamination	No	37	3,023	1.22	Representativeness

Table A2.2
Summary of V&V Observations

Analyte Group	Matrix	QC Category	V&V Observation	Detect	No. of Records w/ Noted Observation	Total No. of V&V Records	Percent Observed (%)	PARCC Parameter Affected
VOC	Water	Blanks	Method, preparation, or reagent blank contamination	Yes	1	3,023	0.03	Representativeness
VOC	Water	Calibration	Continuing calibration verification criteria were not met	No	15	3,023	0.50	Accuracy
VOC	Water	Calibration	Continuing calibration verification criteria were not met	Yes	2	3,023	0.07	Accuracy
VOC	Water	Confirmation	Results were not confirmed	No	5	3,023	0.17	Precision
VOC	Water	Documentation Issues	Record added by the validator	No	7	3,023	0.23	N/A
VOC	Water	Documentation Issues	Transcription error	No	341	3,023	11.28	N/A
VOC	Water	Documentation Issues	Transcription error	Yes	1	3,023	0.03	N/A
VOC	Water	Holding Times	Holding times were exceeded	No	29	3,023	0.96	Representativeness
VOC	Water	Internal Standards	Internal standards did not meet criteria	No	12	3,023	0.40	Accuracy
Wet Chem	Soil	Documentation Issues	Transcription error	No	1	52	1.92	N/A
Wet Chem	Soil	Holding Times	Holding times were exceeded	Yes	1	52	1.92	Representativeness
Wet Chem	Soil	Holding Times	Holding times were grossly exceeded	No	1	52	1.92	Representativeness
Wet Chem	Soil	Matrices	Duplicate sample precision criteria were not met	Yes	1	52	1.92	Precision
Wet Chem	Soil	Matrices	Percent solids < 30 percent	Yes	2	52	3.85	Representativeness
Wet Chem	Soil	Matrices	Predigestion MS recovery was < 30 percent	Yes	22	52	42.31	Accuracy
Wet Chem	Soil	Matrices	Serial dilution criteria were not met	Yes	2	52	3.85	Accuracy
Wet Chem	Soil	Other	IDL is older than 3 months from date of analysis	Yes	15	52	28.85	Accuracy
Wet Chem	Water	Blanks	Method, preparation, or reagent blank contamination	No	4	599	0.67	Representativeness
Wet Chem	Water	Blanks	Negative bias indicated in the blanks	No	5	599	0.83	Representativeness
Wet Chem	Water	Calibration	Calibration correlation coefficient did not meet requirements	Yes	4	599	0.67	Accuracy
Wet Chem	Water	Calibration	Continuing calibration verification criteria were not met	Yes	1	599	0.17	Accuracy

Table A2.2
Summary of V&V Observations

Analyte Group	Matrix	QC Category	V&V Observation	Detect	No. of Records w/ Noted Observation	Total No. of V&V Records	Percent Observed (%)	PARCC Parameter Affected
Wet Chem	Water	Calibration	Original result exceeded linear range, serial dilution value reported	Yes	1	599	0.17	Accuracy
Wet Chem	Water	Documentation Issues	Omissions or errors in data package (not required for validation)	Yes	7	599	1.17	N/A
Wet Chem	Water	Documentation Issues	Transcription error	No	5	599	0.83	N/A
Wet Chem	Water	Documentation Issues	Transcription error	Yes	8	599	1.34	N/A
Wet Chem	Water	Holding Times	Holding times were exceeded	No	6	599	1.00	Representativeness
Wet Chem	Water	Holding Times	Holding times were exceeded	Yes	5	599	0.83	Representativeness
Wet Chem	Water	Holding Times	Holding times were grossly exceeded	No	7	599	1.17	Representativeness
Wet Chem	Water	Holding Times	Holding times were grossly exceeded	Yes	4	599	0.67	Representativeness
Wet Chem	Water	Matrices	Predigestion MS recovery criteria were not met	No	2	599	0.33	Accuracy
Wet Chem	Water	Matrices	Predigestion MS recovery criteria were not met	Yes	21	599	3.51	Accuracy
Wet Chem	Water	Matrices	Predigestion MS recovery was < 30 percent	Yes	1	599	0.17	Accuracy
Wet Chem	Water	Matrices	Serial dilution criteria were not met	Yes	2	599	0.33	Accuracy
Wet Chem	Water	Matrices	Site samples were not used for sample matrix QC	Yes	1	599	0.17	Representativeness
Wet Chem	Water	Other	IDL is older than 3 months from date of analysis	Yes	3	599	0.50	Accuracy
Wet Chem	Water	Sample Preparation	Samples were not properly preserved in the field	Yes	6	599	1.00	Representativeness

Table A2.3
Summary of Data Estimated or Undetected Due to V&V Determinations

Analyte Group	Matrix	No. of CRA Data Records Qualified	Total No. of V&V CRA Records	Detect	Percent Qualified (%)
Herbicide	Soil	3	25	No	12.00
Metal	Soil	245	1,707	No	14.35
Metal	Soil	482	1,707	Yes	28.24
Metal	Water	595	4,652	No	12.79
Metal	Water	420	4,652	Yes	9.03
PCB	Soil	35	175	No	20.00
Pesticide	Soil	103	529	No	19.47
Radionuclide	Soil	1	441	Yes	0.23
Radionuclide	Water	1	701	No	0.14
Radionuclide	Water	13	701	Yes	1.85
SVOC	Soil	206	1,760	No	11.70
SVOC	Water	2	148	No	1.35
SVOC	Water	1	148	Yes	0.68
VOC	Soil	125	769	No	16.25
VOC	Soil	12	769	Yes	1.56
VOC	Water	97	3,023	No	3.21
VOC	Water	3	3,023	Yes	0.10
Wet Chem	Soil	1	52	No	1.92
Wet Chem	Soil	19	52	Yes	36.54
Wet Chem	Water	22	599	No	3.67
Wet Chem	Water	34	599	Yes	5.68
	Total	**2,420**	**14,639**		**16.53%**

Table A2.4
Summary of Data Qualified as Undetected Due to Blank Contamination

Analyte Group	Matrix	No. of CRA Records Qualified as Undetected Due to Blank Contaimination	Total No. of CRA Records with Detected Results[a]	Percent Qualified as Undetected
Metal	Soil	26	1,310	1.98
Metal	Water	65	2,082	3.12
	Total	**91**	**3,392**	**2.68%**

[a] As determined by the laboratory prior to V&V.

Table A2.5
Summary of RPDs/DERs of Field Duplicate Analyte Pairs

Analyte Group	Matrix	No. of Duplicates Failing RPD/DER Criteria	Total No. of Duplicate Pairs	Percent Failure (%)	Field Duplicate Frequency (%)
Herbicide	Soil	0	5	0.00	20.00
Metal	Soil	14	259	5.41	14.62
Metal	Water	15	869	1.73	16.39
PCB	Soil	0	14	0.00	7.69
Pesticide	Soil	0	45	0.00	8.18
Radionuclide	Soil	0	66	0.00	14.04
Radionuclide	Water	0	187	0.00	23.00
SVOC	Soil	0	295	0.00	16.67
SVOC	Water	0	12	0.00	6.42
VOC	Soil	0	24	0.00	3.08
VOC	Water	0	682	0.00	17.46
Wet Chem	Soil	0	5	0.00	9.62
Wet Chem	Water	2	113	1.77	16.92

Table A2.6
Summary of Data Rejected During V&V

Analyte Group	Matrix	Total No. of Rejected Records	Total No. of V&V Records	Percent Rejected (%)
Herbicide	Soil	5	34	14.71
Herbicide	Water	0	2	0.00
Metal	Soil	133	3,001	4.43
Metal	Water	267	7,908	3.38
PCB	Soil	42	266	15.79
PCB	Water	0	28	0.00
Pesticide	Soil	128	799	16.02
Pesticide	Water	0	82	0.00
Radionuclide	Soil	120	707	16.97
Radionuclide	Water	379	1,715	22.10
SVOC	Soil	258	2,262	11.41
SVOC	Water	0	148	0.00
VOC	Soil	242	1,748	13.84
VOC	Water	122	4,807	2.54
Wet Chem	Soil	2	135	1.48
Wet Chem	Water	39	1,110	3.51
	Total	**1,737**	**24,752**	**7.02%**

Table A2.7
Summary of Data Quality Issues Identified by V&V

Analyte Group	Matrix	Categories Description	V&V Observation	Detect	Percent Observed	Percent Qualified U[a]	Percent Qualified J[b]	PARCC Parameter Affected	Impacts Risk Assessment Decisions
Herbicide	Soil	Holding Times	Holding times were exceeded	No	12.00	0.00	12.00	Representativeness	No
Metal	Soil	LCS	LCS recovery criteria were not met	Yes	12.60	0.00	12.60	Accuracy	No
Metal	Soil	Matrices	Predigestion MS recovery criteria were not met	Yes	8.08	0.00	8.08	Accuracy	No
Metal	Soil	Other	IDL is older than 3 months from date of analysis	Yes	20.56	0.00	3.81	Accuracy	No
Metal	Water	Blanks	Method, preparation, or reagent blank contamination	No	5.52	0.02	5.50	Representativeness	No
PCB	Soil	Holding Times	Holding times were exceeded	No	12.00	0.00	12.00	Representativeness	No
PCB	Soil	Surrogates	Surrogate recovery criteria were not met	No	8.00	0.00	8.00	Accuracy	No
Pesticide	Soil	Holding Times	Holding times were exceeded	No	11.91	0.00	11.91	Representativeness	No
Pesticide	Soil	Surrogates	Surrogate recovery criteria were not met	No	7.56	0.00	7.56	Accuracy	No
Radionuclide	Soil	Blanks	Method, preparation, or reagent blank contamination	Yes	7.94	0.00	0.23	Representativeness	No
Radionuclide	Soil	Calibration	Continuing calibration verification criteria were not met	Yes	10.88	0.00	0.00	Accuracy	No
Radionuclide	Soil	Documentation Issues	Sufficient documentation not provided by the laboratory	Yes	11.79	0.00	0.00	Representativeness	No
Radionuclide	Water	Blanks	Method, preparation, or reagent blank contamination	Yes	8.27	0.00	0.43	Representativeness	No
Radionuclide	Water	Calibration	Continuing calibration verification criteria were not met	Yes	17.26	0.00	0.86	Accuracy	No
Radionuclide	Water	Documentation Issues	Sufficient documentation not provided by the laboratory	Yes	18.26	0.00	0.29	Representativeness	No
Radionuclide	Water	LCS	LCS recovery > +/- 3 sigma	Yes	5.56	0.00	0.14	Accuracy	No
Radionuclide	Water	LCS	LCS relative percent error criteria not met	Yes	6.56	0.00	0.00	Accuracy	No
Radionuclide	Water	Matrices	Replicate precision criteria were not met	Yes	7.42	0.00	0.00	Precision	No
SVOC	Soil	Holding Times	Holding times were exceeded	No	10.06	0.00	10.06	Representativeness	No
VOC	Soil	Internal Standards	Internal standards did not meet criteria	No	13.00	0.00	13.00	Accuracy	No
Wet Chem	Soil	Matrices	Predigestion MS recovery was < 30 percent	Yes	42.31	0.00	30.77	Accuracy	No
Wet Chem	Soil	Other	IDL is older than 3 months from date of analysis	Yes	28.85	0.00	17.31	Accuracy	No

[a]Defined as validation qualifier codes containing "U"
[b]Defined as validation qualifier codes containing "J", except "UJ"

COMPREHENSIVE RISK ASSESSMENT

ROCK CREEK DRAINAGE EXPOSURE UNIT

VOLUME 4: ATTACHMENT 3

Statistical Analyses and Professional Judgment

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ACRONYMS AND ABBREVIATIONS

μg/kg	micrograms per kilogram
CDH	Colorado Department of Health
COC	contaminant of concern
CRA	Comprehensive Risk Assessment
DOE	U.S. Department of Energy
ECOI	ecological contaminant of interest
EcoSSL	Ecological Soil Screening Level
ECOPC	ecological contaminant of potential concern
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERA	Ecological Risk Assessment
ESL	ecological screening level
EU	Exposure Unit
HQ	hazard quotient
IAEU	Industrial Area Exposure Unit
IHSS	Individual Hazardous Substance Site
MDC	maximum detected concentration
mg/kg	milligrams per kilogram
NCP	National Contingency Plan
NOAEL	no observed adverse effect level
PCOC	potential contaminant of concern
PMJM	Preble's meadow jumping mouse

PRG	preliminary remediation goal
RCEU	Rock Creek Drainage Exposure Unit
RFETS	Rocky Flats Environmental Technology Site
RI/FS	Remedial Investigation/Feasibility Study
tESL	threshold ESL
UCL	upper confidence limit
UTL	upper tolerance limit
WRW	wildlife refuge worker

1.0 INTRODUCTION

This attachment presents the results for the statistical analyses and professional judgment evaluation used to select human health contaminants of concern (COCs) as part of the Human Health Risk Assessment (HHRA) and ecological contaminants of potential concern (ECOPCs) as part of the Ecological Risk Assessment (ERA) for the Rock Creek Drainage Exposure Unit (EU) (RCEU) at the Rocky Flats Environmental Technology Site (RFETS). The methods used to perform the statistical analysis and to develop the professional judgment sections are described in Appendix A, Volume 2, Section 2 of the Resource Conservation and Recovery Act (RCRA) Facility Investigation-Remedial Investigation/Corrective Measures Study (CMS)-Feasibility Study (RI/FS) Report (hereafter referred to as the RI/FS Report) and follow the Final Comprehensive Risk Assessment (CRA) Work Plan and Methodology (DOE 2005).

2.0 RESULTS OF STATISTICAL COMPARISONS TO BACKGROUND FOR THE ROCK CREEK DRAINAGE EXPOSURE UNIT

The results of the statistical background comparisons for inorganic and radionuclide potential contaminants of concern (PCOCs) and ecological contaminants of interest (ECOIs) in surface soil/surface sediment, subsurface soil/subsurface sediment, surface soil, and subsurface soil samples collected from the RCEU are presented in this section. Box plots are provided for analytes that were carried forward into the statistical comparison step and are presented in Figures A3.2.1 to A3.2.17.[1] The box plots display several reference points: 1) the line inside the box is the median; 2) the lower edge of the box is the 25th percentile; 3) the upper edge of the box is the 75th percentile; 4) the upper lines (called whiskers) are drawn to the greatest value that is less than or equal to 1.5 times the inter-quartile range (the interquartile range is between the 75th and 25th percentiles); 5) the lower whiskers are drawn to the lowest value that is greater than or equal to 1.5 times the inter-quartile range; and 6) solid circles are data points greater or less than the whiskers.

ECOIs for surface soil (Preble's meadow jumping mouse [PMJM] receptor) and PCOCs with concentrations in the RCEU that are statistically greater than background (or those where background comparisons were not performed) are carried through to the professional judgment step of the COC/ECOPC selection processes. ECOIs (for non-PMJM receptors) with concentrations in the RCEU that are statistically greater than background (or those where background comparisons were not performed) are carried

[1] Statistical background comparisons are not performed for analytes if: 1) the background concentrations are nondetections; 2) background data are unavailable; 3) the analyte has low detection frequency in the RCEU or background data set (less than 20 percent); or 4) the analyte is an organic compound. Box plots are not provided for these analytes. However, these analytes are carried forward into the professional judgment evaluation.

through to the upper-bound exposure point concentration (EPC) – threshold ecological screening level (tESL) comparison step of the ECOPC selection processes.

PCOCs and ECOIs with concentrations that are not statistically greater than background are not identified as COCs/ECOPCs and are not evaluated further.

2.1 Surface Soil/Surface Sediment Data Used in the HHRA

For the RCEU surface soil/surface sediment data set, the maximum detected concentrations (MDCs) and upper confidence limits on the mean (UCLs) for arsenic, manganese, cesium-134, cesium-137, and radium-228 exceed the wildlife refuge worker (WRW) preliminary remediation goals (PRGs) for the RCEU data set, and these PCOCs were carried forward into the statistical background comparison step. The RCEU MDC for iron exceeds the PRG, but the UCL for the RCEU data set does not exceed the PRG, and this analyte was not evaluated further. The results of the statistical comparison of the RCEU surface soil/surface sediment data to background data for these PCOCs are presented in Table A3.2.1 and the summary statistics for background and RCEU surface soil/surface sediment data are shown in Table A3.2.2. The RCEU MDCs for all other PCOCs do not exceed the PRGs and were not evaluated further.

The results of the statistical comparisons of the RCEU surface soil/surface sediment data to background data indicate the following:

Statistically Greater than Background at the 0.1 Significance Level

- Arsenic
- Manganese

Not Statistically Greater than Background at the 0.1 Significance Level

- None

Background Comparison Not Performed[1]

- Cesium-134
- Cesium-137
- Radium-228

2.2 Subsurface Soil/Subsurface Sediment Data Used in the HHRA

For the RCEU PCOCs in subsurface soil/subsurface sediment, the MDCs and UCLs do not exceed the PRGs. Therefore, no analytes were carried forward into the statistical background comparison step.

2.3 Surface Soil Data Used in the ERA (Non-PMJM)

For the ECOIs in surface soil, the MDCs for aluminum, arsenic, barium, boron, cadmium, tin, chromium, cobalt, copper, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, vanadium, and zinc exceed a non-PMJM ecological screening level (ESL), and these ECOIs were carried forward into the statistical background comparison step. The MDCs for bis(2-ethylhexyl)phthalate and di-n-butylphthalate also exceed a non-PMJM ESL. The results of the statistical comparison of RCEU surface soil data to background data are presented in Table A3.2.3 and the summary statistics for background and RCEU surface soil data are shown in Table A3.2.4.

The results of the statistical comparisons of the RCEU surface soil to background data indicate the following:

Statistically Greater than Background at the 0.1 Significance Level

- Aluminum
- Barium
- Chromium
- Lithium
- Manganese
- Nickel
- Vanadium
- Zinc

Not Statistically Greater than Background at the 0.1 Significance Level

- Arsenic
- Cadmium
- Cobalt
- Copper
- Lead
- Mercury
- Selenium

***Background Comparison not Performed*[1]**

- Boron
- Molybdenum
- Tin
- Bis(2 ethylhexyl)phthalate
- di-n-butylphthalate

2.4 Surface Soil Data Used in the ERA (PMJM)

For the ECOIs in surface soil in PMJM habitat, the MDCs for arsenic, chromium, manganese, molybdenum, nickel, selenium, tin, vanadium, and zinc exceed the PMJM ESLs, and were carried forward into the background comparison step. The results of the statistical comparison of the RCEU surface soil data to background data are presented in Table A3.2.5 and the summary statistics for background and RCEU surface soil data are shown in Table A3.2.6.

The results of the statistical comparisons of the RCEU surface soil in PMJM habitat to background data indicate the following:

Statistically Greater than Background at the 0.1 Significance Level

- Chromium
- Manganese
- Nickel
- Vanadium

Not Statistically Greater than Background at the 0.1 Significance Level

- Arsenic
- Selenium
- Zinc

***Background Comparison not Performed*[1]**

- Molybdenum
- Tin

2.5 Subsurface Soil Data Used in the ERA

For the ECOIs in subsurface soil, the MDC for arsenic exceeds the prairie dog ESL and was carried forward into the statistical background comparison step. The MDCs for all other ECOIs do not exceed the prairie dog ESL. The results of the statistical comparison of RCEU subsurface soil data to background data are presented in Table A3.7 and the summary statistics for background and RCEU subsurface soil data are shown in Table A3.8.

The results of the statistical comparisons of the surface soil data to background data indicate the following:

Statistically Greater than Background at the 0.1 Significance Level

- Arsenic

Not Statistically Greater than Background at the 0.1 Significance Level

- None

Background Comparison not Performed[1]

- None

3.0 UPPER-BOUND EXPOSURE POINT CONCENTRATION COMPARISON TO LIMITING ECOLOGICAL SCREENING LEVELS

ECOIs in surface soil and subsurface soil with concentrations that are statistically greater than background, or background comparisons were not performed, are evaluated further by comparing the RCEU EPCs to the tESLs. The EPCs are the 95 percent UCLs of the 90th percentile [upper tolerance limit (UTL)] for small home-range receptors, the UCL for large home-range receptors, or the MDC in the event that the UCL or UTL is greater than the MDC.

3.1 ECOIs in Surface Soil

No ECOIs in surface soil (non-PMJM) were eliminated from further consideration because the EPCs are not greater than the limiting tESLs. Aluminum, barium, boron, chromium, lithium, manganese, molybdenum, nickel, tin, vanadium, and zinc along with two organics (bis(2-ethylhexyl)phthalate and di-n-butylphthalate) have EPCs greater than the limiting tESLs, and these are evaluated in the professional judgment evaluation screening step (Section 4.0).

3.2 ECOIs in Subsurface Soil

No ECOIs in subsurface soil were eliminated from further consideration because the EPCs are not greater than the tESLs. Arsenic has an EPC greater than the limiting tESL and is evaluated in the professional judgment evaluation screening step (Section 4.0).

4.0 PROFESSIONAL JUDGMENT

This section presents the results of the professional judgment step of the COC and ECOPC selection processes for the HHRA and ERA, respectively. Based on the weight of evidence evaluated in the professional judgment step, PCOCs and ECOIs are either included for further evaluation as COCs/ECOPCs in the risk characterization step, or excluded from further evaluation.

The professional judgment evaluation takes into account the following lines of evidence: process knowledge, spatial trends, pattern recognition[2], comparison to RFETS background and regional background data sets (see Table A3.4.1 for a summary of regional background data)[3], and risk potential. For PCOCs or ECOIs where the process knowledge and/or spatial trends indicate that the presence of the analyte in the EU may be a result of historical site-related activities, the professional judgment discussion includes only two of the lines of evidence listed above, and it is concluded that these analytes are COCs/ECOPCs and are carried forward into risk characterization. For the other PCOCs and ECOIs that are evaluated in the professional judgment step, each of the lines of evidence listed above is included in the discussion.

For metals, Appendix A, Volume 2, Attachment 8 of the RI/FS Report provides the details of the process knowledge and spatial trend evaluations. The conclusions from these evaluations are noted in this attachment.

The following PCOCs/ECOIs are evaluated further in the professional judgment step for RCEU:

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[2] The pattern recognition evaluation includes the use of probability plots. If two or more distinct populations are evident in the probability plot, this suggests that one or more local releases may have occurred. Conversely, if only one distinct low-concentration population is defined, likely representing a background population, a local release may or may not have occurred. Similar to all statistical methods, the probability plot has limitations in cases where there is inadequate sampling and the magnitude of the release is relatively small. Thus, absence of two clear populations in the probability plots is consistent with, but not definitive proof of, the hypothesis that no releases have occurred. However, if a release has occurred within the sampled area and has been included in the samples, then the elemental concentrations associated with that release are either within the background concentration range or the entire sampled population represents a release, a highly unlikely probability.

[3] The regional background data set for Colorado and the bordering states was extracted from data for the western United States (Shacklette and Boerngen 1984), and is composed of data from Colorado as well as Arizona, Kansas, Nebraska, New Mexico, Oklahoma, Utah, and Wyoming. Although the background data set for Colorado and the bordering states is not specific to Colorado's Front Range, it is useful for the professional judgment evaluation in the absence of a robust data set for the Front Range. Colorado's Front Range has highly variable terrain that changes elevation over short distances. Consequently, numerous soil types and geologic materials are present at RFETS, and the data set for Colorado and the bordering states provides regional benchmarks for naturally-occurring metals in soil. The comparison of RFETS's soil data to these regional benchmarks is only performed for non-PMJM professional judgment because the PMJM habitat is restricted to the front range of Colorado.

- Surface soil/surface sediment (HHRA)
  - Arsenic
  - Manganese
  - Cesium-137
  - Radium-228
- Subsurface soil/subsurface sediment (HHRA)
  - No PCOCs were found to be statistically greater than background and above a PRG in accordance with the COC selection process; therefore, no PCOCs in subsurface soil/subsurface sediment are evaluated using professional judgment.
- Surface soil for non-PMJM receptors (ERA)
  - Aluminum
  - Barium
  - Boron
  - Chromium
  - Lithium
  - Manganese
  - Molybdenum
  - Nickel
  - Tin
  - Vanadium
  - Zinc
  - bis(2-Ethylhexyl)phthalate
  - Di-n-butylphthalate
- Surface soil for PMJM receptors (ERA)
  - Chromium
  - Manganese
  - Molybdenum
  - Nickel
  - Tin
  - Vanadium
- Subsurface soil (ERA)
  - Arsenic

The following sections provide the professional judgment evaluations by analyte and medium for the PCOCs/ECOIs listed above.

4.1 Aluminum

Aluminum has an EPC in surface soil (for non-PMJM receptors) greater than the tESL and, therefore, was carried forward to the professional judgment step. The lines of evidence used to determine whether aluminum should be retained for risk characterization are summarized below.

4.1.1 Summary of Process Knowledge

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, process knowledge indicates a potential for aluminum to have been released into RFETS soil because of the large aluminum metal inventory and presence of aluminum in waste generated during former operations. However, there are no Individual Hazardous Substance Sites (IHSSs) in the RCEU. Therefore aluminum is unlikely to be present in RCEU soil as a result of historical site-related activities.

4.1.2 Evaluation of Spatial Trends

Surface Soil (Non-PMJM)

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that aluminum concentrations in RCEU surface soil reflect variations in naturally occurring aluminum.

4.1.3 Pattern Recognition

Surface Soil (Non-PMJM)

The probability plot for aluminum in surface soil (Figure A3.4.1) suggests the presence of a single population, which is indicative of background conditions.

4.1.4 Comparison to RFETS Background and Other Background Data Sets

Surface Soil (Non-PMJM)

Aluminum concentrations in RCEU surface soil range from 7,420 to 21,800 milligrams per kilogram (mg/kg) with a mean concentration of 14,530 mg/kg and a standard deviation of 3,375 mg/kg. Aluminum concentrations in the background data set range from 4,050 to 17,100 mg/kg, with a mean concentration of 10,203 mg/kg and a standard deviation of 3,256 mg/kg (Table A3.2.4). The concentrations of aluminum in surface soil samples at the RCEU are slightly elevated compared to background but the data populations overlap considerably.

Aluminum concentrations RCEU surface soil are well within the range for aluminum in soils of Colorado and the bordering states (5,000 to 100,000 mg/kg, with a mean concentration of 50,800 mg/kg and a standard deviation of 23,500 mg/kg) (Table A3.4.1).

4.1.5 Risk Potential for Plants and Wildlife

Surface Soil (Non-PMJM)

The MDC for aluminum in the RCEU (21,800 mg/kg) exceeds the no observed adverse effect level (NOAEL) ESL for only one receptor group, terrestrial plants (50 mg/kg). However, U.S. Environmental Protection Agency (EPA) Ecological Soil Screening Level (Eco-SSL) guidance (EPA 2003) for aluminum recommends that aluminum should not be considered an ECOPC for soils at sites where the soil pH exceeds 5.5 due to its limited bioavailability in non-acidic soils. The average pH value for RFETS surface soils is 8.2. Therefore, aluminum concentrations in RCEU surface soil are unlikely to result in risk concerns for wildlife populations.

4.1.6 Conclusion

The weight of evidence presented above shows that aluminum concentrations in RCEU surface soil (non-PMJM receptors) are not likely to be a result of historical site-related activities based on process knowledge; a spatial distribution that suggests aluminum is naturally occurring; a probability plot that suggests the presence of a single population which is also indicative of background conditions; RCEU concentrations that are well within regional background levels; and RCEU concentrations that are unlikely to result in risk concerns for wildlife populations. Aluminum is not considered an ECOPC in surface soil for the RCEU and, therefore, is not further evaluated quantitatively.

4.2 Arsenic

Arsenic has concentrations statistically greater than background in surface soil/surface sediment and in subsurface soil and, therefore, was carried forward to the professional judgment step. The lines of evidence used to determine whether arsenic should be retained for risk characterization are summarized below.

4.2.1 Summary of Process Knowledge

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, process knowledge indicates arsenic is unlikely to be present in RCEU soil as a result of historical site-related activities.

4.2.2 Evaluation of Spatial Trends

Surface Soil/Surface Sediment

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that arsenic concentrations in RCEU surface soil/surface sediment reflect variations in naturally occurring arsenic.

Subsurface Soil

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that arsenic concentrations in RCEU subsurface soil reflect variations in naturally occurring arsenic.

4.2.3 Pattern Recognition

Surface Soil/Surface Sediment

The probability plot for arsenic in surface soil/surface sediment (Figure A3.4.2) suggests the presence of a single population which is indicative of background conditions. Although the highest concentration of arsenic does not fit the distribution of the other data, this single data point does not provide sufficient evidence of a second population.

Subsurface Soil

The probability plot for arsenic in subsurface soil (Figure A3.4.3) suggests the presence of a single population, which is indicative of background conditions.

4.2.4 Comparison to RFETS Background and Other Background Data Sets

Surface Soil/Surface Sediment

Arsenic concentrations in RCEU surface soil/surface sediment range from 1.70 to 15.0 mg/kg, with a mean concentration of 5.89 mg/kg and a standard deviation of 2.29 mg/kg. Arsenic concentrations in the background data set range from 0.27 to 9.6 mg/kg, with a mean concentration of 3.42 mg/kg and a standard deviation of 2.55 mg/kg (Table A3.2.2). The range of concentrations of arsenic in the RCEU and background samples overlap considerably with only one detection (9.6 mg/kg) greater than the background MDC.

Arsenic concentrations RCEU surface soil/surface sediment are well within the range for arsenic in soils of Colorado and the bordering states (1.22 to 97 mg/kg, with a mean concentration of 6.9 mg/kg and a standard deviation of 7.64 mg/kg) (Table A3.4.1).

Subsurface Soil

Arsenic concentrations in RCEU subsurface soil range from 2.50 to 13.1 mg/kg, with a mean concentration of 8.08 mg/kg and a standard deviation of 4.07 mg/kg. Arsenic concentrations in the background data set range from 1.70 to 41.8 mg/kg, with a mean concentration of 5.48 mg/kg and a standard deviation of 6.02 mg/kg (Table A3.2.8). The range of arsenic concentrations in the RCEU and background samples overlap considerably, with the background MDC greater than the RCEU MDC.

4.2.5 Risk Potential for HHRA

Surface Soil/Surface Sediment

The arsenic MDC for surface soil/surface sediment is 15.0 mg/kg and the UCL is 6.20 mg/kg. The UCL is less than three times greater than the PRG (2.41 mg/kg), with 45 of the 51 detections greater than the PRG. Because the PRG is based on an excess carcinogenic risk of 1E-06, the cancer risk based on the UCL concentration is less than 3E-06, and is well within the National Contingency Plan (NCP) risk range of 1E-06 to 1E-04. Arsenic was detected in 67 of 73 background samples, and detected concentrations in 39 of the 67 samples exceeded the PRG. The background UCL for arsenic in surface soil/surface sediment is 4.03 mg/kg (Appendix A, Volume 2, Attachment 9 of the RI/FS Report), which equates to a cancer risk of 2E-06. Therefore, the excess cancer risks to the WRW from exposure to arsenic in surface soil/surface sediment in the RCEU is similar to background risk.

4.2.6 Risk Potential for Plants and Wildlife

Subsurface Soil

The MDC and UTL for arsenic in RCEU (13.1 mg/kg) subsurface soil exceed the NOAEL ESL for the prairie dog (9.35 mg/kg). However, the MDC is less than the mammalian Eco-SSL of 46 mg/kg (EPA 2005a). The ESL is also less than the MDC for background subsurface soil concentrations. Because risks are not typically expected at background concentrations and the MDC is less than the Eco-SSL for mammals, arsenic is unlikely to result in risk concerns for burrowing mammals in the RCEU.

4.2.7 Conclusion

The weight of evidence presented above shows that arsenic concentrations in RCEU surface soil/surface sediment and subsurface soil are not likely to be a result of historical site-related activities based on process knowledge; spatial distribution suggests arsenic is naturally occurring; probability plots that suggest the presence of single arsenic data populations which are also indicative of background conditions; RCEU concentrations that are well within regional background levels; and RCEU concentrations that are unlikely to result in risks to humans significantly above background risks. Arsenic is not considered a COC in surface soil/surface sediment or an ECOPC in subsurface soil for the RCEU and, therefore, is not further evaluated quantitatively.

4.3 Barium

Barium has an EPC in surface soil (for non-PMJM receptors) greater than the limiting tESL and, therefore, was carried forward to the professional judgment step. The lines of evidence used to determine whether barium should be retained for risk characterization are summarized below.

4.3.1 Summary of Process Knowledge

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, process knowledge indicates barium is unlikely to be present in RFETS soil as a result of historical site-related activities.

4.3.2 Evaluation of Spatial Trends

Surface Soil (Non-PMJM)

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that barium concentrations in RCEU surface soil reflect variations in naturally occurring barium.

4.3.3 Pattern Recognition

Surface Soil (Non-PMJM)

The probability plot for barium in surface soil (Figure A3.4.4) indicates two separate populations: one population extending from 110 to approximately 150 mg/kg, and a second population extending from 160 to 470 mg/kg. Because of the absence of sources in the RCEU, the two populations appear to be different due to background geologic conditions.

4.3.4 Comparison to RFETS Background and Other Background Data Sets

Surface Soil (Non-PMJM)

Barium concentrations in RCEU surface soil range from 110 to 470 mg/kg, with a mean concentration of 168 mg/kg and a standard deviation of 73.9 mg/kg. Barium concentrations in the background data set range from 45.7 to 134 mg/kg, with a mean concentration of 102 and a standard deviation of 19.4 mg/kg (Table A3.2.4). The concentrations of barium in surface soil samples at the RCEU are slightly elevated compared to background, but the data populations do overlap considerably.

Barium concentrations RCEU surface soil are well within the range for barium in soils of Colorado and the bordering states (100 to 3,000 mg/kg, with mean concentration of 642 mg/kg and a standard deviation of 330 mg/kg) (Table A3.4.1).

4.3.5 Risk Potential for Plants and Wildlife

Surface Soil (Non-PMJM)

The UTL for barium in the RCEU (324 mg/kg) exceeds the NOAEL ESL of only one receptor group, the herbivorous mourning dove (159 mg/kg). The NOAEL ESLs for all other non-PMJM receptors were greater than the UTL. Although there is no Eco-SSL for birds, the UTL of 324 mg/kg is less than the available Eco-SSLs for soil invertebrates (330 mg/kg) and mammals (2,000 mg/kg) (EPA 2005b).

4.3.6 Conclusion

The weight of evidence presented above shows that barium concentrations in RCEU surface soil (non-PMJM receptors) are not likely to be a result of historical site-related activities based on process knowledge; a spatial distribution that suggests barium is naturally occurring; and RCEU concentrations that are well within regional background levels. Although there are two data populations present for RCEU surface soil, the absence of historical sources suggests this represents two background geologic conditions. Barium is not considered an ECOPC in surface soil for the RCEU and, therefore, is not further evaluated quantitatively.

4.4 Bis(2-ethylhexyl)phthalate

Bis(2-ethylhexyl)phthalate has an EPC in surface soil (for non-PMJM receptors) greater than the limiting tESL and, therefore, was carried forward to the professional judgment step. The lines of evidence used to determine whether bis(2-ethylhexyl)phthalate should be retained for risk characterization are summarized below.

4.4.1 Summary of Process Knowledge

There are no documented historical source areas present in the RCEU, and no documented operations or activities that occurred in the RCEU involving the use of bis(2-ethylhexyl)phthalate (CDH 1991; DOE 1995). Therefore, the potential for bis(2-ethylhexyl)phthalate to be present in RCEU surface soil as a result of historical site-related activities is unlikely.

4.4.2 Evaluation of Spatial Trends

Surface Soil (Non-PMJM)

Bis(2-ethylhexyl)phthalate was detected in 23.5 percent of the RCEU surface soil samples. The detections are estimated values well below the reported detection limits of 330 to 480 micrograms per kilogram (μg/kg). As shown in Figure A3.4.5, the detections occur randomly throughout the RCEU, and only at one location is the concentration greater than the ESL.

4.4.3 Pattern Recognition

Surface Soil (Non-PMJM)

Bis(2-ethylhexyl)phthalate is not naturally occurring and, therefore, a pattern recognition analysis is not applicable.

4.4.4 Comparison to RFETS Background and Other Background Data Sets

Surface Soil (Non-PMJM)

Bis(2-ethylhexyl)phthalate is not naturally occurring and, therefore, a comparison to background analysis is not applicable.

4.4.5 Risk Potential for Plants and Wildlife

Surface Soil (Non-PMJM)

The UTL for bis(2-ethylhexyl)phthalate (240 J µg/kg) exceeds the NOAEL ESL for seven ecological receptors (herbivorous mourning dove, insectivorous mourning dove, American kestrel, insectivorous deer mouse, carnivorous coyote, insectivorous coyote, and generalist coyote).

4.4.6 Conclusion

The weight of evidence presented above shows that bis(2-ethylhexyl)phthalate concentrations in RCEU surface soil (non-PMJM receptors) are not likely to be a result of historical site-related activities based on process knowledge. Bis(2-ethylhexyl)phthalate is not considered an ECOPC in surface soil for the RCEU and, therefore, is not further evaluated quantitatively.

4.5 Boron

For boron in surface soil, a statistical comparison between RCEU and RFETS background data could not be performed because RFETS background surface soil samples were not analyzed for boron. Boron has an EPC in surface soil (for non-PMJM receptors) greater than the limiting tESL and, therefore, was carried forward to the professional judgment step. The lines of evidence used to determine whether boron should be retained for risk characterization are summarized below.

4.5.1 Summary of Process Knowledge

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, process knowledge indicates boron is unlikely to be present in RFETS soil as a result of historical site-related activities.

4.5.2 Evaluation of Spatial Trends

Surface Soil (Non-PMJM)

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that boron concentrations in RCEU surface soil reflect variations in naturally occurring boron.

4.5.3 Pattern Recognition

Surface Soil (Non-PMJM)

The probability plot for the detected boron concentrations suggest a single population, which is indicative of background conditions (Figure A3.4.6).

4.5.4 Comparison to RFETS Background and Other Background Data Sets

Surface Soil (Non-PMJM)

The reported range for boron in surface soil within Colorado and the bordering states is 20 to 150 mg/kg, with a mean concentration of 27.9 mg/kg and a standard deviation of 19.7 mg/kg (Table A3.4.1). Boron concentrations reported in surface soil samples at the RCEU is 3.90 to 7.90 mg/kg, with a mean concentration of 5.72 mg/kg and a standard deviation of 1.00 mg/kg (Table A3.2.4). The range of concentrations of boron in surface soil in the RCEU is well within the range for boron in soils of Colorado and the bordering states.

4.5.5 Risk Potential for Plants and Wildlife

Surface Soil (Non-PMJM)

The UTL for boron in the RCEU (7.7 mg/kg) exceeds the NOAEL ESL for only one receptor group, terrestrial plants (0.5 mg/kg). All other NOAEL ESLs were greater than the UTL and ranged from 30 to 6,070 mg/kg. Site-specific background data for boron were not available, but the MDC did not exceed the low end (20 mg/kg) of the background range presented in Shacklette and Boerngen (1984). This indicates the terrestrial plant NOAEL ESL (0.5 mg/kg) is well below expected background concentrations and, because risks are not typically expected at background concentrations, boron concentrations are not likely to be indicative of site-related risk to the terrestrial plant community in the RCEU. Kabata-Pendias and Pendias (1992) indicate soil with boron concentrations equal to 0.3 mg/kg is critically deficient in boron, and effects on plant reproduction would be expected. Additionally, the summary of boron toxicity in Efroymson et al. (1997) notes that the source of the 0.5-mg/kg NOAEL ESL indicates boron was toxic when added at 0.5 mg/kg to soil, but gives no indication of the boron concentration in the baseline soil before addition. The confidence placed by Efroymson et al. (1997) was low. No boron Eco-SSLs are currently available. Because no NOAEL ESLs other than the terrestrial plant NOAEL ESL are exceeded by the MDC, boron is unlikely to present a risk to terrestrial receptors in the RCEU.

4.5.6 Conclusion

The weight of evidence presented above shows that boron concentrations in RCEU surface soil (non-PMJM receptors) are not likely to be a result of historical site-related activities based on process knowledge; a spatial distribution that suggests boron is naturally occurring; a probability plot that suggests the presence of a single population which is also indicative of background conditions; RCEU concentrations that are well within regional background levels; and RCEU concentrations that are unlikely to result in risk concerns for wildlife populations. Boron is not considered an ECOPC in surface soil for the RCEU and, therefore, is not further evaluated quantitatively.

4.6 Cesium-137

Cesium-137 has activities statistically greater than background in surface soil/surface sediment and, therefore, was carried forward to the professional judgment step. The lines of evidence used to determine whether cesium-137 should be retained for risk characterization are summarized below.

4.6.1 Summary of Process Knowledge

The ChemRisk Task 1 Report did not identify cesium-137 as a radionuclide used at RFETS (CDH 1991) and no cesium-137 waste was reported to have been generated. It is unlikely that cesium-137 is present in soil at RFETS as a result of historical site-related activities.

4.6.2 Evaluation of Spatial Trends

Surface Soil/Surface Sediment

As shown in Figure A3.4.7, cesium-137 activity exceeds the PRG of 0.221 picocuries per gram (pCi/g) at locations throughout the RCEU. There are only two locations where the cesium-137 concentration exceeds the background MDC, and neither is situated near Individual Hazardous Substance Sites (IHSSs) since no historical IHSSs are designated in the RCEU. Thus it appears that cesium-137 activity in RCEU surface soil reflect variations in background levels of this radionuclide.

4.6.3 Pattern Recognition

Surface Soil/Surface Sediment

The probability plot for cesium-137 activity suggests a single population, which is indicative of background conditions (Figure A3.4.8).

4.6.4 Comparison to RFETS Background and Other Background Data Sets

Surface Soil/Surface Sediment

Cesium-137 activity in surface soil/surface sediment samples at the RCEU range from 0.103 to 2.50 pCi/g, with a mean concentration of 1.01 pCi/g and a standard deviation of 0.710 pCi/g, while the cesium-137 activities in the background data set range from -0.027 to 1.80 pCi/g, with a mean activity of 0.692 pCi/g and a standard deviation of 0.492 pCi/g (Table A3.2.2). The activities of cesium-137 in surface soil samples at the RCEU are slightly elevated compared to background, but the data populations do overlap considerably.

4.6.5 Risk Potential for HHRA

The cesium-137 PRG for surface soil/surface sediment is 0.221 pCi/g, while the UCL is approximately five times greater, at 1.14 pCi/g. Because the PRG is based on an excess carcinogenic risk of 1E-06, the cancer risk based on the UCL activity is approximately 5E-06, well within the NCP risk range of 1E-06 to 1E-04.

4.6.6 Conclusion

The weight of evidence presented above shows that cesium-137 concentrations in RCEU surface soil/surface sediment are not likely to be a result of historical site-related activities based on process knowledge; a spatial distribution which suggests cesium-137 is at fallout levels; a probability plot that suggests the presence of a single population which is also indicative of fallout levels; and RCEU activities that are unlikely to result in significant risks to humans. Cesium-137 is not considered a COC in surface soil/surface sediment for the RCEU and, therefore, is not further evaluated quantitatively.

4.7 Chromium

Chromium has an EPC in surface soil (for non-PMJM receptors) greater than the tESL and, therefore, was carried forward to the professional judgment step. In addition, chromium in surface soil (for PMJM receptors) has concentrations statistically greater than background. The lines of evidence used to determine whether chromium should be retained for risk characterization are summarized below.

4.7.1 Summary of Process Knowledge

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, process knowledge indicates a potential for chromium to have been released into RFETS soil because of the moderate chromium metal inventory and presence of chromium in waste generated during former operations. Spills of chromium-contaminated wastes have also occurred at RFETS. However, there are no IHSSs in the RCEU. Therefore, chromium is unlikely to be present in RCEU soil as a result of historical site-related activities.

4.7.2 Evaluation of Spatial Trends

Surface Soil (Non-PMJM)

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that chromium concentrations in RCEU surface soil reflect variations in naturally occurring chromium.

Surface Soil (PMJM)

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that chromium concentrations in RCEU surface soil in PMJM habitat reflect variations in naturally occurring chromium.

4.7.3 Pattern Recognition

Surface Soil (Non-PMJM)

The probability plot for chromium suggests a single population, which is indicative of background conditions (Figure A3.4.9).

4.7.4 Comparison to RFETS Background and Other Background Data Sets

Surface Soil (Non-PMJM)

Chromium concentrations in surface soil samples at the RCEU range from 9.00 to 22.0 mg/kg, with a mean concentration of 15.4 mg/kg and a standard deviation of 2.78 mg/kg. Chromium concentrations in the background data set range from 5.50 to 16.9 mg/kg, with a mean concentration of 11.2 mg/kg and a standard deviation of 2.78 mg/kg (Table A3.2.4). The concentrations of chromium in surface soil samples at the RCEU are slightly elevated compared to background, but the data populations do overlap considerably.

Chromium concentrations reported in surface soil samples at the RCEU are well within the range for chromium in soils of Colorado and the bordering states (3 to 500 mg/kg, with mean concentration of 48.2 mg/kg and a standard deviation of 41 mg/kg) (Table A3.4.1).

Surface Soil (PMJM)

Chromium concentrations in surface soil samples in PMJM habitat at the RCEU range from 9.00 to 21.6 mg/kg, with a mean concentration of 15.2 mg/kg and a standard deviation of 2.93 mg/kg. Chromium concentrations in the background data set range from 5.50 to 16.9 mg/kg, with a mean concentration of 11.2 mg/kg and a standard deviation of 2.78 mg/kg (Table A3.2.6). The concentrations of chromium in surface soil samples at the RCEU are slightly elevated compared to background, but the data populations do overlap considerably.

Chromium concentrations reported in surface soil samples at the RCEU are well within the range for chromium in soils of Colorado and the bordering states (3 to 500 mg/kg, with mean concentration of 48.2 mg/kg and a standard deviation of 41 mg/kg) (Table A3.4.1).

4.7.5 Risk Potential for Plants and Wildlife

Surface Soil (Non-PMJM)

The UTL for chromium in the RCEU (20.2 mg/kg) exceeds the NOAEL ESL for five receptor groups: terrestrial plants (1 mg/kg), terrestrial invertebrates (0.4 mg/kg), mourning dove insectivore (1.34 mg/kg), American kestrel (14.0 mg/kg), and deer mouse insectivore (15.9 mg/kg). All other NOAEL ESLs were greater than the UTL and ranged from 24.6 to 4,173 mg/kg. All of these ESLs are less than the MDC in background surface soils. The chromium ESLs are based on toxicity of hexavalent chromium, which is likely to represent only a small fraction of the total chromium detected in soils. The mammalian ESLs for trivalent chromium are considerably greater than the hexavalent chromium ESLs. The UTL of 19 mg/kg was also less than the avian Eco-SSL for trivalent chromium of 26 mg/kg, the mammalian Eco-SSLs for trivalent chromium (34 mg/kg) and hexavalent chromium (81 mg/kg) (EPA 2005c). No chromium Eco-SSLs are currently available for plants, invertebrates and birds (hexavalent chromium only).

Surface Soil (PMJM)

The MDC for chromium in the RCEU (21.6 mg/kg) exceeds the NOAEL ESL for PMJM (19.3). The chromium ESL is based on toxicity of hexavalent chromium, which is likely to represent only a small fraction of the total chromium detected in soils. The PMJM ESL for trivalent chromium is equal to 16,100 mg/kg. This indicates that the ESL based on hexavalent chromium may be overly conservative for use in assessing risk to the PMJM. In addition, the UTL of 21.6 mg/kg was less than the mammalian Eco-SSLs for trivalent chromium (34 mg/kg) and hexavalent chromium (81 mg/kg) (EPA 2005c).

4.7.6 Conclusion

The weight of evidence presented above shows that chromium concentrations in RCEU surface soil (PMJM and non-PMJM receptors) are not likely to be a result of historical site-related activities based on process knowledge; a spatial distribution that suggests chromium is naturally occurring; a probability plot that suggests the presence of a single population which is also indicative of background conditions; and RCEU concentrations that are well within regional background levels. Chromium is not considered an ECOPC in surface soil for the RCEU and, therefore, is not further evaluated quantitatively.

4.8 Di-n-butylphthalate

Di-n-butylphthalate has an EPC in surface soil (for non-PMJM receptors) greater than the limiting tESL and, therefore, was carried forward to the professional judgment step. The lines of evidence used to determine whether di-n-butylphthalate should be retained risk characterization are summarized below.

4.8.1 Summary of Process Knowledge

There are no documented historical source areas present in the RCEU and no documented operations or activities that occurred in RCEU involving the use of di-n-butylphthalate (CDH 1991; DOE 1995). Therefore, the potential for di-n-butylphthalate to be present in RCEU surface soil as a result of historical site-related activities is unlikely.

4.8.2 Evaluation of Spatial Trends

Surface Soil (Non-PMJM)

Di-n-butylphthalate was detected only twice (39 µg/kg and 44 µg/kg), and in both instances the concentration exceeds the ESL of 16 µg/kg. As shown in Figure A3.4.10, the locations of the detections are not near an IHSS given that no historical IHSSs were located in the RCEU. Thus, it appears that di-n-butylphthalate concentrations in RCEU surface soil do not show a pattern of release.

4.8.3 Pattern Recognition

Surface Soil (Non-PMJM)

Di-n-butylphthalate is not naturally occurring and, therefore, a pattern recognition analysis is not applicable.

4.8.4 Comparison to RFETS Background and Other Background Data Sets

Surface Soil (Non-PMJM)

Di-n-butylphthalate is not naturally occurring and, therefore, a comparison to background analysis is not applicable.

4.8.5 Risk Potential for Plants and Wildlife

Surface Soil (Non-PMJM)

The UTL for di-n-butylphthalate (240 J μg/kg) exceeds the NOAEL ESL for two ecological receptors (insectivorous mourning dove and American kestrel).

4.8.6 Conclusion

The weight of evidence presented above shows that di-n-butylphthalate concentrations in RCEU surface soil (non-PMJM receptors) are not likely to be a result of historical site-related activities based on process knowledge. Di-n-butylphthalate is not considered an ECOPC in surface soil for the RCEU and, therefore, is not further evaluated quantitatively.

4.9 Lithium

Lithium has an EPC in surface soil (for non-PMJM receptors) greater than the limiting tESL and, therefore, was carried forward to the professional judgment step. The lines of evidence used to determine if lithium should be retained for risk characterization are summarized below.

4.9.1 Summary of Process Knowledge

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, process knowledge indicates a potential for lithium to have been released into RFETS soil because of the moderate lithium metal inventory and presence of lithium in waste generated during former operations. However, there are no IHSSs in the RCEU. Therefore, lithium is unlikely to be present in RCEU soil as a result of historical site-related activities.

4.9.2 Evaluation of Spatial Trends

Surface Soil (Non-PMJM)

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that lithium concentrations in RCEU surface soil reflect variations in naturally occurring lithium.

4.9.3 Pattern Recognition

Surface Soil (Non-PMJM)

The probability plot for lithium concentrations suggests a single population, which indicates background conditions (Figure A3.4.11).

4.9.4 Comparison to RFETS Background and Other Background Data Sets

Surface Soil (Non-PMJM)

Lithium concentrations in surface soil samples at the RCEU range from 6.80 to 17.7 mg/kg, with a mean concentration of 11.5 mg/kg and a standard deviation of 2.33 mg/kg. Lithium concentrations in the background data set range from 4.80 to 11.6 mg/kg, with a mean concentration of 7.66 mg/kg and a standard deviation of 1.89 mg/kg (Table A3.2.4). The concentrations of lithium in surface soil samples at the RCEU are slightly elevated compared to background, but the data populations do overlap considerably.

Lithium concentrations reported in surface soil samples at the RCEU are well within the range for lithium in soils of Colorado and the bordering states (5 to 130 mg/kg, with mean concentration of 25.3 mg/kg and a standard deviation of 14.4 mg/kg) (Table A3.4.1).

4.9.5 Risk Potential for Plants and Wildlife

Surface Soil (Non-PMJM)

The UTL for lithium in the RCEU (16 mg/kg) exceeds the NOAEL ESL for only one receptor group, terrestrial plants (2 mg/kg). All other NOAEL ESLs were greater than the UTL and ranged from 610 to 18,431 mg/kg. The ESL for terrestrial plants is also lower than all detected background concentrations. The authors of the document from which the lithium NOAEL ESL for plants was selected (Efroymson et al. 1997) placed a low confidence rating on the value. Other studies reported in Efroymson et al. (1997) cited no observed adverse effects at 25 mg/kg, which is greater than the MDC. No lithium Eco-SSLs are currently available.

4.9.6 Conclusion

The weight of evidence presented above shows that lithium concentrations in RCEU surface soil (non-PMJM receptors) are not likely to be a result of historical site-related activities based on process knowledge; a spatial distribution indicative of naturally occurring lithium; a probability plot that suggests the presence of a single population which is also indicative of background conditions; and RCEU concentrations that are well within regional background levels. Lithium is not considered an ECOPC in surface soil for the RCEU and, therefore, is not further evaluated quantitatively.

4.10 Manganese

Manganese has concentrations statistically greater than background in surface soil/surface sediment and in surface soil in PMJM habitat in the RCEU. Manganese also has an EPC in surface soil (for non-PMJM receptors) greater than the limiting tESL. Therefore, manganese in surface soil/surface sediment, surface soil (PMJM receptor), and surface soil (non-PMJM receptor) was carried forward to the professional judgment step. The lines of evidence used to determine if manganese should be retained for risk characterization are summarized below.

4.10.1 Summary of Process Knowledge

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, process knowledge indicates manganese is unlikely to be present in RFETS soil as a result of historical site-related activities.

4.10.2 Evaluation of Spatial Trends

Surface Soil/Surface Sediment

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that manganese concentrations in RCEU surface soil reflect variations in naturally occurring manganese.

Surface Soil (Non-PMJM)

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that manganese concentrations in RCEU surface soil reflect variations in naturally occurring manganese.

Surface Soil (PMJM)

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that manganese concentrations in RCEU surface soil in PMJM habitat reflect variations in naturally occurring manganese.

4.10.3 Pattern Recognition

Surface Soil/Surface Sediment

The probability plot for manganese concentrations suggests a single population, which indicates background conditions (Figure A3.4.12).

Surface Soil (Non-PMJM)

The probability plot of the natural logarithm of manganese concentrations indicates a single population extending from 160 to about 425 mg/kg, with two to three anomalous samples containing elevated manganese concentrations. The anomalous samples are too few to estimate the nature of this occurrence; however, because of the absence of sources in the RCEU, they could represent different background geologic conditions. (Figure A3.4.13).

4.10.4 Comparison to RFETS Background and Other Background Data Sets

Surface Soil/Surface Sediment

Manganese concentrations in surface soil/surface sediment samples at the RCEU range from 80.2 to 2,500 mg/kg, with a mean concentration of 385 mg/kg and a standard deviation of 446 mg/kg. Manganese concentrations in the background data set range from 9.00 to 1,280 mg/kg, with a mean concentration of 241 mg/kg and a standard deviation of 189 mg/kg (Table A3.2.2). The concentrations of manganese in surface soil samples at the RCEU are slightly elevated compared to background but the data populations do overlap considerably.

Manganese concentrations reported in surface soil samples at the RCEU are similar to the range for manganese in soils of Colorado and the bordering states (70 to 2,000 mg/kg, with a mean concentration of 414 mg/kg and a standard deviation of 272 mg/kg) (Table A3.4.1).

Surface Soil (Non-PMJM)

Manganese concentrations in surface soil samples at the RCEU range from 160 to 2,220 mg/kg, with a mean concentration of 363 mg/kg and a standard deviation of 333 mg/kg. Manganese concentrations in the background data set range from 129 to 357 mg/kg, with a mean concentration of 237 mg/kg and a standard deviation of 63.9 mg/kg (Table A3.2.4). The range of concentrations of manganese in the RCEU and background samples overlap considerably with only three of the 36 RCEU concentrations greater than the background MDC.

Manganese concentrations reported in surface soil samples at the RCEU are similar to the range for manganese in soils of Colorado and the bordering states (70 to 2,000 mg/kg, with mean concentration of 414 mg/kg and a standard deviation of 272 mg/kg) (Table A3.4.1).

Surface Soil (PMJM)

Manganese concentrations in surface soil samples at the RCEU range from 160 to 2,220 mg/kg, with a mean concentration of 405 mg/kg and a standard deviation of 447 mg/kg. Manganese concentrations in the background data set range from 129 to 357 mg/kg, with a mean concentration of 237 mg/kg and a standard deviation of 63.9 mg/kg (Table A3.2.6). The range of concentrations of manganese in the RCEU and background samples overlap considerably with only two of the 19 RCEU concentrations greater than the background MDC.

Manganese concentrations reported in surface soil samples at the RCEU are similar to the range for manganese in soils of Colorado and the bordering states (70 to 2,000 mg/kg, with mean concentration of 414 mg/kg and a standard deviation of 272 mg/kg) (Table A3.4.1).

4.10.5 Risk Potential for HHRA

Surface Soil/Surface Sediment

The manganese UCL for surface soil/surface sediment is 641 mg/kg. The UCL is less than two times greater than the PRG (419 mg/kg), with seven of the 51 detections greater than the PRG. The PRG is based on a hazard quotient (HQ) of 0.1, therefore the risk to human health is well below the EPA guideline of an HQ of 1.

4.10.6 Risk Potential for Plants and Wildlife

Surface Soil (Non-PMJM)

The UTL for manganese in the RCEU (734 mg/kg) exceeds the NOAEL ESL for three receptor groups: terrestrial plants (500 mg/kg), deer mouse herbivore (486 mg/kg), and prairie dog (221 mg/kg). All other NOAEL ESLs were greater than the UTL and ranged from 1,032 to 19,115 mg/kg. No manganese Eco-SSLs are currently available for any receptor (the manganese Eco-SSL document is “pending”).

Surface Soil (PMJM)

The MDC for manganese in the PMJM habitat within the RCEU (2,220 mg/kg) exceeds the NOAEL ESL for the PMJM (388 mg/kg).

4.10.7 Conclusion

The weight of evidence presented above shows that manganese concentrations in RCEU surface soil/surface sediment as well as surface soil (both non-PMJM and PMJM receptors) are not likely to be a result of historical site-related activities based on process knowledge; spatial distributions indicative of naturally occurring manganese; probability plots that suggest the presence of single populations which are also indicative of background conditions; RCEU concentrations that are near regional background levels; and RCEU concentrations that are unlikely to result in significant risks to humans. Manganese is not considered a COC in surface soil/surface sediment or an ECOPC for non-PMJM receptors in surface soil for the RCEU and, therefore, is not further evaluated quantitatively. However, manganese is identified as an ECOPC for PMJM receptors in the RCEU.

4.11 Molybdenum

For molybdenum in surface soil, a statistical comparison between RCEU and RFETS background data could not be performed because molybdenum was not detected in RFETS background surface soil samples. Molybdenum had an EPC in surface soil (for non-PMJM receptors) greater than the limiting tESL and, therefore, was carried forward to the professional judgment step. The lines of evidence used to determine if molybdenum should be retained for risk characterization are summarized below.

4.11.1 Summary of Process Knowledge

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, process knowledge indicates molybdenum is unlikely to be present in RFETS soil as a result of historical site-related activities.

4.11.2 Evaluation of Spatial Trends

Surface Soil (Non-PMJM)

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that molybdenum concentrations in RCEU surface soil reflect variations in naturally occurring molybdenum.

Surface Soil (PMJM)

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that molybdenum concentrations in RCEU surface soil in PMJM habitat reflect variations in naturally occurring molybdenum.

4.11.3 Pattern Recognition

Surface Soil (Non-PMJM)

Figure A3.4.14 is a probability plot of the molybdenum concentrations. This background population has a very limited range of detected values extending from 0.69 to 1.1 mg/kg, but with one anomalous sample containing an elevated molybdenum concentration of 2.7 mg/kg. The other data shown in the probability plot are for non-detects. Because of the heavy data censoring and varying detection limits, the probability plot for molybdenum has limited utility in identifying the presence of two or more populations.

4.11.4 Comparison to RFETS Background and Other Background Data Sets

Surface Soil (Non-PMJM)

The reported range for molybdenum in surface soil within Colorado and the bordering states is 3 to 7 mg/kg, with a mean concentration of 1.59 mg/kg and a standard deviation of 0.522 mg/kg (Table A3.4.1). Molybdenum concentrations reported in surface soil samples at the RCEU is 0.690 to 2.70 mg/kg, with a mean concentration of 1.25 mg/kg and a standard deviation of 0.708 mg/kg (Table A3.2.4). The range of concentrations of molybdenum in surface soil is below the range for molybdenum in soils of Colorado and the bordering states.

Surface Soil (PMJM)

The reported range for molybdenum in surface soil within Colorado and the bordering states is 3 to 7 mg/kg, with a mean concentration of 1.59 mg/kg and a standard deviation of 0.522 mg/kg (Table A3.4.1). Molybdenum concentrations reported in surface soil samples at the RCEU is 0.560 to 2.70 mg/kg, with a mean concentration of 1.26 mg/kg and a standard deviation of 0.734 mg/kg (Table A3.2.6). The range of concentrations of molybdenum in surface soil is below the range for molybdenum in soils of Colorado and the bordering states.

4.11.5 Risk Potential for Plants and Wildlife

Surface Soil (Non-PMJM)

The UTL for molybdenum in the RCEU (2.7 mg/kg) exceeds the NOAEL ESL for two receptor groups, terrestrial plants (2.0 mg/kg), and deer mouse insectivore (1.9 mg/kg). All other NOAEL ESLs were greater than the UTL and ranged from 6.97 to 275 mg/kg. Only the ESL for terrestrial plants is within the range of background concentrations. No molybdenum Eco-SSLs are currently available.

Surface Soil (PMJM)

The MDC for molybdenum within PMJM habitat in the RCEU (2.70 mg/kg) exceeds the NOAEL ESL for the PMJM (1.84 mg/kg).

4.11.6 Conclusion

The weight of evidence presented above shows that molybdenum concentrations in RCEU surface soil (PMJM and non-PMJM receptors) are not likely to be a result of historical site-related activities based on process knowledge, a spatial distribution that suggests molybdenum is naturally occurring, and RCEU concentrations that are well within regional background levels. Although the probability plot is inconclusive with regard to the presence of a single background population, molybdenum is not considered an ECOPC in surface soil for the RCEU and, therefore, is not further evaluated quantitatively.

4.12 Nickel

Nickel had an EPC in surface soil (for non-PMJM receptors) greater than the limiting tESL and, therefore, was carried forward to the professional judgment step. In addition, nickel in surface soil (for PMJM receptors) had concentrations statistically greater than background, and was carried forward to the professional judgment step. The lines of evidence used to determine if nickel should be retained for risk characterization are summarized below.

4.12.1 Summary of Process Knowledge

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, process knowledge indicates a potential for nickel to have been released into RFETS soil because of the moderate nickel metal inventory and presence of nickel in waste generated during former operations. However, there are no IHSSs in the RCEU. Therefore, nickel is unlikely to be present in RCEU soil as a result of historical site-related activities.

4.12.2 Evaluation of Spatial Trends

Surface Soil (Non-PMJM)

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that nickel concentrations in RCEU surface soil reflect variations in naturally occurring nickel.

Surface Soil (PMJM)

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that nickel concentrations in RCEU surface soil in PMJM habitat reflect variations in naturally occurring nickel.

4.12.3 Pattern Recognition

Surface Soil (Non-PMJM)

The probability plot for nickel concentrations suggests a single population which indicates background conditions (Figure A3.4.15).

4.12.4 Comparison to RFETS Background and Other Background Data Sets

Surface Soil (Non-PMJM)

Nickel concentrations in surface soil samples at the RCEU range from 7.8 to 25.0 mg/kg, with a mean concentration of 12.5 mg/kg and a standard deviation of 3.57 mg/kg. Nickel concentrations in the background data set range from 3.8 to 14.0 mg/kg, with a mean concentration of 9.6 mg/kg and a standard deviation of 2.59 mg/kg (Table A3.2.4). The range of concentrations of nickel in the RCEU and background samples overlap and the means are similar.

The reported range for nickel in surface soil within Colorado and the bordering states is 5 to 700 mg/kg, with a mean concentration of 18.8 mg/kg and a standard deviation of 39.8 mg/kg (Table A3.4.1). Nickel concentrations reported in surface soil samples at the RCEU is 7.80 to 25.0 mg/kg, with a mean concentration of 12.5 mg/kg and a standard deviation of 3.57 mg/kg (Table A3.2.4). The range of concentrations of nickel in surface soil is at the low end of the range for nickel in soils of Colorado and the bordering states.

Surface Soil (PMJM)

The reported range for nickel in surface soil within Colorado and the bordering states is 5 to 700 mg/kg, with a mean concentration of 18.8 mg/kg and a standard deviation of 39.8 mg/kg (Table A3.4.1). Nickel concentrations reported in surface soil samples at the RCEU is 8.20 to 25.0 mg/kg, with a mean concentration of 12.8 mg/kg and a standard deviation of 4.15 mg/kg (Table A3.2.6). The range of concentrations of nickel in surface soil is at the low end of the range for nickel in soils of Colorado and the bordering states.

4.12.5 Risk Potential for Plants and Wildlife

Surface Soil (Non-PMJM)

The UTL for nickel in the RCEU (18.7 mg/kg) exceeds the NOAEL ESL for six receptor groups: mourning dove insectivore (1.24 mg/kg), American kestrel (13.1 mg/kg), deer mouse herbivore (16.4 mg/kg), deer mouse insectivore (0.43 mg/kg), coyote generalist (6.02 mg/kg), and coyote insectivore (1.86 mg/kg). All other NOAEL ESLs were greater than the UTL and ranged from 30 to 200 mg/kg. All of the ESLs exceeded by the UTL (except deer mouse herbivore) are lower than the MDC in background surface soils (14 mg/kg). No nickel Eco-SSLs are currently available for any receptor (the nickel Eco-SSL document is “pending”).

Surface Soil (PMJM)

The MDC for nickel in PMJM habitat in the RCEU (25.0 mg/kg) exceeds the NOAEL ESL for PMJM (0.51 mg/kg). All 18 samples in PMJM habitat had concentrations greater than the NOAEL ESL of 0.5 mg/kg for the PMJM. The ESL is less than all background sample concentrations.

4.12.6 Conclusion

The weight of evidence presented above shows that nickel concentrations in RCEU surface soil (PMJM and non-PMJM receptors) are not likely to be a result of historical site-related activities based on process knowledge; a spatial distribution that suggests nickel is naturally occurring; a probability plot that suggests the presence of a single population which is also indicative of background conditions; and RCEU concentrations that are well within regional background levels. Nickel is not considered an ECOPC in surface soil for the RCEU and, therefore, is not further evaluated quantitatively.

4.13 Radium-228

Radium-228 has activities statistically greater than background in surface soil/surface sediment, and was carried forward to the professional judgment step. The lines of evidence used to determine if radium-228 should be retained for risk characterization are summarized below.

4.13.1 Summary of Process Knowledge

The ChemRisk Task 1 Report did not identify radium-228 as a radionuclide used at RFETS (CDH 1991) and no radium-228 waste was reported to have been generated. It is unlikely that radium-228 is present in soil at RFETS as a result of historical site-related activities.

4.13.2 Evaluation of Spatial Trends

Surface Soil/Surface Sediment

As shown in Figure A3.4.16, radium-228 concentrations exceed the PRG of 0.111 pCi/g at locations throughout the RCEU. There are no locations where the radium-228 concentration exceeds the background MDC, and none of the locations are near IHSSs since no historical IHSSs are designated in the RCEU. Thus, it appears that radium-228 activities in RCEU surface soil reflect variations in naturally occurring radium-228.

4.13.3 Pattern Recognition

Surface Soil/Surface Sediment

The probability plot for radium-228 activities suggests a single population, which is indicative of background conditions (Figure A3.4.17).

4.13.4 Comparison to RFETS Background and Other Background Data Sets

Surface Soil/Surface Sediment

Radium-228 activities in surface soil/surface sediment samples at the RCEU range from 1.30 to 2.90 picocuries per gram (pCi/g) with a mean activity of 2.01 pCi/g and a standard deviation of 0.572 pCi/g. The radium-228 activities in the background data set range from 0.200 to 4.10 pCi/g with a mean activities of 1.60 pCi/g and a standard deviation of 0.799 pCi/g (Table A3.2.2). The range of radium-228 activities in the RCEU and background samples considerably overlap and the means are similar. Furthermore, radium-228 activities in RCEU surface soil/surface sediment are all below the background MDC.

4.13.5 Risk Potential for HHRA

The radium-228 UCL for surface soil/surface sediment is 2.20 pCi/g. The PRG is 0.111 pCi/g, with all of the detections greater than the PRG. Because the PRG is based on an excess carcinogenic risk of 1E-06, the cancer risk based on the UCL activity is less than 2E-05, and is well within the NCP risk range of 1E-06 to 1E-04. Because the radium-228 activities appear to be naturally occurring, the excess cancer risks to the WRW from exposure to radium-228 in surface soil/surface sediment in the RCEU is similar to background risk.

4.13.6 Conclusion

The weight of evidence presented above shows that radium-228 activities in RCEU surface soil/surface sediment are not likely to be a result of historical site-related activities based on process knowledge; a spatial distribution indicative of naturally occurring radium-228; a probability plot that suggests the presence of a single population which is also indicative of background conditions; and RCEU activity that are unlikely to result in risks to humans significantly above background risks. Radium-228 is not considered a COC in surface soil/surface sediment or an ECOPC in surface soil for the RCEU and, therefore, is not further evaluated quantitatively.

4.14 Tin

For tin in surface soil, a statistical comparison between RCEU and RFETS background data could not be performed because tin was not detected in RFETS background surface soil samples. Tin has an EPC in surface soil (for non-PMJM receptors) greater than the limiting tESL and, therefore, was carried forward to the professional judgment step. The lines of evidence used to determine if tin should be retained for risk characterization are summarized below.

4.14.1 Summary of Process Knowledge

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, process knowledge indicates a potential for tin to have been released into RFETS soil because of the moderate tin metal inventory during former operations. However, there are no IHSSs in the RCEU. Therefore tin is unlikely to be present in RCEU soil as a result of historical site-related activities.

4.14.2 Evaluation of Spatial Trends

Surface Soil (Non-PMJM)

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that tin concentrations in RCEU surface soil reflect variations in naturally occurring tin.

Surface Soil (PMJM)

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that tin concentrations in RCEU surface soil in PMJM habitat reflect variations in naturally occurring tin.

4.14.3 Pattern Recognition

Surface Soil (Non-PMJM)

The probability plot for concentrations of tin suggests two populations (Figure A3.4.18). Two populations are possible but unusual in a natural setting. Review of the data indicates that these two populations represent two sampling events and, therefore, sampling and/or analytical methods may be the underlying cause.

4.14.4 Comparison to RFETS Background and Other Background Data Sets

Surface Soil (Non-PMJM)

The reported range for tin in surface soil within Colorado and the bordering states is 0.117 to 5.001 mg/kg, with a mean concentration of 1.15 mg/kg and a standard deviation of 0.772 mg/kg (Table A3.4.1). Tin concentrations reported in surface soil samples at the RCEU are 1.20 to 41.9 mg/kg, with a mean concentration of 13.7 mg/kg and a standard deviation of 14.0 mg/kg (Table A3.2.4). The range of concentrations of tin in surface soil is greater than the range for tin in soils of Colorado and the bordering states.

Surface Soil (PMJM)

The reported range for tin in surface soil within Colorado and the bordering states is 0.117 to 5.001 mg/kg, with a mean concentration of 1.15 mg/kg and a standard deviation of 0.772 mg/kg (Table A3.4.1). Tin concentrations reported in surface soil samples at the RCEU are 1.20 to 33.0 mg/kg, with a mean concentration of 10.1 mg/kg and a standard deviation of 12.3 mg/kg (Table A3.2.6). The range of concentrations of tin in surface soil is greater than the range for tin in soils of Colorado and the bordering states.

4.14.5 Risk Potential for Plants and Wildlife

Surface Soil (Non-PMJM)

The UTL for tin in the RCEU (41.3 mg/kg) exceeds the NOAEL ESL for six receptor groups: mourning dove herbivore (26.1 mg/kg), mourning dove insectivore (2.90 mg/kg), American kestrel (18.98 mg/kg), deer mouse insectivore (3.77 mg/kg), coyote generalist (36.1 mg/kg), and coyote insectivore (16.2 mg/kg). All other NOAEL ESLs were greater than the UTL and ranged from 45.0 to 242 mg/kg. None of the ESLs, except the ESLs for the mourning dove insectivore and deer mouse insectivore, are within the range of background concentrations. The NOAEL ESLs are modeled values based on a variety of exposure factors that are assumed to be similar to conditions at the site based on available information. The TRVs used in the derivation of the NOAEL ESLs may also have associated uncertainties, and the resulting NOAEL ESLs may be over-protective of some receptor groups (see Attachment 5). No tin Eco-SSLs are currently available. In addition, even though there was a moderate tin metal inventory during former operations, no known sources of tin contamination have been found in the RCEU; therefore, tin concentrations are most likely due to local variations in natural sources.

Surface Soil (PMJM)

The MDC for tin in PMJM habitat in the RCEU (33.0 mg/kg) exceeds the NOAEL ESL for the PMJM (4.22). The ESL is within the range of background concentrations. As stated above for non-PMJM receptors, the TRVs used in the derivation of the NOAEL

ESL may also have associated uncertainties, and the resulting NOAEL ESL for PMJM may be over-protective of some receptor groups (see Attachment 5).

4.14.6 Conclusion

The weight of evidence presented above shows that tin concentrations in RCEU surface soil are not likely to be a result of historical site-related activities based on process knowledge and a spatial distribution indicative of naturally occurring tin. The two populations of tin concentrations in the RCEU appear to be related to sampling and/or analytical methods. Tin is not considered an ECOPC in surface soil for non-PMJM receptors; however, tin is identified as an ECOPC for PMJM receptors for the RCEU.

4.15 Vanadium

Vanadium has an EPC in surface soil (for non-PMJM receptors) greater than the limiting tESL and, therefore, was carried forward to the professional judgment step. In addition, vanadium in surface soil (for PMJM receptors) has concentrations statistically greater than background, and was carried forward to the professional judgment step. The lines of evidence used to determine if vanadium should be retained as a COC are summarized below.

4.15.1 Summary of Process Knowledge

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, process knowledge indicates vanadium is unlikely to be present in RFETS soil as a result of historical site-related activities.

4.15.2 Evaluation of Spatial Trends

Surface Soil (Non-PMJM)

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that vanadium concentrations in RCEU surface soil reflect variations in naturally occurring vanadium.

Surface Soil (PMJM)

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that vanadium concentrations in RCEU surface soil in PMJM habitat reflect variations in naturally occurring vanadium.

4.15.3 Pattern Recognition

Surface Soil (Non-PMJM)

The probability plot for vanadium concentrations suggests a single population which indicates background conditions (Figure A3.4.19).

4.15.4 Comparison to RFETS Background and Other Background Data Sets

Surface Soil (Non-PMJM)

Vanadium concentrations in surface soil samples at the RCEU range from 21.1 to 49.0 mg/kg, with a mean concentration of 33.1 mg/kg and a standard deviation of 6.84 mg/kg. Vanadium concentrations in the background data set range from 10.8 to 45.8 mg/kg, with a mean concentration of 27.7 mg/kg and a standard deviation of 7.68 mg/kg (Table A3.2.4). The range of concentrations of vanadium in the RCEU and background samples considerably overlap and the means are similar.

The reported range for vanadium in surface soil within Colorado and the bordering states is 7 to 300 mg/kg, with a mean concentration of 73 mg/kg and a standard deviation of 41.7 mg/kg (Table A3.4.1). Vanadium concentrations reported in surface soil samples at the RCEU are 21.1 to 49.0 mg/kg, with a mean concentration of 33.1 mg/kg and a standard deviation of 6.84 mg/kg (Table A3.2.4). The range of concentrations of vanadium in surface soil is within the range for vanadium in soils of Colorado and the bordering states.

Surface Soil (PMJM)

Vanadium concentrations in PMJM habitat surface soil at the RCEU range from 21.1 to 49.0 mg/kg, with a mean concentration of 33.5 mg/kg and a standard deviation of 7.83 mg/kg. Vanadium concentrations in the background data set range from 10.8 to 45.8 mg/kg, with a mean concentration of 27.7 mg/kg and a standard deviation of 7.68 mg/kg (Table A3.2.6). The range of concentrations of vanadium in the RCEU and background samples considerably overlap and the means are similar.

The reported range for vanadium in surface soil within Colorado and the bordering states is 7 to 300 mg/kg, with a mean concentration of 73 mg/kg and a standard deviation of 41.7 mg/kg (Table A3.4.1). Vanadium concentrations reported in surface soil samples at the RCEU are 21.1 to 49.0 mg/kg, with a mean concentration of 33.5 mg/kg and a standard deviation of 7.83 mg/kg (Table A3.2.6). The range of concentrations of vanadium in surface soil is within the range for vanadium in soils of Colorado and the bordering states.

4.15.5 Risk Potential for Plants and Wildlife

Surface Soil (Non-PMJM)

The UTL for vanadium in the RCEU (44.9 mg/kg) exceeds the NOAEL ESL for two receptor groups: terrestrial plants (2 mg/kg), and deer mouse insectivore (29.9 mg/kg). The NOAEL ESLs for all other non-PMJM receptors were greater than the UTL and ranged from 64 to 1,514 mg/kg. The NOAEL ESL for the insectivorous deer mouse is less than the MDC in background soils (45.8 mg/kg). In addition, the UTL is less than the mammalian Eco-SSL of 280 mg/kg (EPA 2005d). The plant NOAEL ESL is lower than all background concentrations of vanadium. However, the confidence placed on the plant

ESL value by the source (Efroymson et al. 1997) is low. Other studies reported in the same reference (Efroymson et al. 1997) indicate no effects at concentrations up to 40 mg/kg and low effects at concentrations up to 60 mg/kg. No vanadium Eco-SSL is currently available for plants (EPA 2005d).

Surface Soil (PMJM)

The MDC for vanadium in PMJM habitat in the RCEU (49.0 mg/kg) exceeds the NOAEL ESL for the PMJM (21.6 mg/kg). This ESL is less than all but three background surface soil concentrations. In addition, the MDC is less than the mammalian Eco-SSL of 280 mg/kg (EPA 2005d).

4.15.6 Conclusion

The weight of evidence presented above shows that vanadium concentrations in RCEU surface soil are not likely to be a result of historical site-related activities based on process knowledge; a spatial distribution that suggests vanadium is naturally occurring; a probability plot that suggests the presence of a single population which is also indicative of background conditions; and RCEU concentrations that are well within regional background levels. Vanadium is not considered an ECOPC in surface soil for the RCEU and, therefore, is not further evaluated quantitatively.

4.16 Zinc

Zinc has an EPC in surface soil (for non-PMJM receptors) greater than the limiting tESL and, therefore, was carried forward to the professional judgment step. In addition, zinc in surface soil (non-PMJM) has concentrations statistically greater than background. The lines of evidence used to determine if zinc should be retained for risk characterization are summarized below.

4.16.1 Summary of Process Knowledge

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, process knowledge indicates a potential for zinc to have been released into RFETS soil because of the moderate zinc metal inventory and the presence of zinc in waste generated during former operations. However, there are no IHSSs in the RCEU. Therefore, zinc is unlikely to be present in RCEU soil as a result of historical site-related activities.

4.16.2 Evaluation of Spatial Trends

Surface Soil (Non-PMJM)

As discussed in Appendix A, Volume 2, Attachment 8 of the RI/FS Report, the spatial trend analysis indicates that zinc concentrations in RCEU surface soil reflect variations in naturally occurring zinc.

4.16.3 Pattern Recognition

Surface Soil (Non-PMJM)

The probability plot for zinc concentrations (Figure A3.4.20) suggests one population extending from 36 to about 65 mg/kg, with four anomalous samples containing elevated zinc concentrations. The anomalous samples are too few to estimate the nature of this occurrence; however, because of the absence of sources in the RCEU, they could represent different background geologic conditions.

4.16.4 Comparison to RFETS Background and Other Background Data Sets

Surface Soil (Non-PMJM)

Zinc concentrations in surface soil samples at the RCEU range from 36.0 to 130 mg/kg, with a mean concentration of 56.4 mg/kg and a standard deviation of 16.7 mg/kg. Zinc concentrations in the background data set range from 21.1 to 75.9 mg/kg, with a mean concentration of 49.8 mg/kg and a standard deviation of 12.2 mg/kg (Table A3.2.4). The range of concentrations of zinc in the RCEU and background samples considerably overlap and the means are similar.

The reported range for zinc in surface soil within Colorado and the bordering states is 10 to 2,080 mg/kg, with a mean concentration of 72.4 mg/kg and a standard deviation of 159 mg/kg (Table A3.4.1). Zinc concentrations reported in surface soil samples at the RCEU are 36.0 to 130 mg/kg, with a mean concentration of 56.4 mg/kg and a standard deviation of 16.7 mg/kg (Table A3.2.4). The range of concentrations of zinc in surface soil is within the range for zinc in soils of Colorado and the bordering states.

4.16.5 Risk Potential for Plants and Wildlife

Surface Soil (Non-PMJM)

The UTL for zinc in the RCEU (90.2 mg/kg) exceeds the NOAEL ESL for three receptor groups: terrestrial plants (50 mg/kg), mourning dove insectivore (0.65 mg/kg), and deer mouse insectivore (5.29 mg/kg). All other NOAEL ESLs were greater than the UTL and ranged from 109 to 16,489 mg/kg. No zinc Eco-SSLs are currently available for any receptor (the zinc Eco-SSL document is “pending”).The mourning dove and deer mouse (insectivore) ESLs are both considerably lower than the range of zinc concentrations in background soils (21.1 to 75.9 mg/kg). The terrestrial plant ESL is approximately equal to the mean background concentration of 49.8 mg/kg.

4.16.6 Conclusion

The weight of evidence presented above shows that zinc concentrations in RCEU surface soil (non-PMJM receptors) are not likely to be a result of historical site-related activities based on process knowledge; a spatial distribution indicative of naturally occurring zinc; and RCEU concentrations that are well within regional background levels. Although there may be two data populations present for RCEU surface soil, the absence of historical sources suggest this represents two background geologic conditions. Zinc is not considered an ECOPC in surface soil for the RCEU and, therefore, is not further evaluated quantitatively.

5.0 REFERENCES

CDH, 1991. Colorado Department of Health Project Task 2, Selection of the Chemicals and Radionuclides of Concern. Prepared by ChemRisk. June.

Department of Energy (DOE), 1992. Historical Release Report, Rocky Flats Environmental Technology Site, Golden, Colorado. June.

DOE, 1995. Final Geochemical Characterization of Background Surface Soils: Background Soils: Background Soils Characterization Program, U.S. Department of Energy, Rocky Flats Environmental Technology Site, Golden, Colorado.

DOE, 2005. Final Comprehensive Risk Assessment Work Plan and Methodology, Rocky Flats Environmental Technology Site, Golden, Colorado. Revision 1. September.

Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten, 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants. 1997 Revision, ES/ER/TM-85/R3. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Environmental Protection Agency (EPA), 1989. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A). EPA 15011-891002. Office of Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. April.

EPA, 2003. Ecological Soil Screening Level for Aluminum – Interim Final. OSWER Directive 9285.7-60. Office of Solid Waste and Emergency Response. November.

EPA, 2005a. Ecological Soil Screening Levels for Arsenic – Interim Final. OSWER Directive 9285.7-62. Office of Solid Waste and Emergency Response, March.

EPA, 2005b. Ecological Soil Screening Levels for Barium – Interim Final. OSWER Directive 9285.7-63. Office of Solid Waste and Emergency Response, February.

EPA, 2005c. Ecological Soil Screening Levels for Chromium – Interim Final. OSWER Directive 9285.7-66. Office of Solid Waste and Emergency Response, March.

EPA, 2005d. Ecological Soil Screening Levels for Vanadium – Interim Final. OSWER Directive 9285.7-75. Office of Solid Waste and Emergency Response, April.

Kabata-Pendias, A., and H. Pendias, 1992. Trace Elements in Soils and Plants. Second Edition. CRC Press, Boca Raton, Florida. 365 pp

Shacklette, H.T., and J.G. Boerngen, 1984. Element Concentrations in Soils and Other Surface Materials of the Contiguous United States. Professional Paper 1270. U.S. Geological Survey, Washington, D.C.

TABLES

Table A3.2.1
Statistical Distribution and Comparison to Background for RCEU Surface Soil/Surface Sediment

Analyte	Units	Statistical Distribution Testing Results						Background Comparison Test		
		Background Data Set			RCEU Data Set (excluding background samples)			Test	1 - p	Statistically Greater than Background?
		Total Samples	Distribution Recommended by ProUCL	Detects (%)	Total Samples	Distribution Recommended by ProUCL	Detects (%)			
Arsenic	**mg/kg**	**73**	**GAMMA**	**91.8**	**46**	**NON-PARAMETRIC**	**100**	**WRS**	**2.29E-07**	**Yes**
Manganese	**mg/kg**	**73**	**GAMMA**	**100**	**46**	**NON-PARAMETRIC**	**100**	**WRS**	**6.23E-04**	**Yes**
Cesium-134	pCi/g	77	NON-PARAMETRIC	N/A	11	NORMAL	N/A	N/A	0.999	No
Cesium-137	pCi/g	105	NON-PARAMETRIC	N/A	18	NORMAL	N/A	N/A	0.0239	No
Radium-228	pCi/g	40	GAMMA	N/A	14	NORMAL	N/A	N/A	0.0118	No

Test: WRS = Wilcoxon Rank Sum.

N/A = Not applicable. Background comparison was not performed because background data were not available or detection frequency of an analyte in EU or background data set is less than 20%.

Table A3.2.2
Summary Statistics for Background and RCEU Surface Soil/Surface Sediment[a]

Analyte	Units	Background Data Set					RCEU Data Set (excluding background samples)				
		Total Samples	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Standard Deviation	Total Samples	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Standard Deviation
Arsenic	mg/kg	73	0.270	9.60	3.42	2.55	46	1.70	15.0	5.89	2.29
Manganese	mg/kg	73	9.00	1,280	241	189	46	80.2	2,500	385	446
Radium-228	pCi/g	40	0.200	4.10	1.60	0.799	14	1.3	2.90	2.01	0.572
Cesium-137	pCi/g	105	-0.027	1.80	0.692	0.492	18	0.103	2.50	1.01	0.710

[a] Statistics are computed using one-half of the reported values for nondetects.

Table A3.2.3
Statistical Distribution and Comparison to Background for RCEU Surface Soil (non-PMJM)

Analyte	Units	Statistical Distribution Testing Results						Background Comparison Test Results		
		Background Data Set			RCEU Data Set (excluding background samples)			Test	1 - p	Statistically Greater than Background?
		Total Samples	Distribution Recommended by ProUCL	Detects (%)	Total Samples	Distribution Recommended by ProUCL	Detects (%)			
Aluminum	**mg/kg**	**20**	**NORMAL**	**100**	**36**	**NORMAL**	**100**	**WRS**	**1.08E-05**	**Yes**
Arsenic	mg/kg	20	NORMAL	100	36	NORMAL	100	WRS	0.504	No
Barium	**mg/kg**	**20**	**NORMAL**	**100**	**36**	**NON-PARAMETRIC**	**100**	**WRS**	**1.33E-08**	**Yes**
Boron	**mg/kg**	**N/A**	**N/A**	**N/A**	**17**	**NORMAL**	**100**	**N/A**	**N/A**	**Yes[a]**
Cadmium	mg/kg	20	NON-PARAMETRIC	65	34	GAMMA	47.1	WRS	0.994	No
Chromium	**mg/kg**	**20**	**NORMAL**	**100**	**36**	**NORMAL**	**100**	**WRS**	**1.04E-06**	**Yes**
Cobalt	mg/kg	20	NORMAL	100	36	NON-PARAMETRIC	100	WRS	0.854	No
Copper	mg/kg	20	NON-PARAMETRIC	100	36	NORMAL	100	WRS	0.369	No
Lead	mg/kg	20	NORMAL	100	36	NORMAL	100	WRS	0.560	No
Lithium	**mg/kg**	**20**	**NORMAL**	**100**	**36**	**NORMAL**	**100**	**WRS**	**2.27E-08**	**Yes**
Manganese	**mg/kg**	**20**	**NORMAL**	**100**	**36**	**NON-PARAMETRIC**	**100**	**WRS**	**0.001**	**Yes**
Mercury	mg/kg	20	NON-PARAMETRIC	40	34	NON-PARAMETRIC	50	WRS	1.000	No
Molybdenum	**mg/kg**	**20**	**NORMAL**	**0**	**36**	**NON-PARAMETRIC**	**50**	**N/A**	**N/A**	**Yes[a]**
Nickel	**mg/kg**	**20**	**NORMAL**	**100**	**36**	**GAMMA**	**97.2**	**WRS**	**0.002**	**Yes**
Selenium	mg/kg	20	NON-PARAMETRIC	60	36	NON-PARAMETRIC	44.4	WRS	0.930	No
Tin	**mg/kg**	**20**	**NORMAL**	**0**	**36**	**NON-PARAMETRIC**	**33.3**	**N/A**	**N/A**	**Yes[a]**
Vanadium	**mg/kg**	**20**	**NORMAL**	**100**	**36**	**NORMAL**	**100**	**WRS**	**0.005**	**Yes**
Zinc	**mg/kg**	**20**	**NORMAL**	**100**	**36**	**NON-PARAMETRIC**	**100**	**WRS**	**0.097**	**Yes**

WRS = Wilcoxon Rank Sum.
N/A = Not applicable.
Bold = Analyte retained for further consideration in the next ECOPC selection step.

Table A3.2.4
Summary Statistics for Background and RCEU Surface Soil (non-PMJM)[a]

Analyte	Units	Background Data Set					RCEU Data Set (excluding background samples)				
		Total Samples	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Standard Deviation	Total Samples	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Standard Deviation
Aluminum	mg/kg	20	4,050	17,100	10,203	3,256	36	7,420	21,800	14,530	3,375
Arsenic	mg/kg	20	2.30	9.60	6.09	2.00	36	2.20	8.70	6.08	1.50
Barium	mg/kg	20	45.7	134	102	19.4	36	110	470	168	73.9
Boron	mg/kg	N/A	N/A	N/A	N/A	N/A	17	3.90	7.90	5.72	1.00
Cadmium	mg/kg	20	0.670	2.30	0.708	0.455	34	0.075	1.80	0.456	0.427
Chromium	mg/kg	20	5.50	16.9	11.2	2.78	36	9.00	22.0	15.4	2.78
Cobalt	mg/kg	20	3.40	11.2	7.27	1.79	36	4.80	24.0	7.33	3.22
Cobalt	mg/kg	20	5.20	16.0	13.0	2.58	36	7.70	22.2	13.5	3.43
Copper	mg/kg	20	8.60	53.3	33.5	10.5	36	21.0	51.0	33.2	7.72
Lead	mg/kg	20	4.80	11.6	7.66	1.89	36	6.80	17.7	11.5	2.33
Lithium	mg/kg	20	4.80	11.6	7.66	1.89	36	6.80	17.7	11.5	2.33
Manganese	mg/kg	20	129	357	237	63.9	36	160	2,220	363	333
Mercury	mg/kg	20	0.090	0.120	0.072	0.031	34	0.021	0.051	0.038	0.014
Molybdenum	mg/kg	20	N/A	N/A	0.573	0.184	36	0.690	2.70	1.25	0.708
Nickel	mg/kg	20	3.80	14.0	9.60	2.59	36	7.80	25.0	12.5	3.57
Selenium	mg/kg	20	0.680	1.40	0.628	0.305	36	0.280	1.30	0.490	0.245
Tin	mg/kg	20	N/A	N/A	2.060	0.410	36	1.200	41.90	13.700	14.000
Vanadium	mg/kg	20	10.8	45.8	27.7	7.68	36	21.1	49.0	33.1	6.84
Zinc	mg/kg	20	21.1	75.9	49.8	12.2	36	36.0	130	56.4	16.7
Cesium-134	pCi/g	70	0.050	0.300	0.148	0.059	8	0.071	0.100	0.085	0.012
Cesium-137	pCi/g	70	0.070	1.80	0.911	0.391	11	0.710	2.50	1.43	0.509

[a] Statistics are computed using one-half of the reported values for nondetects.

Table A3.2.5
Statistical Distributions and Comparison to Background for RCEU Surface Soil (PMJM)

Analyte	Units	Statistical Distribution Testing Results						Background Comparison Test Results		
		Background Data Set			RCEU Data Set (excluding background samples)			Test	1 - p	Statistically Greater than Background
		Total Samples	Distribution Recommended by ProUCL	Detects (%)	Total Samples	Distribution Recommended by ProUCL	Detects (%)			
Arsenic	mg/kg	20	NORMAL	100	19	NORMAL	100	t-Test_N	0.260	No
Chromium	**mg/kg**	**20**	**NORMAL**	**100**	**19**	**NORMAL**	**100**	**t-Test_N**	**5.58E-05**	**Yes**
Manganese	mg/kg	20	NORMAL	100	19	NON-PARAMETRIC	100	WRS	0.005	Yes
Molybdenum	mg/kg	20	NORMAL	0.0	19	NON-PARAMETRIC	63.16	N/A	N/A	N/A
Nickel	**mg/kg**	**20**	**NORMAL**	**100**	**19**	**GAMMA**	**94.74**	**WRS**	**0.008**	**Yes**
Selenium	**mg/kg**	**20**	**NON-PARAMETRIC**	**60.0**	**19**	**NON-PARAMETRIC**	**31.58**	**WRS**	**0.916**	**No**
Tin	**mg/kg**	**20**	**NORMAL**	**0.0**	**19**	**NON-PARAMETRIC**	**36.84**	**N/A**	**N/A**	**N/A**
Vanadium	**mg/kg**	**20**	**NORMAL**	**100**	**19**	**NORMAL**	**100**	**t-Test_N**	**0.014**	**Yes**
Zinc	mg/kg	20	NORMAL	100	19	NON-PARAMETRIC	100	WRS	0.188	No

WRS = Wilcoxon Rank Sum.
t-Test_N = Student's t-test using normal data.
Bold = Analyte retained for further consideration in the next ECOPC selection step.
N/A = Not applicable; site and/or background detection frequency less than 20%.

Table A3.2.6
Summary Statistics for Background and RCEU Surface Soil (PMJM)[a]

Analyte	Units	Background Data					RCEU Data Set (excluding background samples)				
		Total Samples	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Standard Deviation	Total Samples	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Standard Deviation
Arsenic	mg/kg	20	2.30	9.60	6.09	2.00	19	4.80	8.70	6.43	1.23
Chromium	mg/kg	20	5.50	16.9	11.2	2.78	19	9.00	21.6	15.2	2.93
Manganese	mg/kg	20	129	357	237	63.9	19	160	2,220	405	447
Molybdenum	mg/kg	20	N/A	N/A	0.573	0.184	19	0.560	2.70	1.26	0.734
Nickel	mg/kg	20	3.80	14.0	9.60	2.59	19	8.20	25.0	12.8	4.15
Selenium	mg/kg	20	0.680	1.40	0.628	0.305	19	0.370	1.30	0.465	0.244
Tin	mg/kg	20	N/A	N/A	2.06	0.410	19	1.20	33.0	10.1	12.3
Vanadium	mg/kg	20	10.8	45.8	27.7	7.68	19	21.1	49.0	33.5	7.83
Zinc	mg/kg	20	21.1	75.9	49.8	12.2	19	36.0	130	57.1	21.2

[a] Statistics are computed using one-half of the reported values for nondetects.

Table A3.2.7
Statistical Distributions and Comparison to Background for RCEU Subsurface Soil

Analyte	Units	Statistical Distribution Testing Results						Background Comparison Test Results		
		Background Data Set			RCEU Data Set (excluding background samples)			Test	1 - p	Statistically Greater than Background
		Total Samples	Distribution Recommended by ProUCL	Detects (%)	Total Samples	Distribution Recommended by ProUCL	Detects (%)			
Arsenic	**mg/kg**	**45**	**NON-PARAMETRIC**	**93.3**	**8**	**NORMAL**	**100**	**WRS**	**0.015**	**Yes**

Test: WRS = Wilcoxon Rank Sum.
Bold = Analyte retained for further consideration in the next ECOPC selection step.

Table A3.2.8
Summary Statistics for Background and RCEU Subsurface Soil[a]

Analyte	Units	Background Data Set					RCEU Data Set (excluding background samples)				
		Total Samples	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Standard Deviation	Total Samples	Minimum Detected Concentration	Maximum Detected Concentration	Mean Concentration	Standard Deviation
Arsenic	**mg/kg**	**45**	**1.70**	**41.8**	**5.48**	**6.02**	**8**	**2.50**	**13.1**	**8.08**	**4.07**

[a] Statistics are computed using one-half of the reported values for nondetects.

Bold = Analyte retained for further consideration in the next ECOPC selection step.

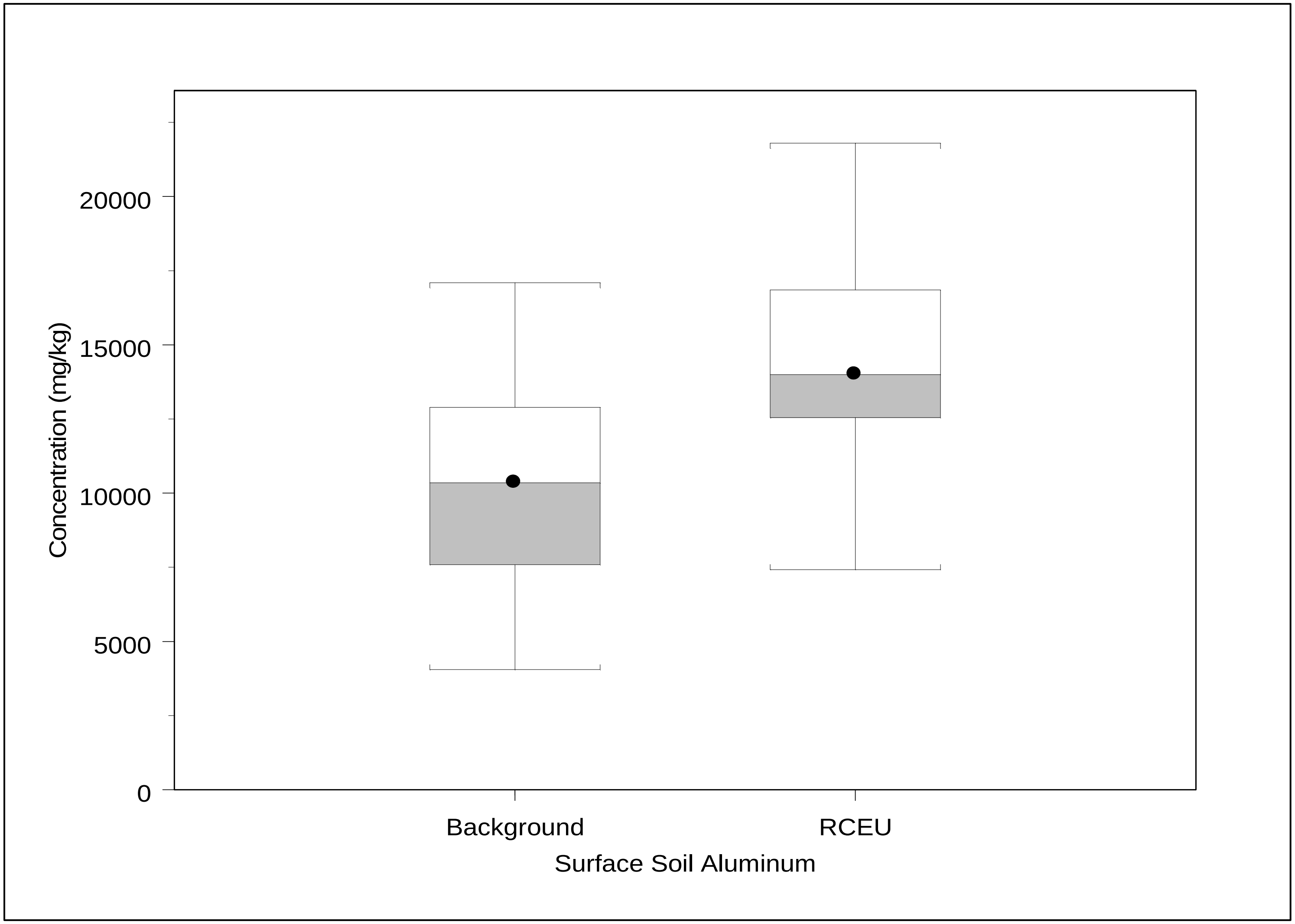
Table A3.4.1
Summary of Element Concentrations in Colorado and Bordering States Surface Soil [a]

Analyte	Total Number of Results	Detection Frequency (%)	Range of Detected Values (mg/kg)	Average (mg/kg)[b]	Standard Deviation (mg/kg)[b]
Aluminum	303	100	5,000 - 100,000	50,800	23,500
Antimony	84	15.0	1.038 - 2.531	0.647	0.378
Arsenic	307	99.0	1.224 - 97	6.9	7.64
Barium	342	100	100 - 3,000	642	330
Beryllium	342	36.0	1 - 7	0.991	0.876
Boron	342	67.0	20 - 150	27.9	19.7
Bromine	85	51.0	0.5038 - 3.522	0.681	0.599
Calcium	342	100	0.055 - 32	3.09	4.13
Carbon	85	100	0.3 - 10	2.18	1.92
Cerium	291	16.0	150 - 300	90	38.4
Chromium	342	100	3 - 500	48.2	41
Cobalt	342	88.6	3 - 30	8.09	5.03
Copper	342	100	2 - 200	23.1	17.7
Fluorine	264	97.3	10 - 1,900	394	261
Gallium	340	99.1	5 - 50	18.3	8.9
Germanium	85	100	0.5777 - 2.146	1.18	0.316
Iodine	85	78.8	0.516 - 3.487	1.07	0.708
Iron	342	100	3,000 - 100,000	21,100	13,500
Lanthanum	341	66.3	30 - 200	39.8	28.8
Lead	342	92.7	10 - 700	24.8	41.5
Lithium	307	100	5 - 130	25.3	14.4
Magnesium	341	100	300 - 50,000	8,630	6,400
Manganese	342	100	70 - 2,000	414	272
Mercury	309	99.0	0.01 - 4.6	0.0768	0.276
Molybdenum	340	3.50	3 - 7	1.59	0.522
Neodymium	256	22.7	70 - 300	47.1	31.7
Nickel	342	96.5	5 - 700	18.8	39.8
Niobium	335	63.3	10 - 100	11.4	8.68
Phosphorus	249	100	40 - 4,497	399	397
Potassium	341	100	1,900 - 63,000	18,900	6,980
Rubidium	85	100	35 - 140	75.8	25
Scandium	342	85.1	5 - 30	8.64	4.69
Selenium	309	80.6	0.1023 - 4.3183	0.349	0.415
Silicon	85	100	149,340 - 413,260	302,000	61,500
Sodium	335	100	500 - 70,000	10,400	6,260
Strontium	342	100	10 - 2,000	243	212
Sulfur	85	16.5	816 - 47,760	1,250	5,300
Thallium	76	100	2.45 - 20.79	9.71	3.54
Tin	85	96.5	0.117 - 5.001	1.15	0.772
Titanium	342	100	500 - 7,000	2,290	1,350
Uranium	85	100	1.11 - 5.98	2.87	0.883
Vanadium	342	100	7 - 300	73	41.7
Ytterbium	330	99.1	1 - 20	3.33	2.06
Yttrium	342	98.0	10 - 150	26.9	18.1
Zinc	330	100	10 - 2,080	72.4	159
Zirconium	342	100	30 - 1,500	220	157

[a] Based on data from Shacklette and Boerngen (1984) for the states of Colorado, Arizona, Kansas, Nebraska, New Mexico, Oklahoma, Utah, and Wyoming.
[b] One-half the detection limit used as proxy value for nondetects in computation of the mean and standard deviation.

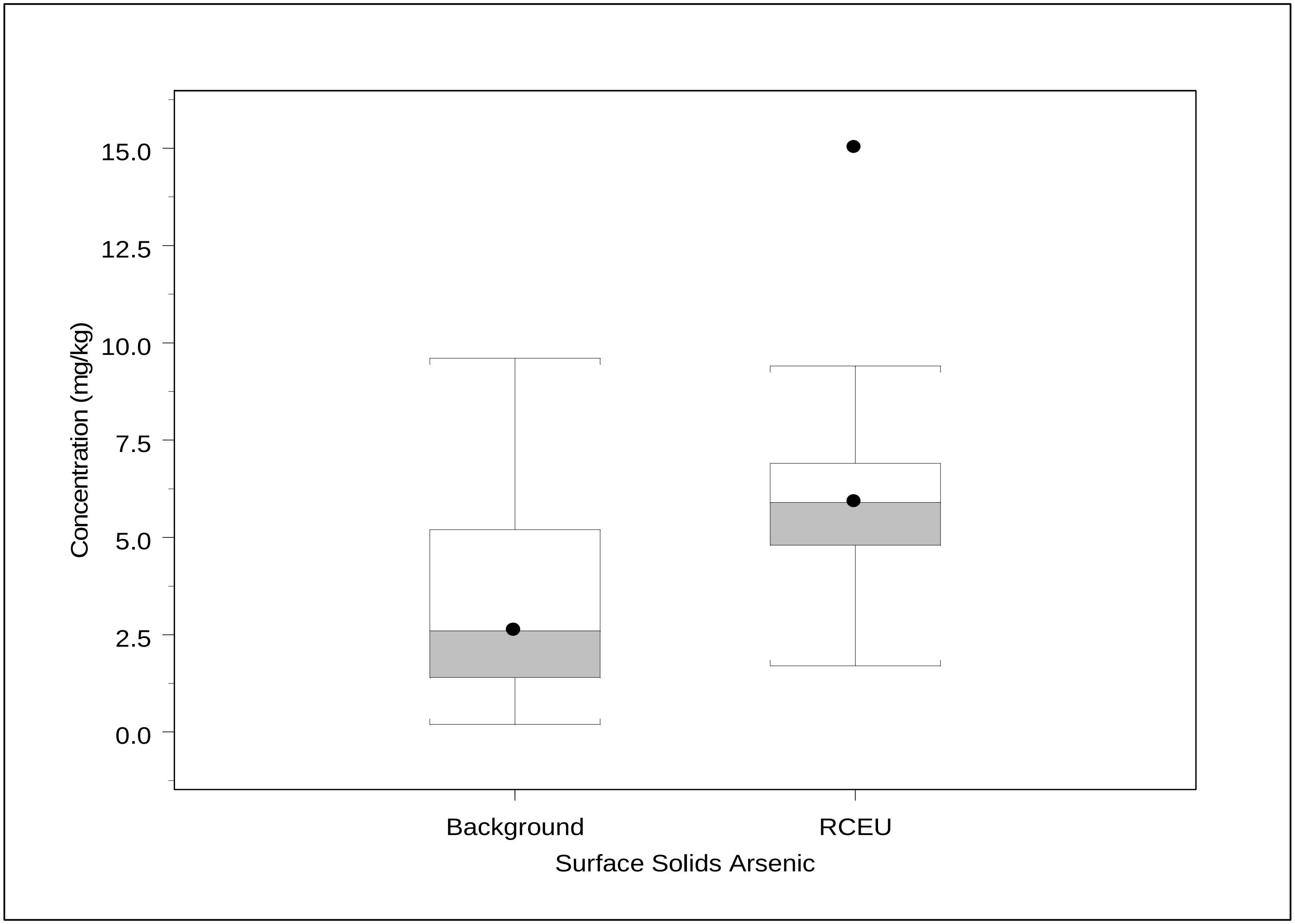
FIGURES

Figure A3.2.1
RCEU Surface Soil Box Plots for Aluminum



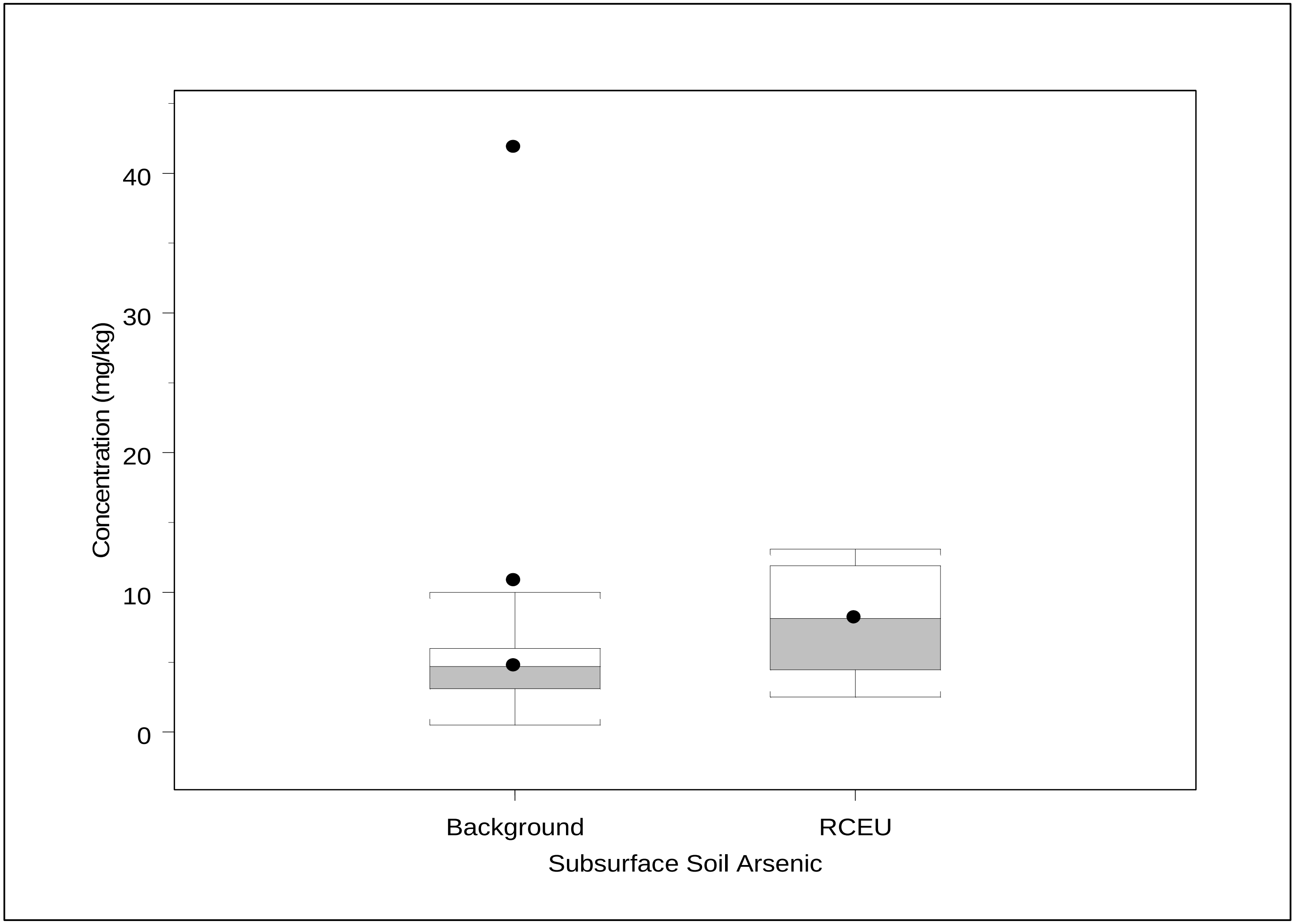
Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.2
RCEU Surface Soil/Surface Sediment Box Plots for Arsenic



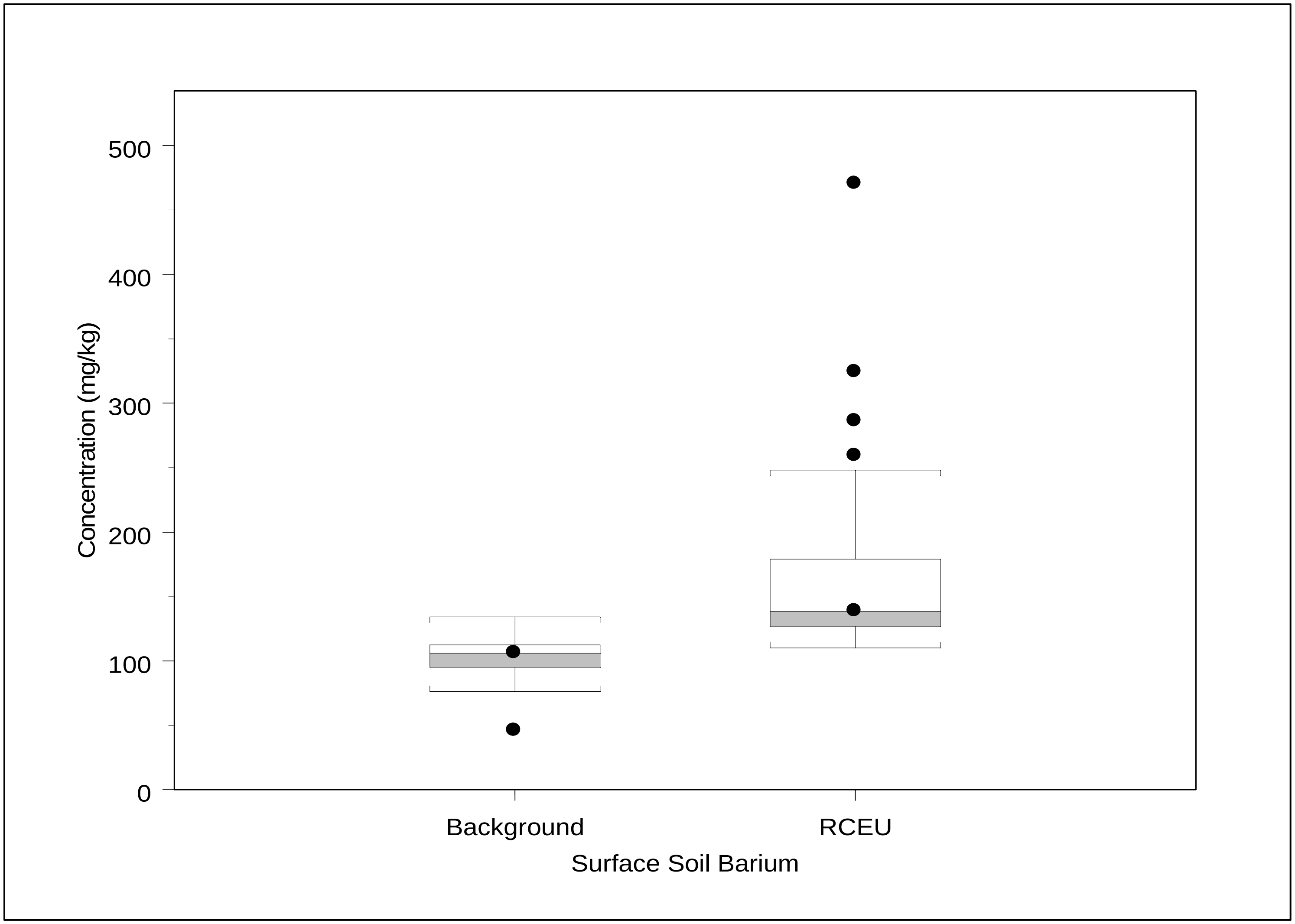
Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.3
RCEU Subsurface Soil Box Plots for Arsenic



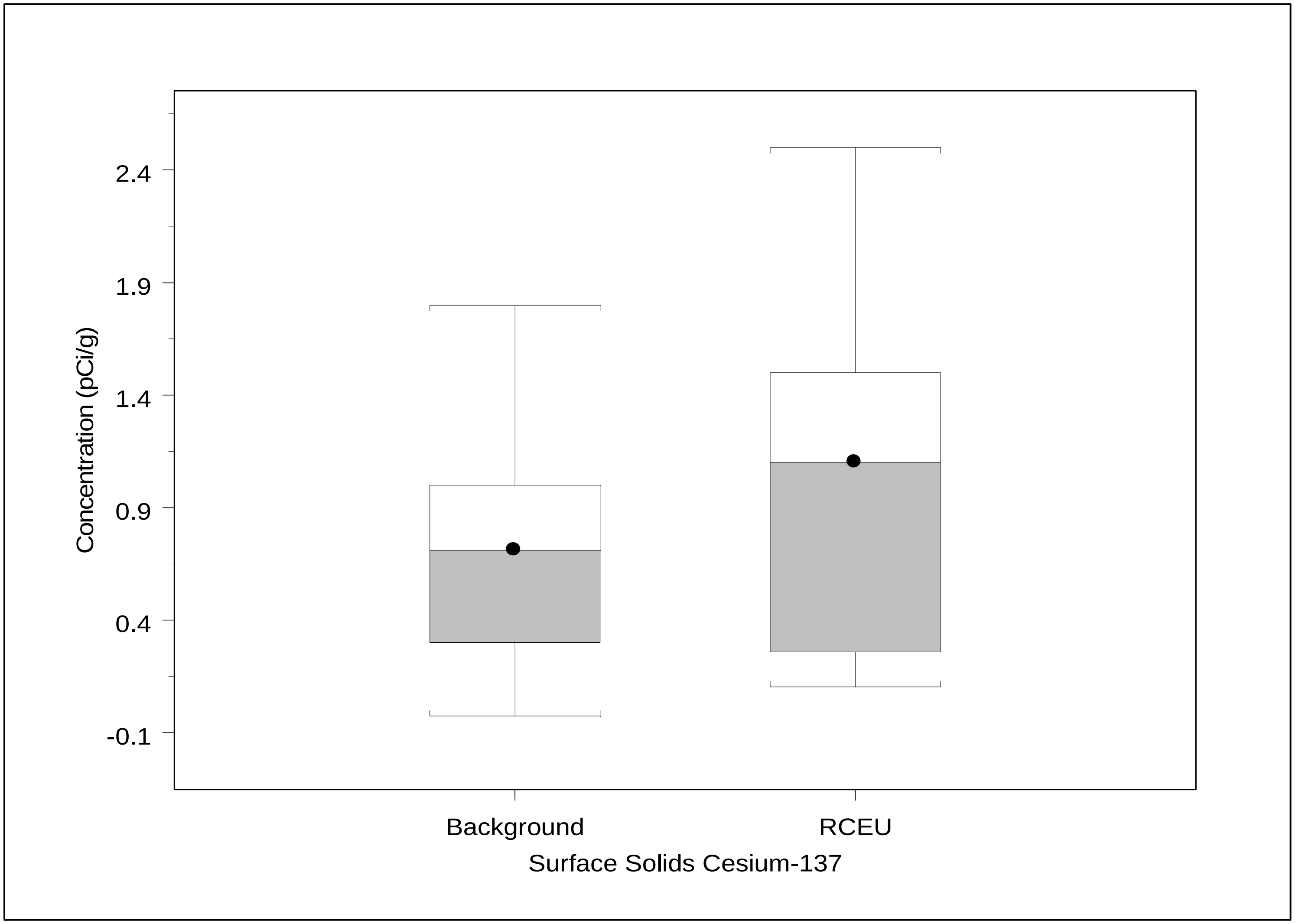
Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.4
RCEU Surface Soil Box Plots for Barium



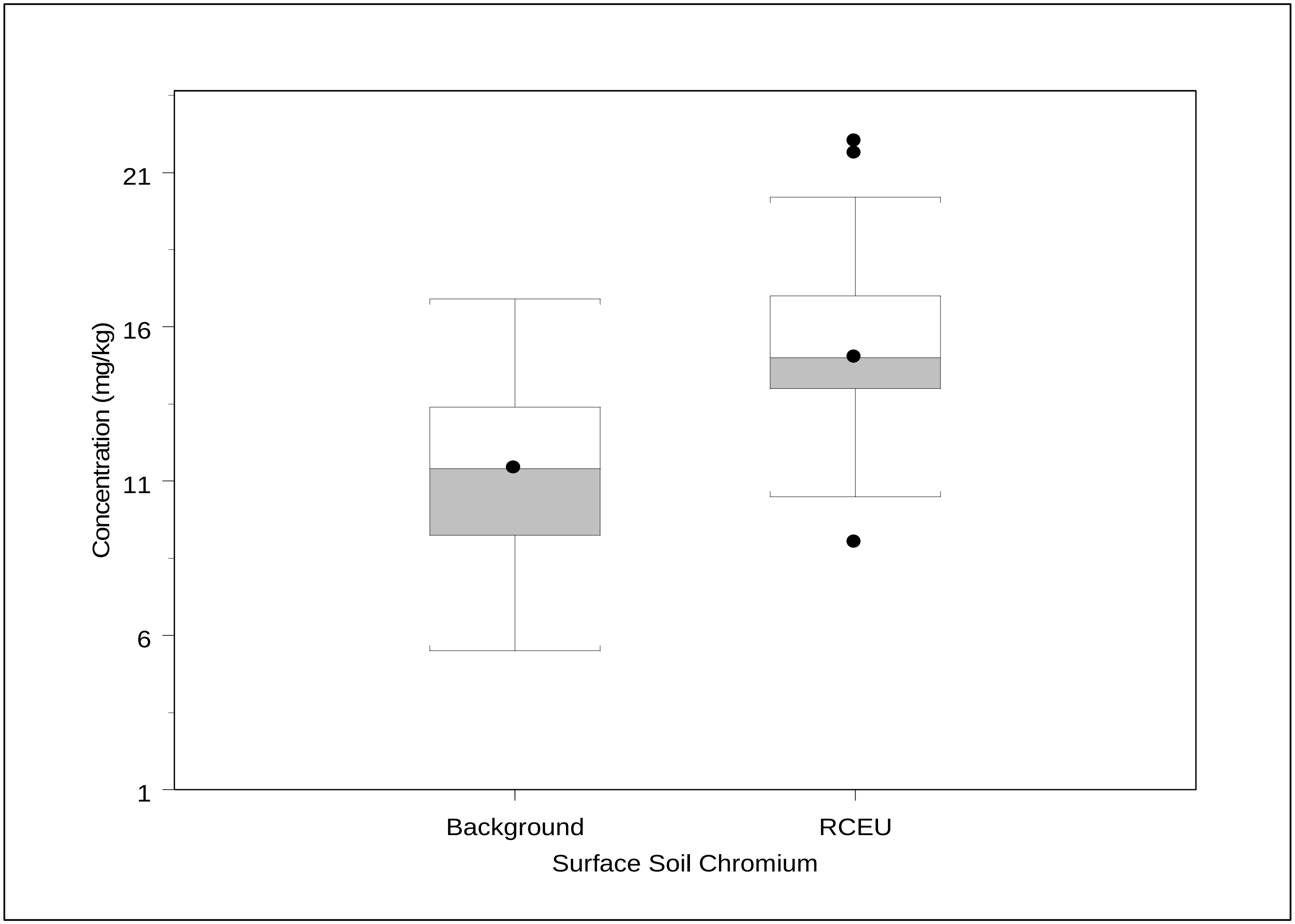
Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.5
RCEU Surface Soil/Surface Sediment Box Plots for Cesium-137



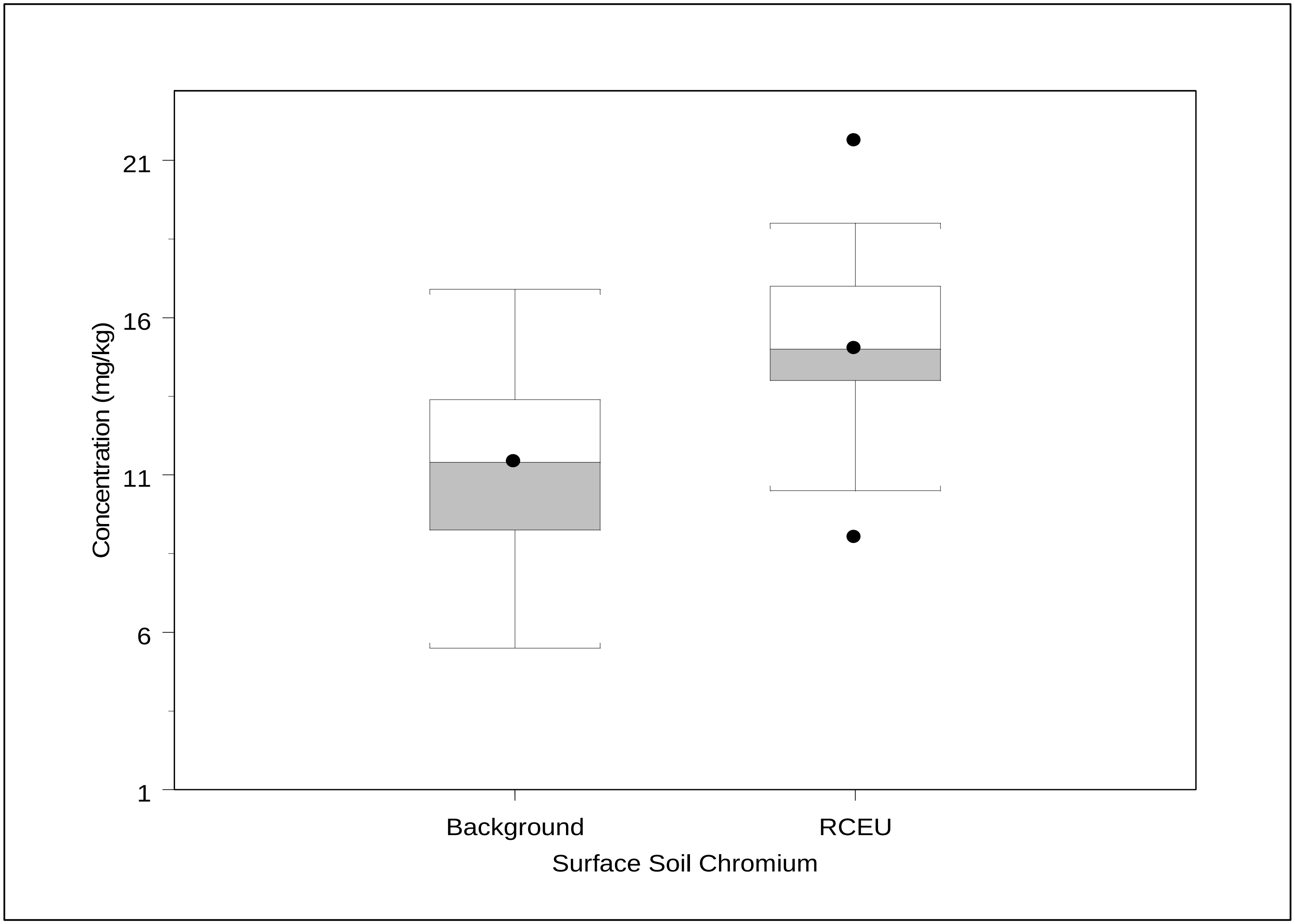
Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.6
RCEU Surface Soil Box Plots for Chromium



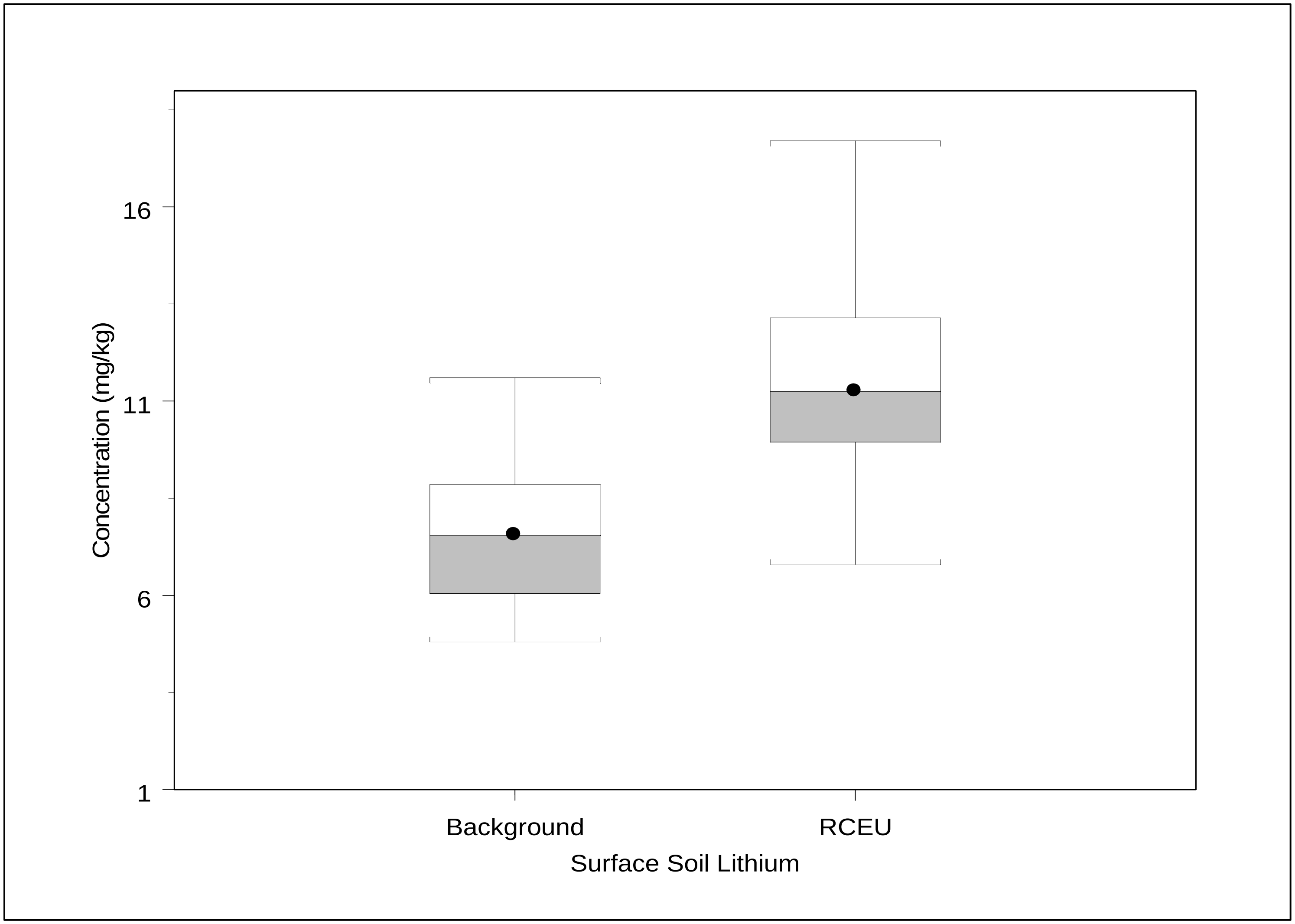
Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.7
RCEU Surface Soil in PMJM Habitat Box Plots for Chromium



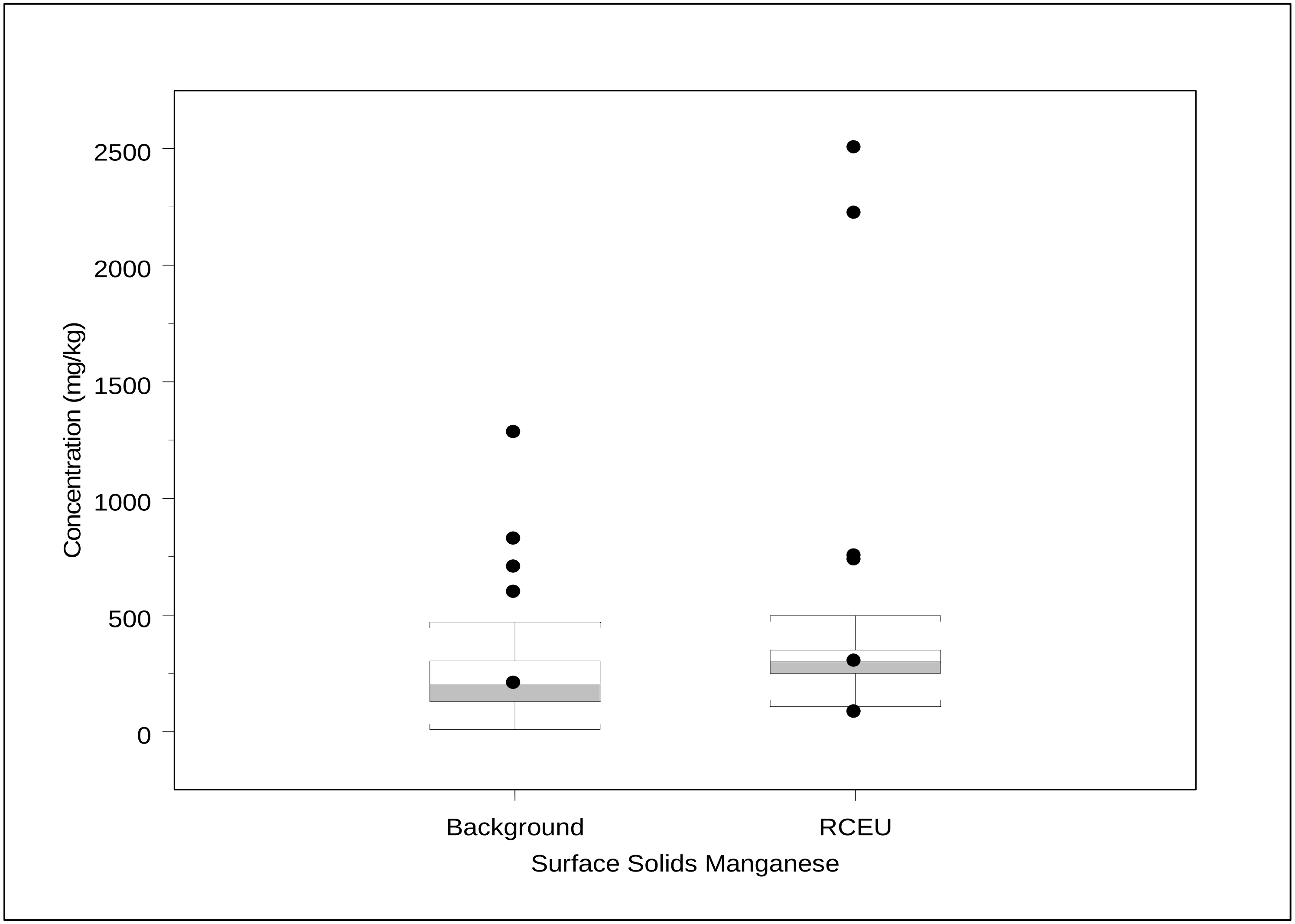
Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.8
RCEU Surface Soil Box Plots for Lithium



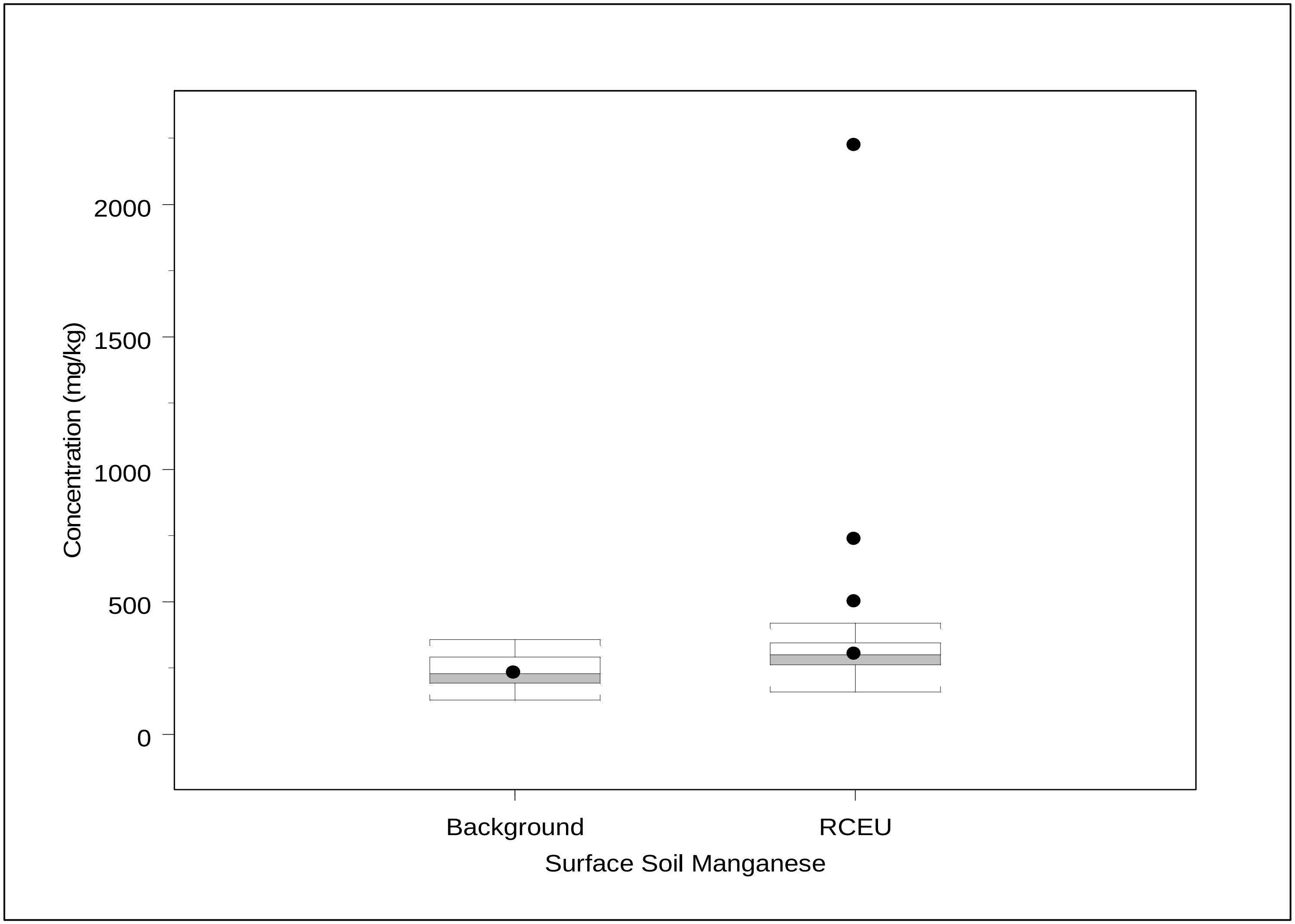
Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.9
RCEU Surface Soil/Surface Sediment Box Plots for Manganese



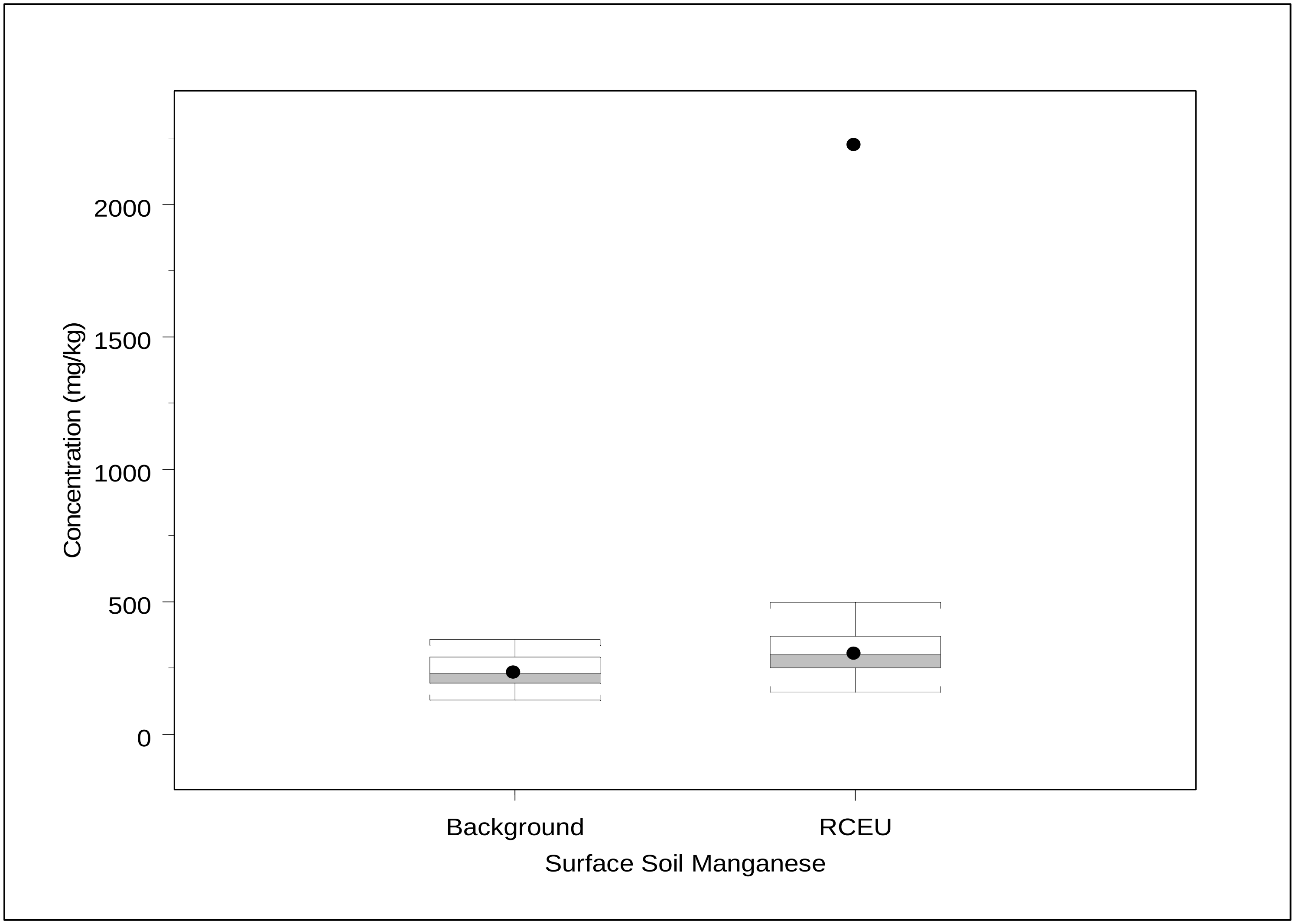
Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.10
RCEU Surface Soil Box Plots for Manganese



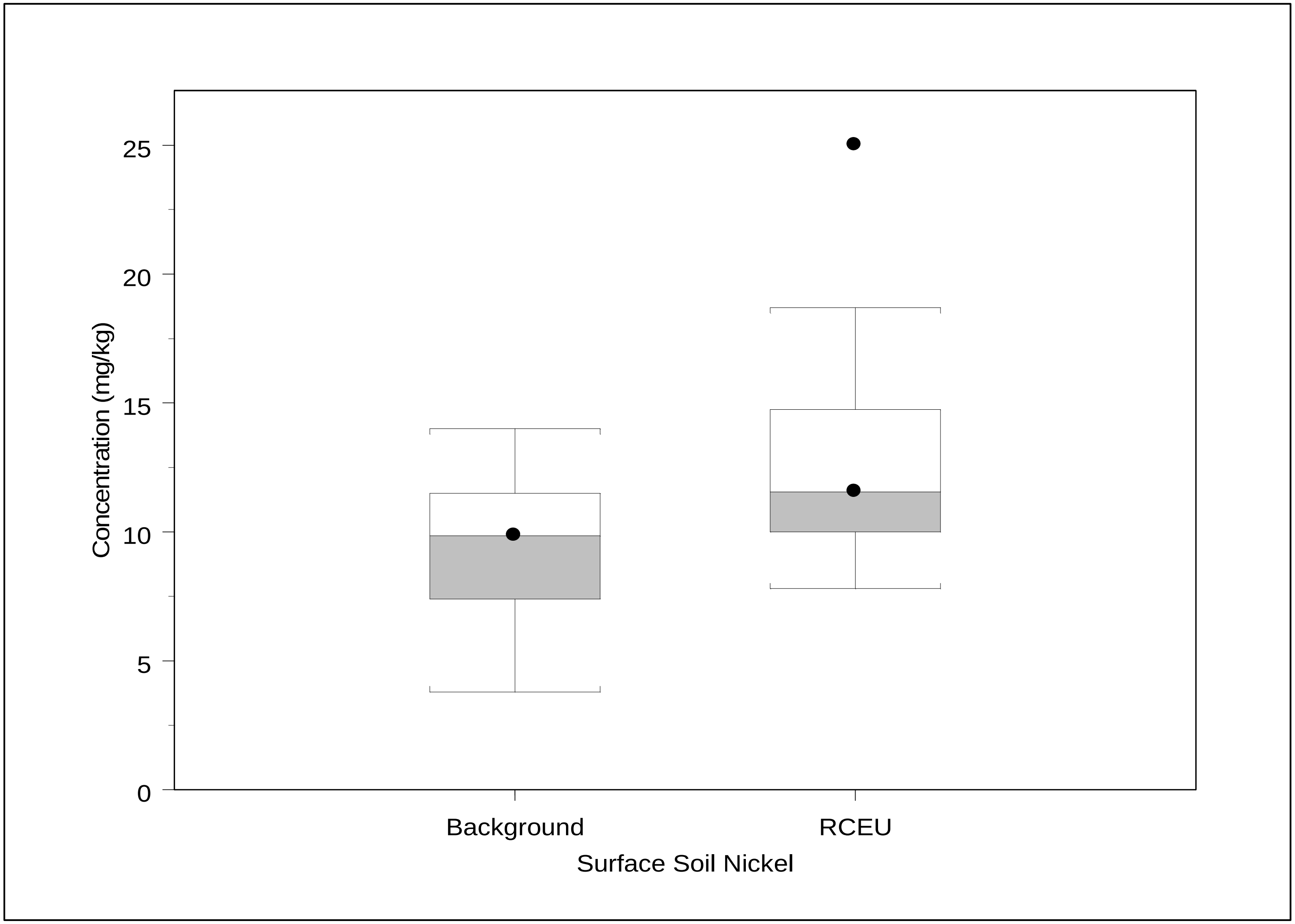
Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.11
RCEU Surface Soil in PMJM Habitat Box Plots for Manganese



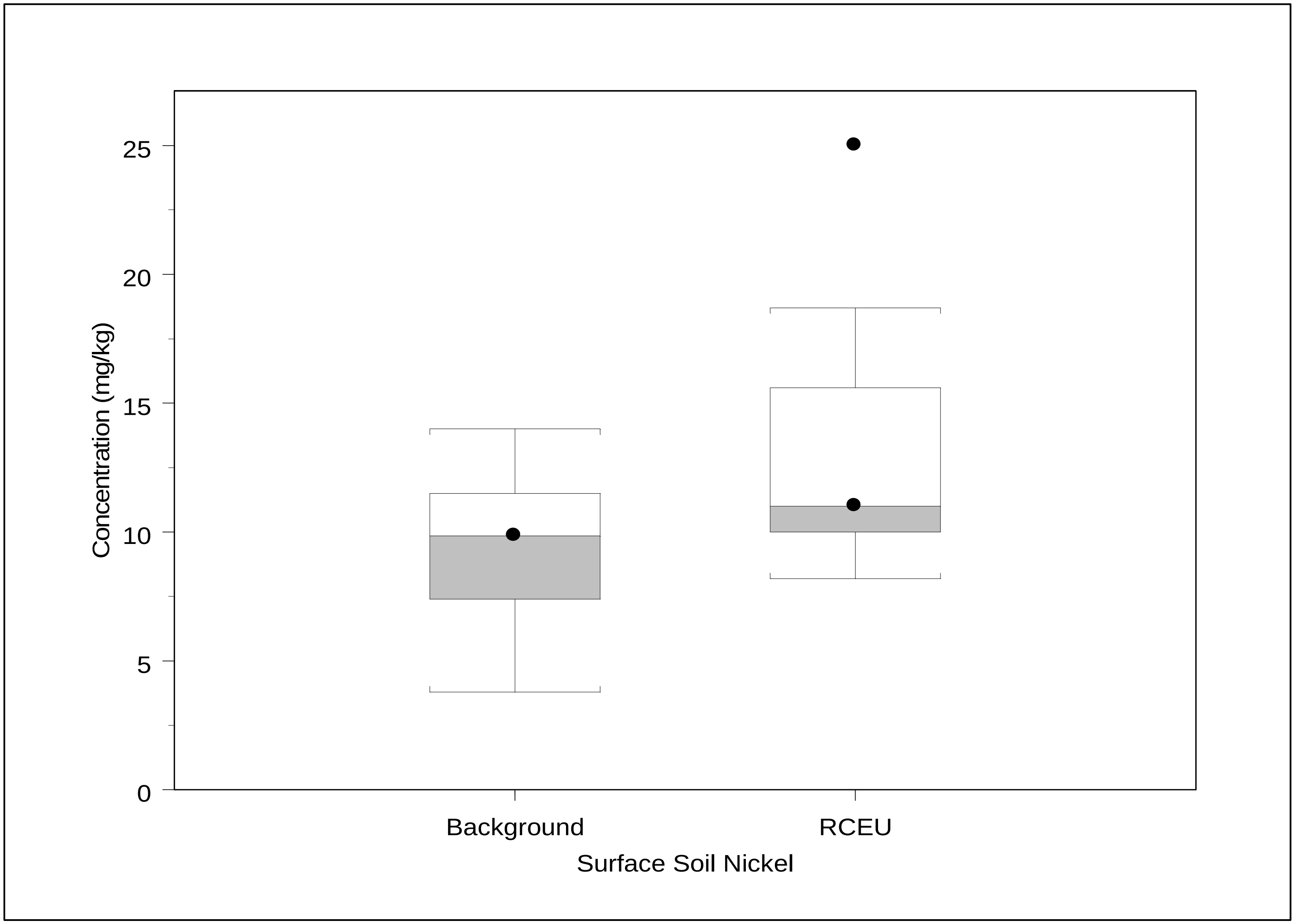
Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.12
RCEU Surface Soil Box Plots for Nickel



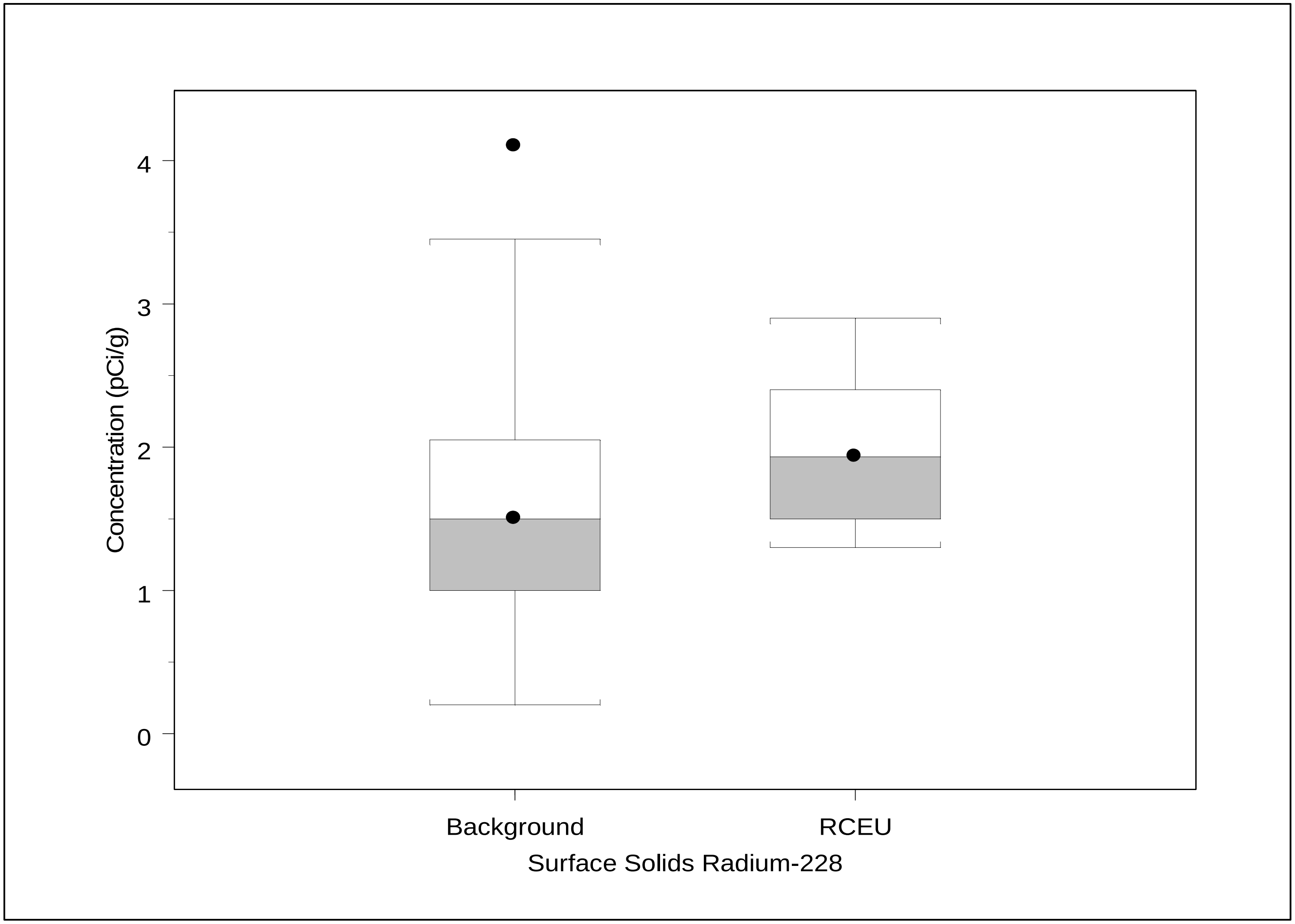
Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.13
RCEU Surface Soil in PMJM Habitat Box Plots for Nickel



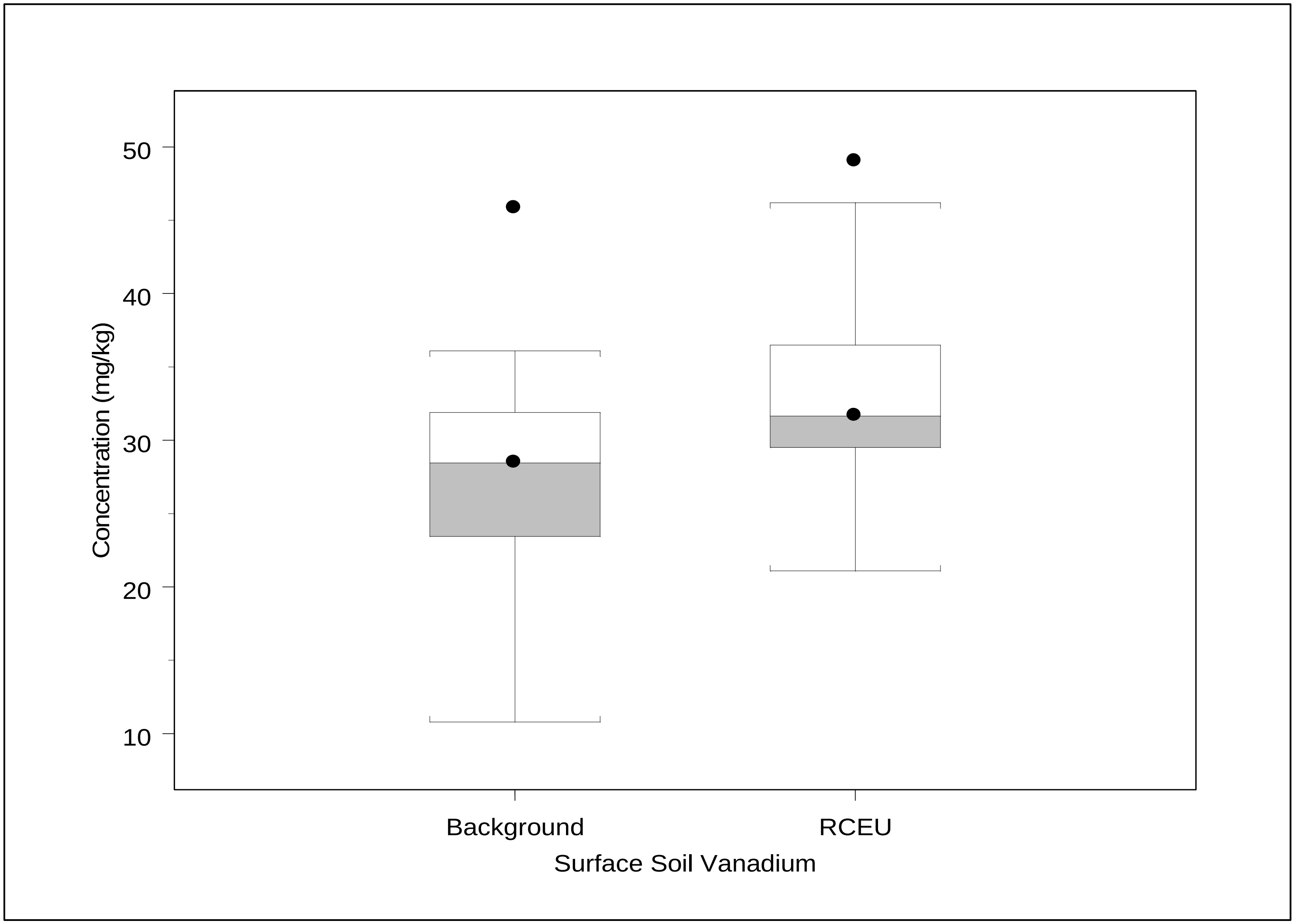
Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.14
RCEU Surface Soil/Surface Sediment Box Plots for Radium-228



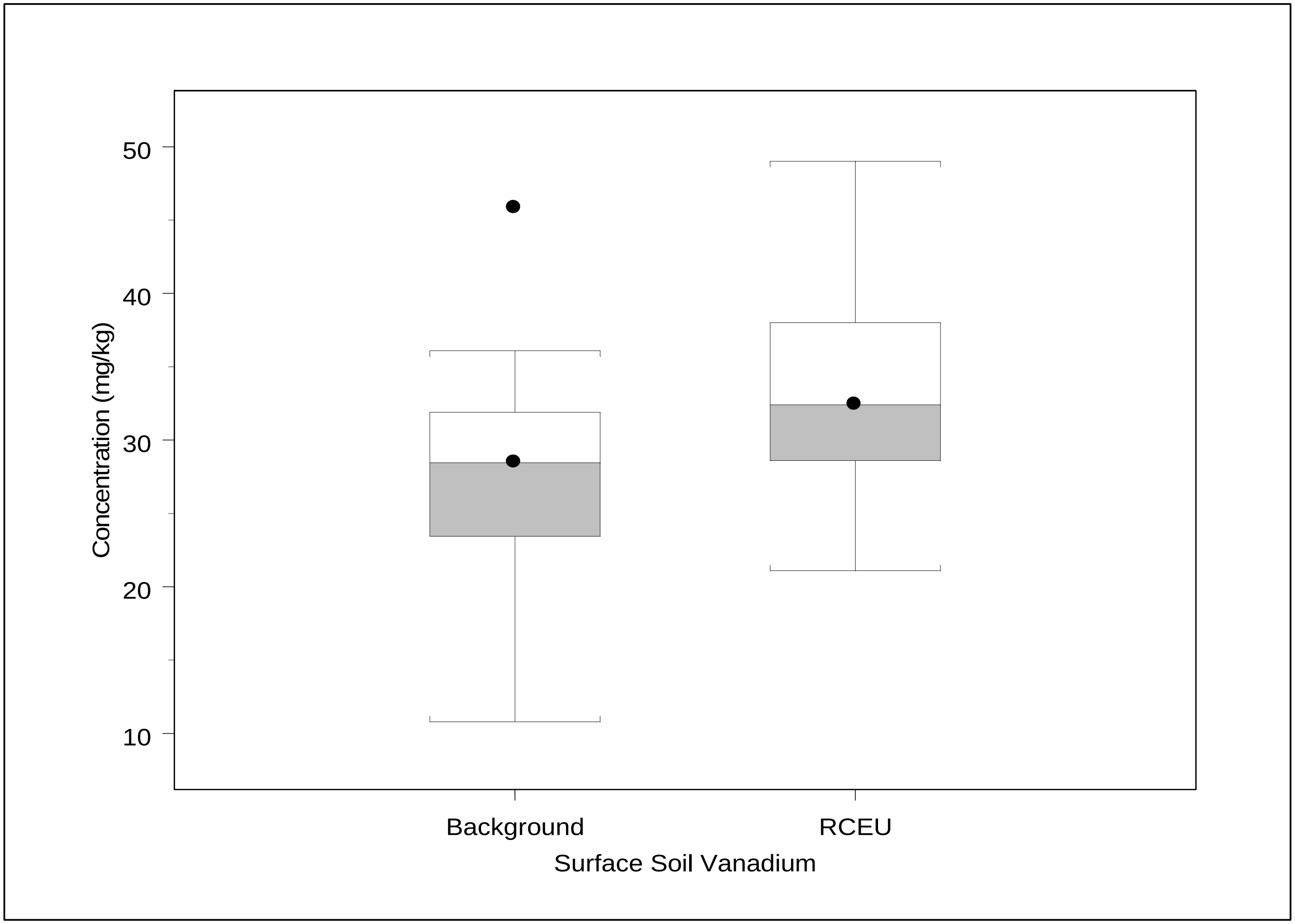
Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.15
RCEU Surface Soil Box Plots for Vanadium



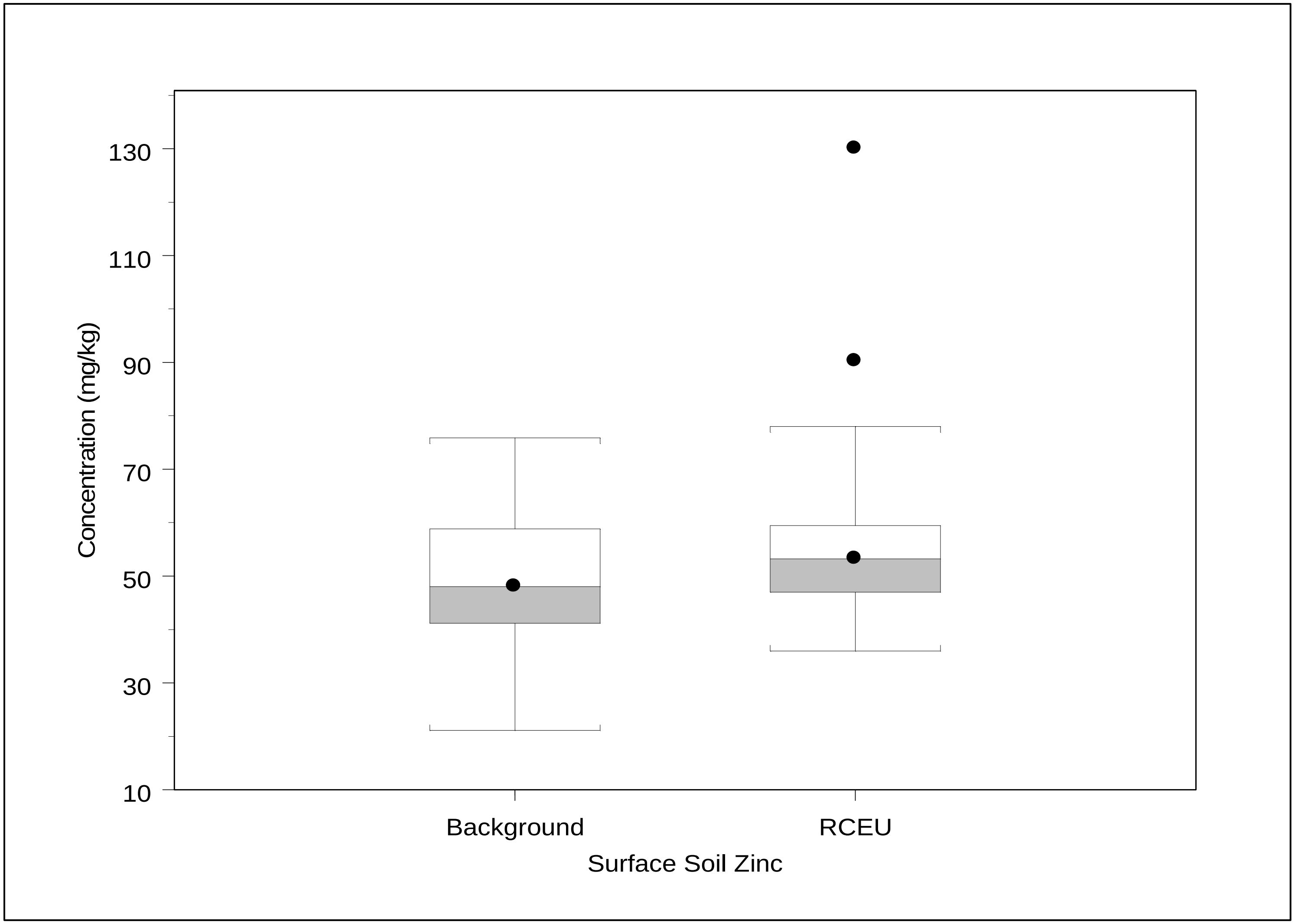
Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.16
RCEU Surface Soil in PMJM Habitat Box Plots for Vanadium



Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

Figure A3.2.17
RCEU Surface Soil Box Plots for Zinc



Box Plot Reference Points - 1) Line inside of box is median, 2) Lower edge of box is 25th percentile, 3) Upper edge of box is 75th percentile, 4) Lower and upper whiskers are drawn to the nearest values not beyond 1.5 times the inter-quartile range.

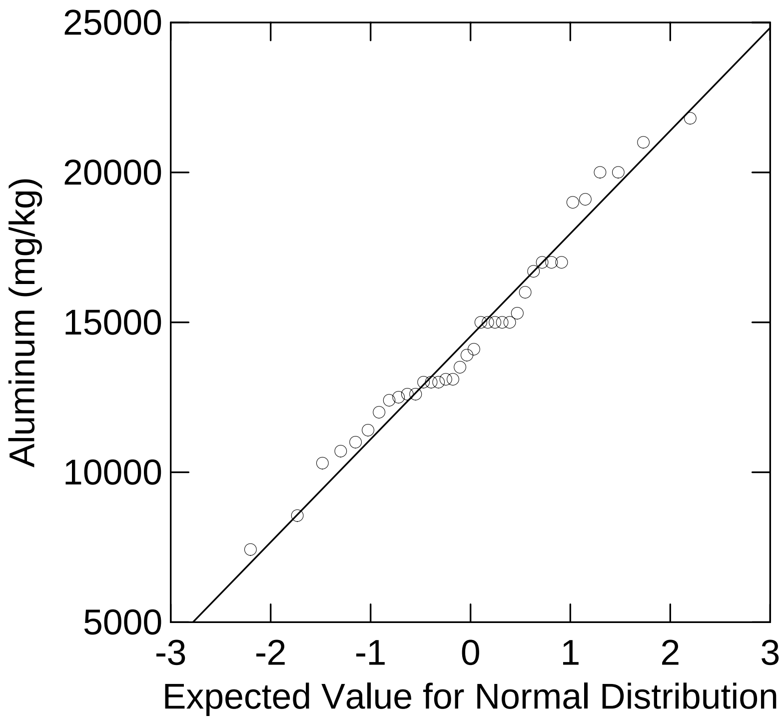


Figure A3.4.1. **Probability Plot for Aluminum Concentrations in RCEU Surface Soil**

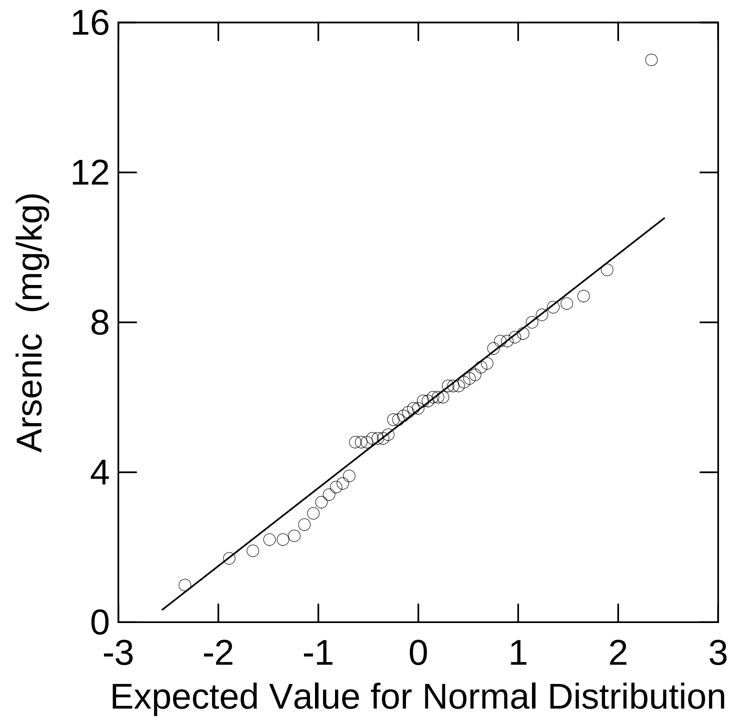


Figure A3.4.2. **Probability Plot for Arsenic Concentrations in RCEU Surface Soil/Surface Sediment**

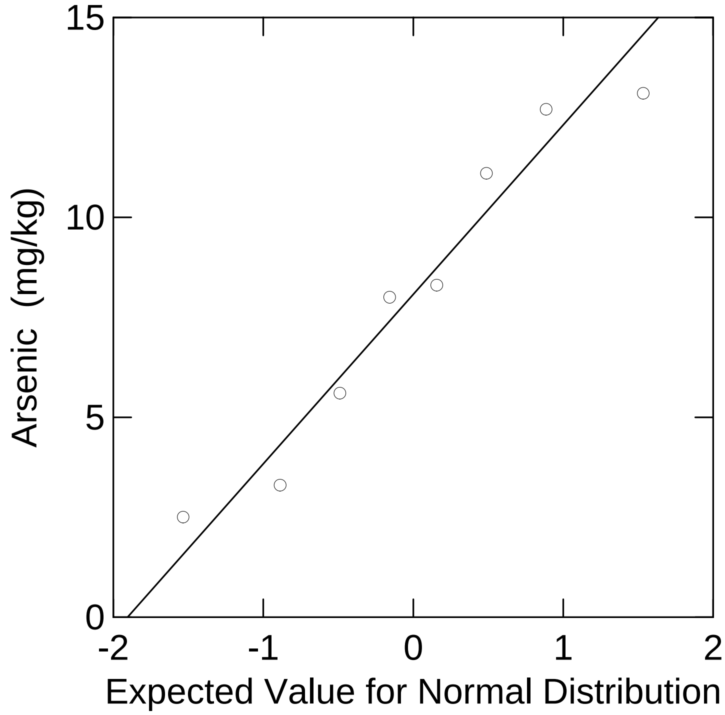


Figure A3.4.3. Probability Plot for Arsenic Concentrations in RCEU Subsurface Soils

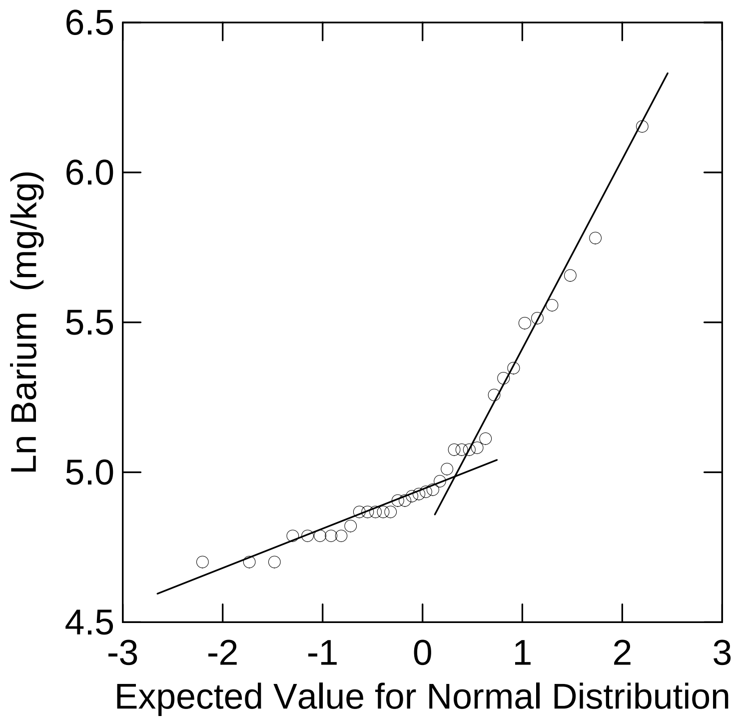
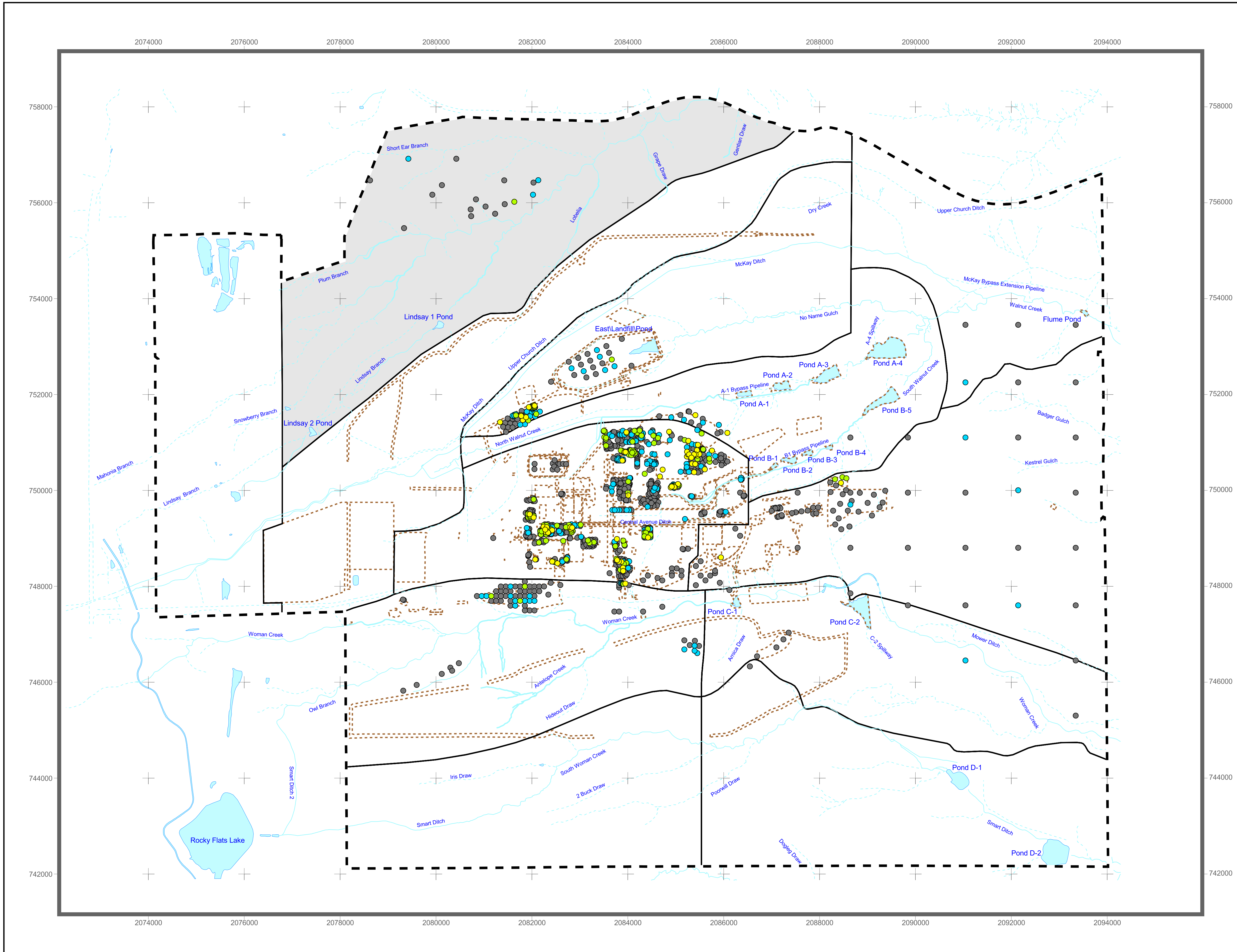


Figure A3.4.4. Probability Plot for Barium Concentrations (Natural Logarithm) in RCEU Surface Soil

Figure A3.4.5

Bis(2-ethylhexyl)phthalate Concentrations in Sitewide Surface Soil (Non-PMJM)



KEY

- Concentration > 3x ESL
- Concentration > ESL and <= 3x ESL
- Concentration <= ESL
- Nondetect (ND)

Min. Non-PMJM ESL = 137 ug/kg
3 x Min. Non-PMJM ESL = 410 ug/kg

Standard Map Features

- Rock Creek Drainage EU
- Exposure Unit boundaries
- Former building where analyte was used or generated as waste
- Historical IHSS/PAC
- Pond
- Ephemeral stream
- Intermittent stream
- Perennial stream
- Site boundary

N S W E

0 1000 2000 Feet

Scale 1:24,000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental
Technology Site

File: W:\Projects\FY2005\CRA\ProfessionalJudgement\FINAL-profjudgment.apr

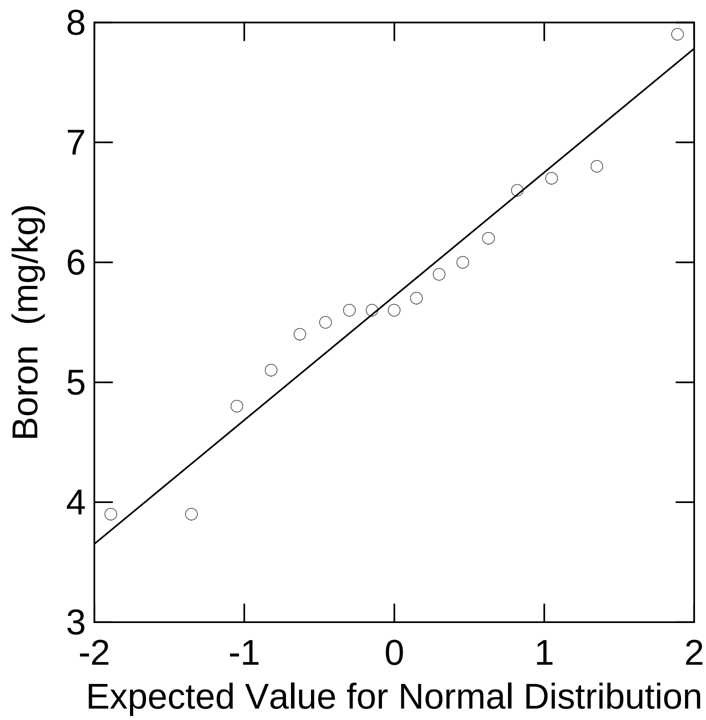


Figure A3.4.6. Probability Plot for Boron Concentrations in RCEU Surface Soil

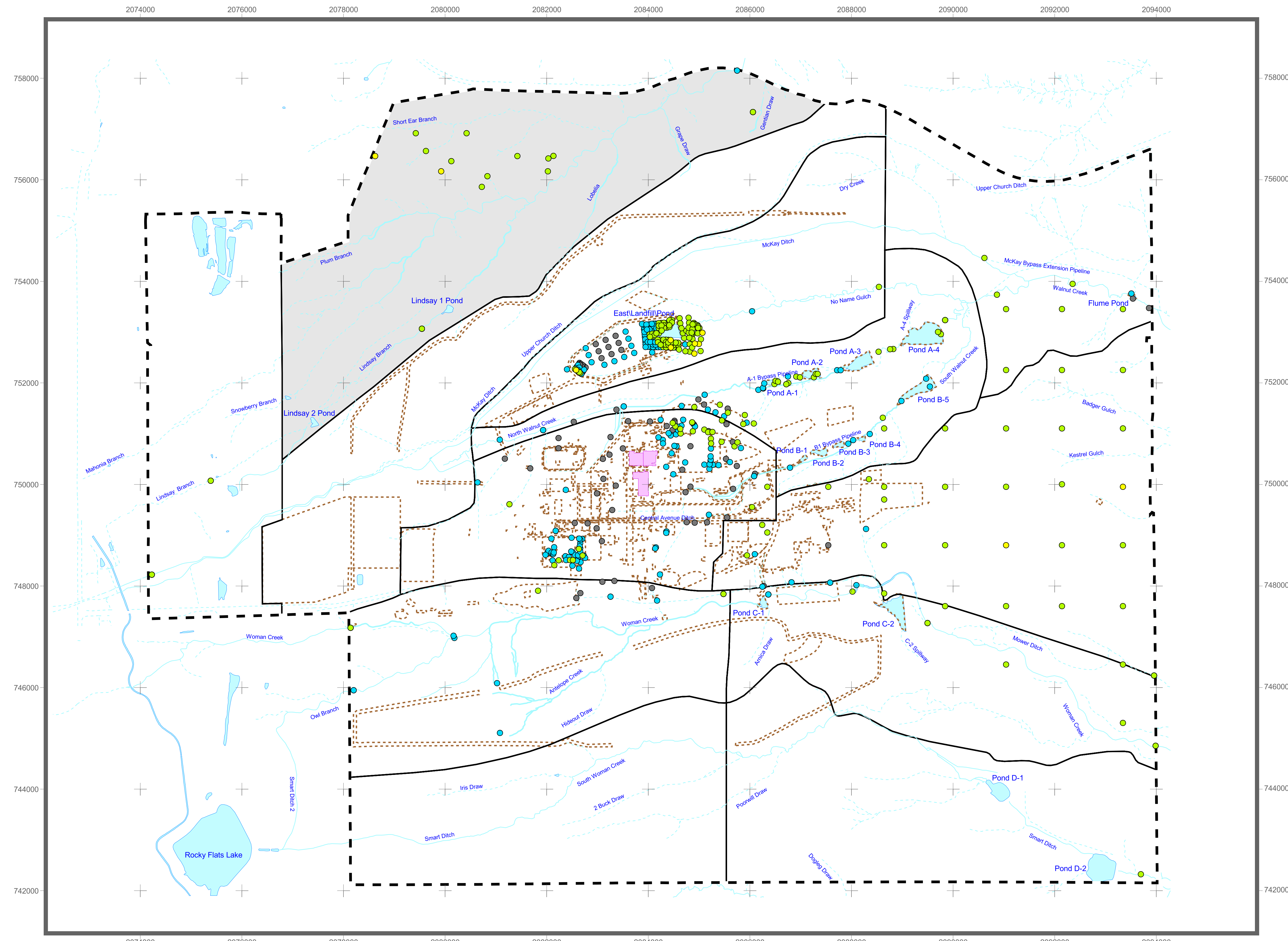


Figure A3.4.7

Cesium-137 Activity in Sitewide Surface Soil/Surface Sediment

KEY

- Concentration > 3x Background MDC
- Concentration > Background MDC and <= 3x Background MDC
- Concentration > WRW PRG and <= Background MDC
- Concentration <= WRW PRG
- Nondetect (ND)

WRW PRG = 0.221 pCi/g
Background MDC = 1.80 pCi/g
3 x Background MDC = 5.4 pCi/g

Standard Map Features

- Rock Creek Drainage EU
- Exposure Unit boundaries
- Former building where analyte was used or generated as waste
- Historical IHSS/PAC
- Pond
- Ephemeral stream
- Intermittent stream
- Perennial stream
- Site boundary

0 1000 2000 Feet

Scale 1:24,000

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

File: W:\Projects\FY2005\CRA\ProfessionalJudgement\FINAL-profjudgment.apr

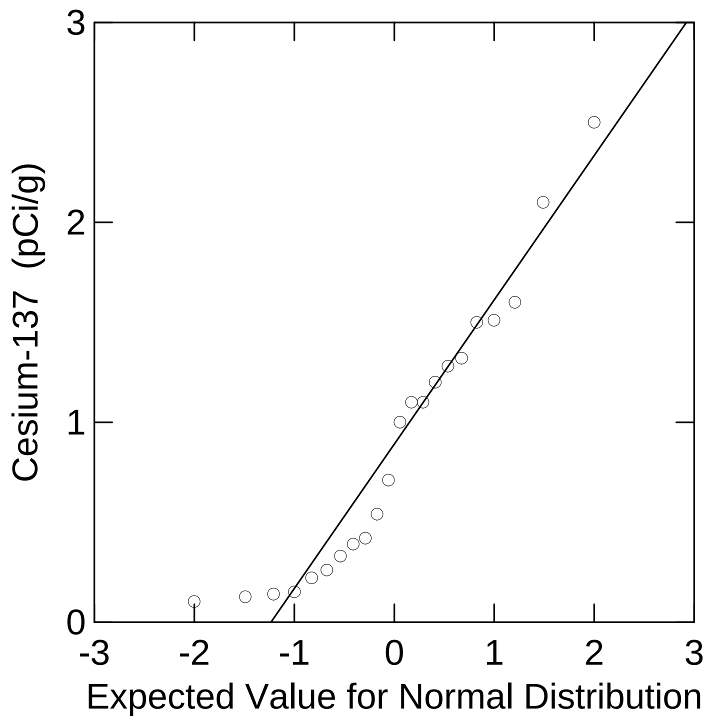


Figure A3.4.8. **Probability Plot for Cesium-137 Activities in RCEU Surface Soil/Surface Sediment**

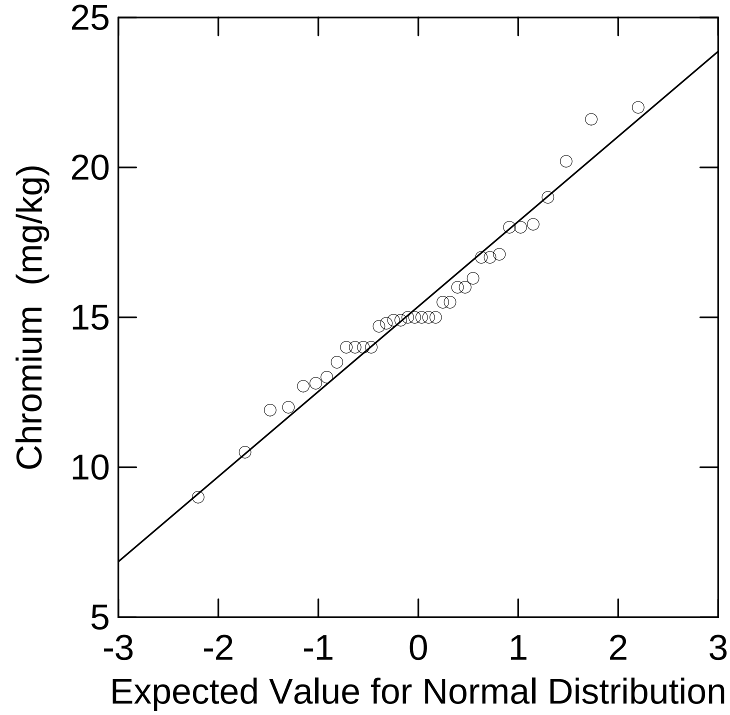


Figure A3.4.9. Probability Plot for Chromium Concentrations in RCEU Surface Soil

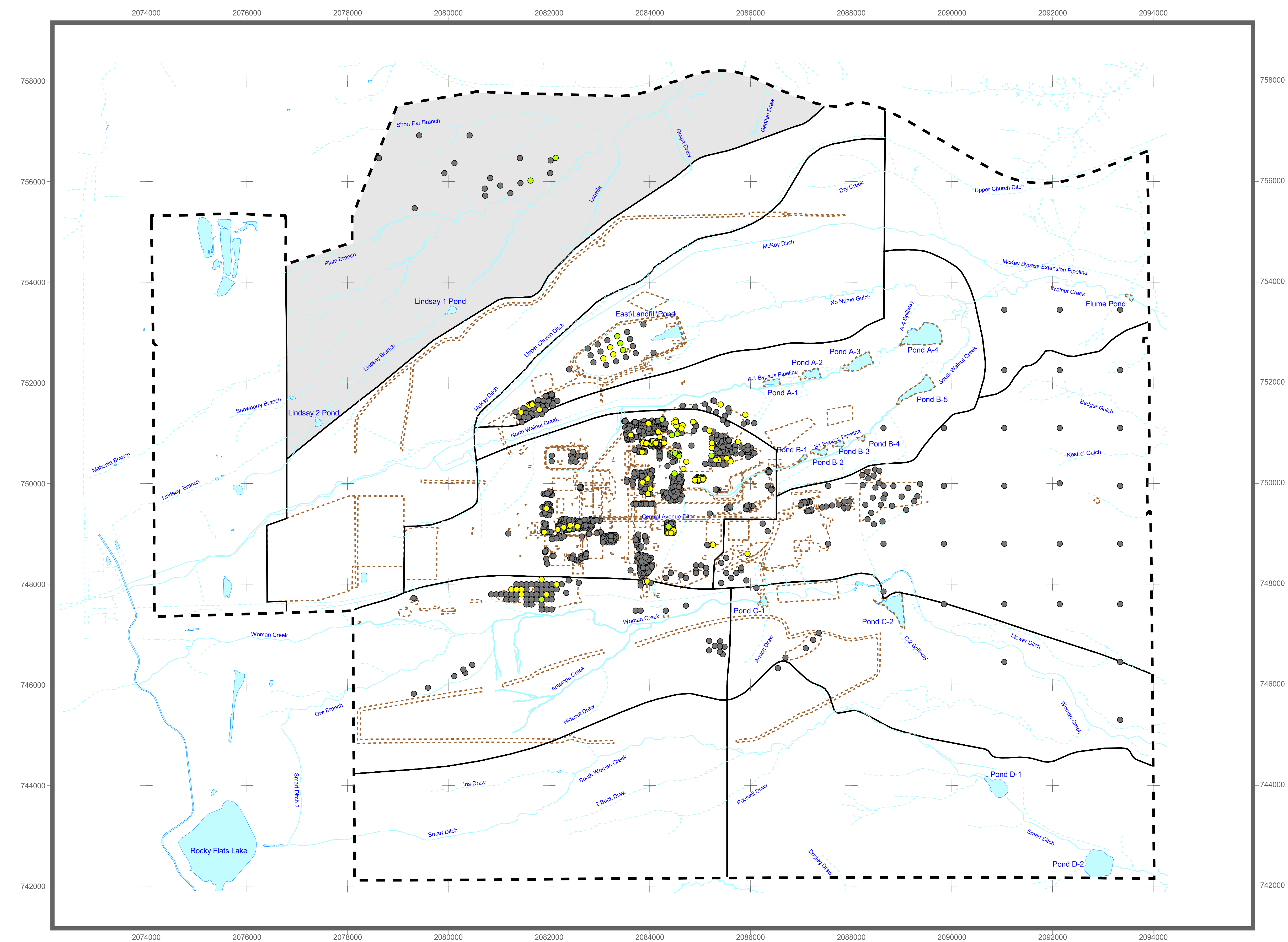


Figure A3.4.10

Di-n-butylphthalate Concentrations in Sitewide Surface Soil (Non-PMJM)

KEY

- Concentration > 3x ESL
- Concentration > ESL and <= 3x ESL
- Concentration <= ESL
- Nondetect (ND)

Min. Non-PMJM ESL = 15.9 ug/kg
3 x Min. Non-PMJM ESL = 47.6 ug/kg

Standard Map Features

- Rock Creek Drainage EU
- Exposure Unit boundaries
- Former building where analyte was used or generated as waste
- Historical IHSS/PAC
- Pond
- Ephemeral stream
- Intermittent stream
- Perennial stream
- Site boundary

0 1000 2000 Feet

Scale 1:24,000

State Plane Coordinate Projection
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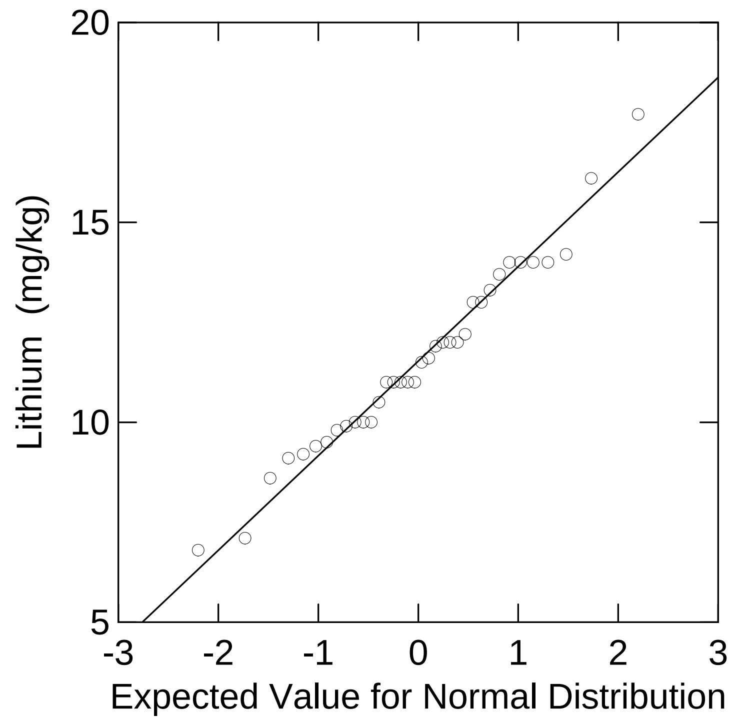


Figure A3.4.11. Probability Plot of Lithium Concentrations in RCEU Surface Soil

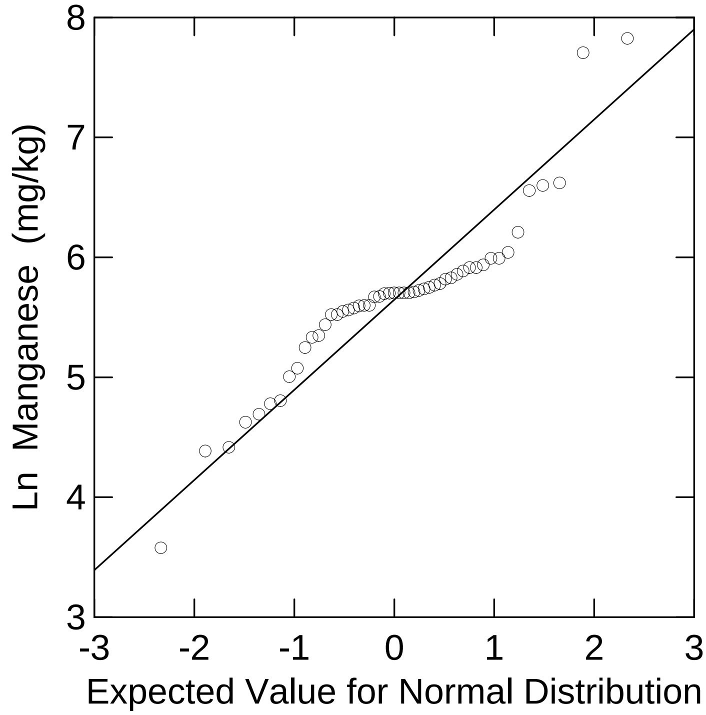


Figure A3.4.12. Probability Plot for Manganese Concentrations (Natural Logarithm) in RCEU Surface Soil/Surface Sediment Data

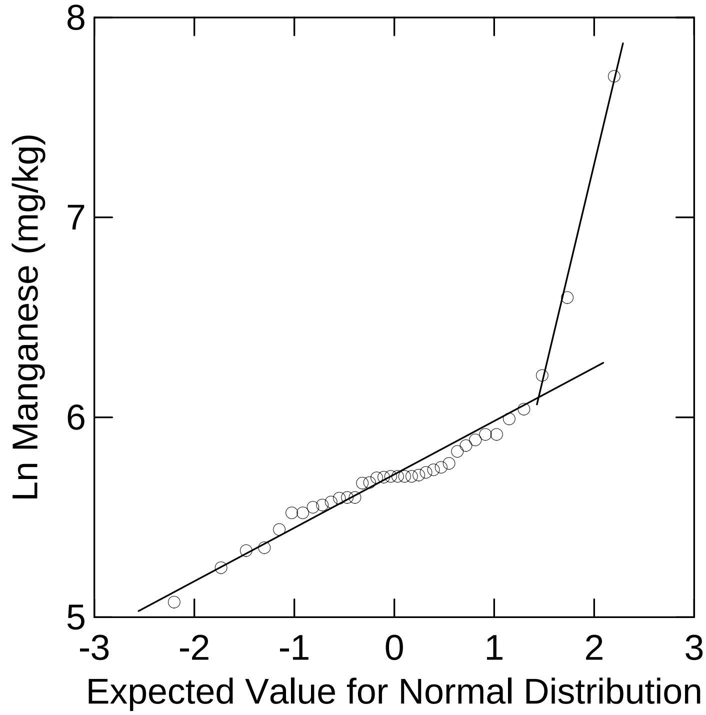


Figure A3.4.13. Probability Plot for Manganese Concentrations (Natural Logarithm) in RCEU Surface Soil

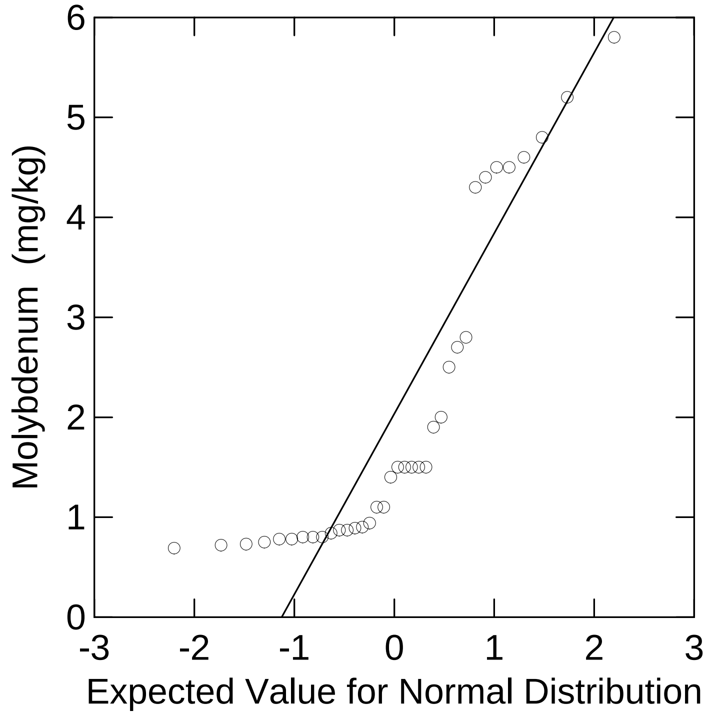


Figure A3.4.14. Probability Plot of Detected Molybdenum Concentrations in RCEU Surface Soil

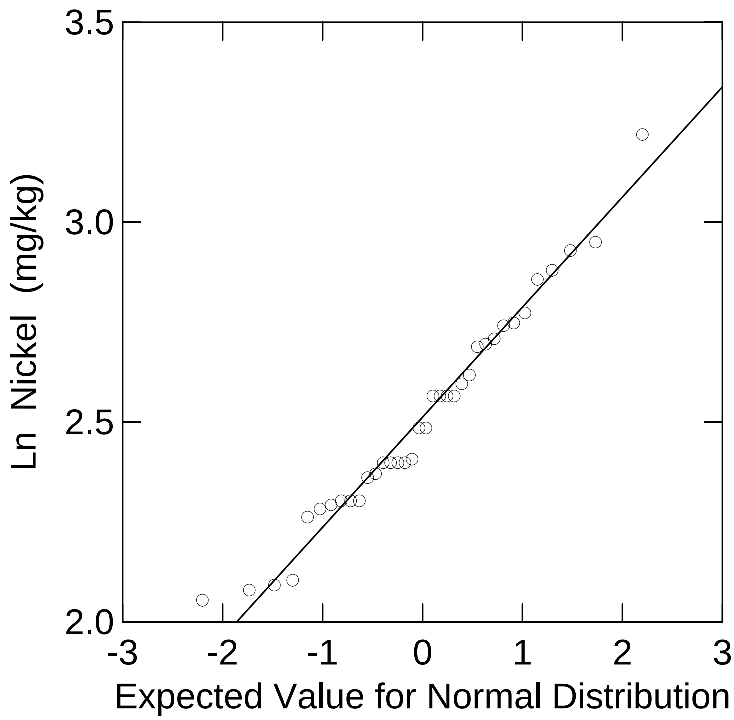
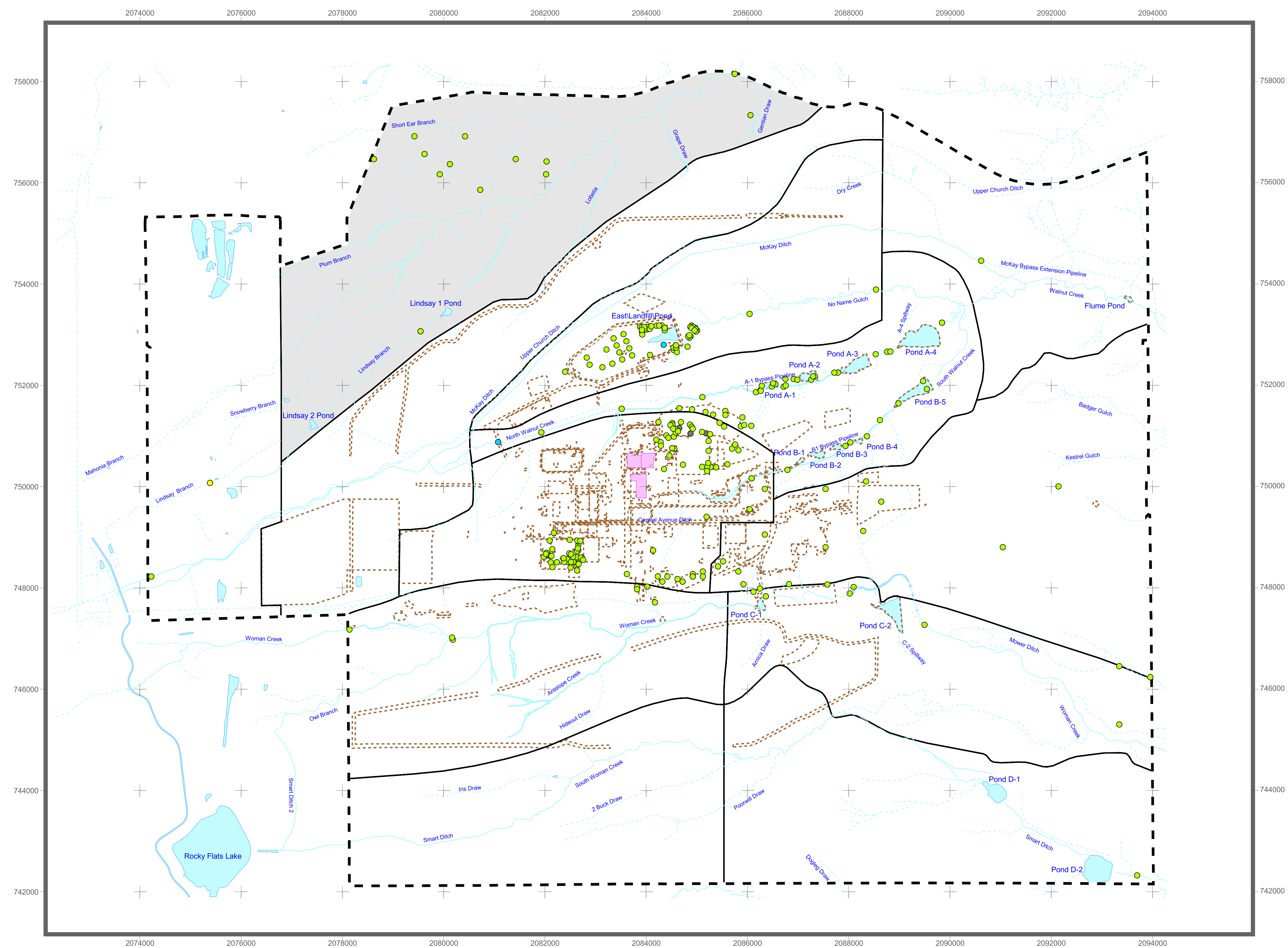


Figure A3.4.15. Probability Plot for Nickel Concentrations (Natural Logarithm) in RCEU Surface Soil

Figure A3.4.16

Radium-228 Activity in Sitewide Surface Soil/Surface Sediment



KEY

- Concentration > 3x Background MDC
- Concentration > Background MDC and <= 3x Background MDC
- Concentration > WRW PRG and <= Background MDC
- Concentration <= WRW PRG
- Nondetect (ND)

WRW PRG = 0.111 pCi/g
Background MDC = 4.10 pCi/g
3 x Background MDC = 12.3 pCi/g

Standard Map Features

- Rock Creek Drainage EU
- Exposure Unit boundaries
- Former building where analyte was used or generated as waste
- Historical IHSS/PAC
- Pond
- Ephemeral stream
- Intermittent stream
- Perennial stream
- Site boundary

0 1000 2000 Feet

Scale 1:24,000

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File: W:\Projects\FY2005\CRA\ProfessionalJudgement\FINAL-profjudgment.apr

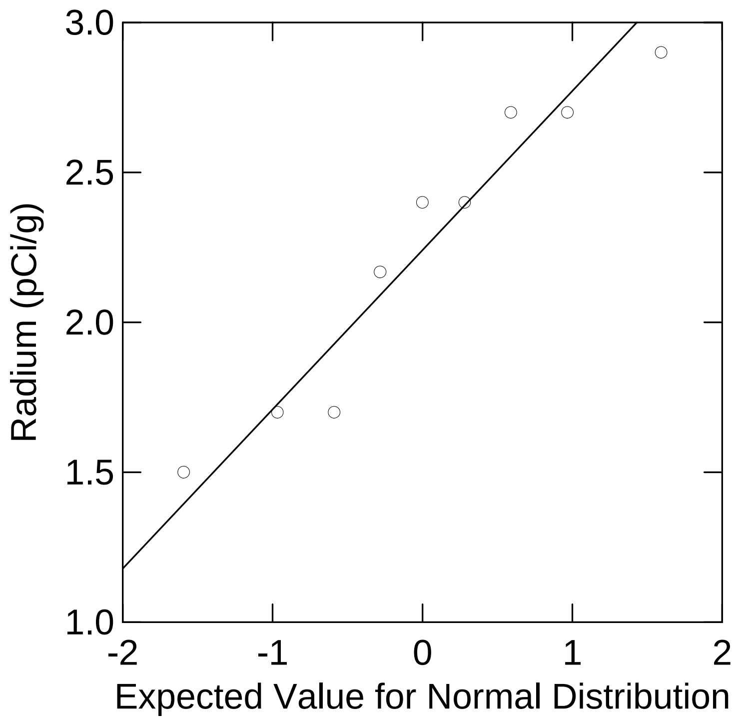

Figure A3.4.17. Probability Plot for Radium-228 Activities in RCEU Surface Soil/Surface Sediment Data

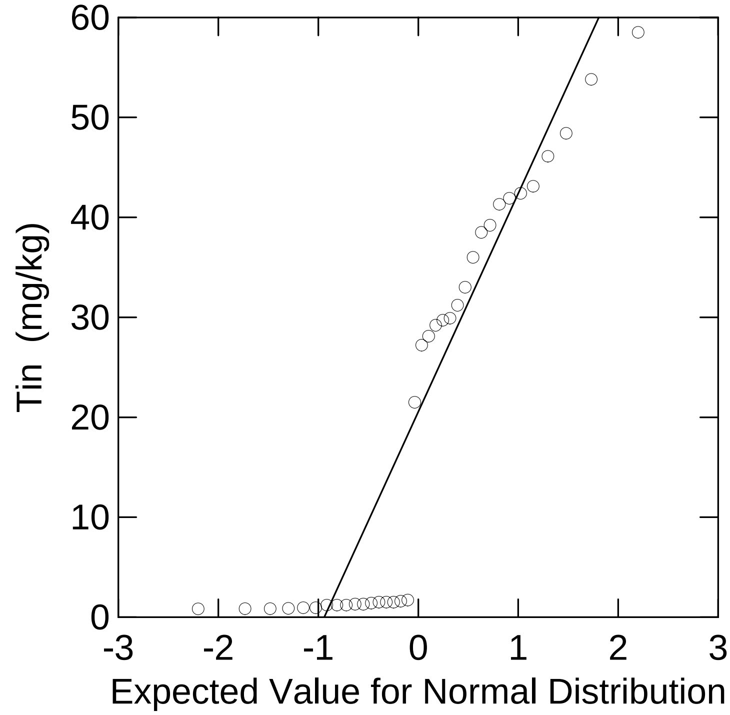

Figure A3.4.18. Probability Plot for Detected Tin Concentrations in RCEU Surface Soil

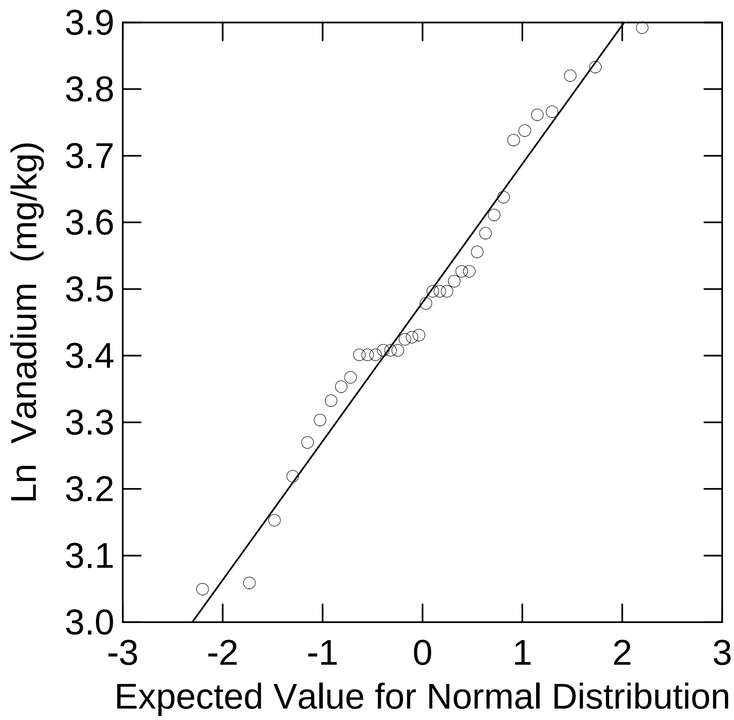

Figure A3.4.19. Probability Plot for Vanadium Concentrations (Natural Logarithm) in RCEU Surface Soil

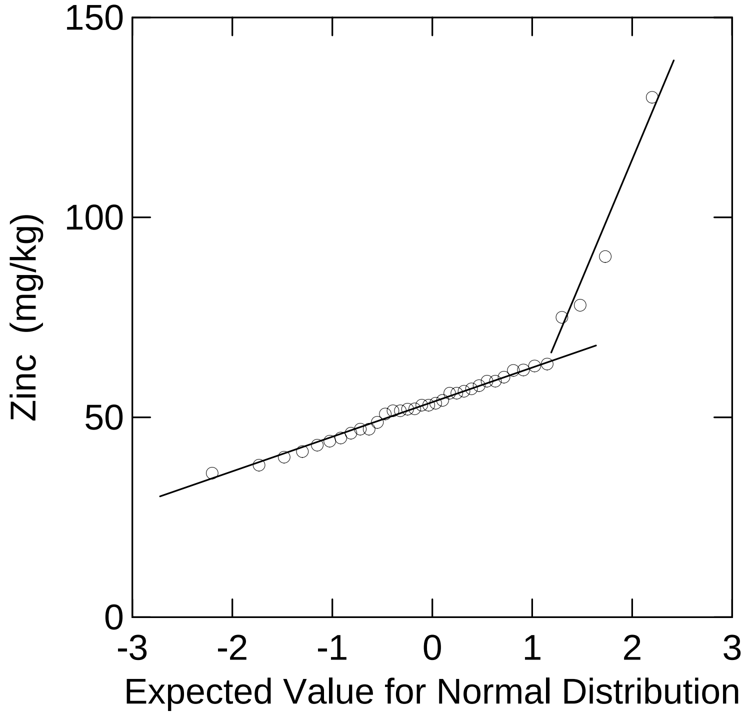

Figure A3.4.20. Probability Plot for Zinc Concentrations in RCEU Surface Soils

COMPREHENSIVE RISK ASSESSMENT

ROCK CREEK DRAINAGE EXPOSURE UNIT

VOLUME 4: ATTACHMENT 4

Risk Assessment Calculations

TABLE OF CONTENTS

1.0 ECOLOGICAL RISK ASSESSMENT TABLES

Table A4.2.1
PMJM Intake Estimates for Manganese; Default Exposure Scenario

Soil to Plant	Soil to Invertebrate	Soil to Small Mammal				
0.234	Ci = 0.809 + 0.682(lnCs	0.037				
Media Concentrations (mg/kg)						
Patch	**Soil Concentration**	**Statistic**	**Plant**	**Earthworm**	**Small Mammal**	**Surface Water (mg/L**
1	310	MDC	72.54	112.3	11.47	0.18
1	N/A	UTL	N/A	N/A	N/A	0.103
1	N/A	UCL	N/A	N/A	N/A	0.032
1	305	Mean	71.37	111.1	11.29	0.025
2	400	MDC	93.60	133.6	14.80	0.18
2	400	UTL	93.60	133.6	14.80	0.103
2	366	UCL	85.64	125.8	13.54	0.032
2	317	Mean	74.18	114.0	11.73	0.025
3A	420	MDC	98.28	138.2	15.54	0.18
3A	N/A	UTL	N/A	N/A	N/A	0.103
3A	N/A	UCL	N/A	N/A	N/A	0.032
3A	325	Mean	76.05	116.0	12.03	0.025
3B	2220	MDC	519.48	430.1	82.14	0.18
3B	N/A	UTL	N/A	N/A	N/A	0.103
3B	N/A	UCL	N/A	N/A	N/A	0.032
3B	N/A	Mean	N/A	N/A	N/A	0.025
5	340	MDC	79.56	119.6	12.58	0.18
5	N/A	UTL	N/A	N/A	N/A	0.103
5	N/A	UCL	N/A	N/A	N/A	0.032
5	280	Mean	65.52	104.8	10.36	0.025
6	250	MDC	58.50	97.0	9.25	0.18
6	N/A	UTL	N/A	N/A	N/A	0.103
6	N/A	UCL	N/A	N/A	N/A	0.032
6	N/A	Mean	N/A	N/A	N/A	0.025
7	160	MDC	37.44	71.5	5.92	0.18
7	N/A	UTL	N/A	N/A	N/A	0.103
7	N/A	UCL	N/A	N/A	N/A	0.032
7	N/A	Mean	N/A	N/A	N/A	0.025
8	497	MDC	116.30	155.0	18.39	0.18
8	N/A	UTL	N/A	N/A	N/A	0.103
8	N/A	UCL	N/A	N/A	N/A	0.032
8	342	Mean	80.03	120.1	12.65	0.025
Intake Parameters						
	$IR_{(food)}$ (kg/kg BW day)	**$IR_{(water)}$** (kg/kg BW day)	**$IR_{(soil)}$** (kg/kg BW day)	**P_{plant}**	**P_{invert}**	**P_{mammal}**
PMJM	0.17	0.15	0.004	0.7	0.3	0
Intake Estimates (mg/kg BW day)						
	Plant Tissue	**Invertebrate Tissue**	**Mammal Tissue**	**Soil**	**Surface Water**	**Total**
Patch 1						
MDC	8.63E+00	5.73E+00	N/A	1.26E+00	2.70E-02	1.57E+01
UTL	N/A	N/A	N/A	N/A	1.55E-02	1.55E-02
UCL	N/A	N/A	N/A	N/A	4.80E-03	4.80E-03
Mean	8.49E+00	5.67E+00	N/A	1.24E+00	3.75E-03	1.54E+01
Patch 2						
MDC	1.11E+01	6.82E+00	N/A	1.63E+00	2.70E-02	1.96E+01
UTL	1.11E+01	6.82E+00	N/A	1.63E+00	1.55E-02	1.96E+01
UCL	1.02E+01	6.42E+00	N/A	1.49E+00	4.80E-03	1.81E+01
Mean	8.83E+00	5.82E+00	N/A	1.29E+00	3.75E-03	1.59E+01
Patch 3A						
MDC	1.17E+01	7.05E+00	N/A	1.71E+00	2.70E-02	2.05E+01
UTL	N/A	N/A	N/A	N/A	1.55E-02	1.55E-02
UCL	N/A	N/A	N/A	N/A	4.80E-03	4.80E-03
Mean	9.05E+00	5.92E+00	N/A	1.33E+00	3.75E-03	1.63E+01
Patch 3B						
MDC	6.18E+01	2.19E+01	N/A	9.06E+00	2.70E-02	9.28E+01
UTL	N/A	N/A	N/A	N/A	1.55E-02	1.55E-02

Table A4.2.1
PMJM Intake Estimates for Manganese; Default Exposure Scenario

UCL	N/A	N/A	N/A	N/A	4.80E-03	4.80E-03
Mean	N/A	N/A	N/A	N/A	3.75E-03	3.75E-03
Patch 5						
MDC	9.47E+00	6.10E+00	N/A	1.39E+00	2.70E-02	1.70E+01
UTL	N/A	N/A	N/A	N/A	1.55E-02	1.55E-02
UCL	N/A	N/A	N/A	N/A	4.80E-03	4.80E-03
Mean	7.80E+00	5.34E+00	N/A	1.14E+00	3.75E-03	1.43E+01
Patch 6						
MDC	6.96E+00	4.95E+00	N/A	1.02E+00	2.70E-02	1.30E+01
UTL	N/A	N/A	N/A	N/A	1.55E-02	1.55E-02
UCL	N/A	N/A	N/A	N/A	4.80E-03	4.80E-03
Mean	N/A	N/A	N/A	N/A	3.75E-03	3.75E-03
Patch 7						
MDC	4.46E+00	3.65E+00	N/A	6.53E-01	2.70E-02	8.78E+00
UTL	N/A	N/A	N/A	N/A	1.55E-02	1.55E-02
UCL	N/A	N/A	N/A	N/A	4.80E-03	4.80E-03
Mean	N/A	N/A	N/A	N/A	3.75E-03	3.75E-03
Patch 8						
MDC	1.38E+01	7.90E+00	N/A	2.03E+00	2.70E-02	2.38E+01
UTL	N/A	N/A	N/A	N/A	1.55E-02	1.55E-02
UCL	N/A	N/A	N/A	N/A	4.80E-03	4.80E-03
Mean	9.52E+00	6.13E+00	N/A	1.40E+00	3.75E-03	1.70E+01

NA = Not applicable or not available

Table A4.2.2
PMJM Hazard Quotients for Manganese

Patch/ EPC Statistic	Total Intake (mg/kg BW day)	TRV (mg/kg BW day)		Hazard Quotients	
		NOAEL	LOAEL	NOAEL	LOAEL
Manganese (Default Exposure)					
Patch 1					
MDC	15.7	13.3	159.1	1	0.1
UTL[a]	0.0155	13.3	159.1	0.001	0.0001
UCL[a]	0.00480	13.3	159.1	0.0004	0.00003
Mean	15.4	13.3	159.1	1	0.1
Patch 2					
MDC	19.6	13.3	159.1	1	0.1
UTL	19.6	13.3	159.1	1	0.1
UCL	18.1	13.3	159.1	1	0.1
Mean	15.9	13.3	159.1	1	0.10
Patch 3A					
MDC	20.5	13.3	159.1	**2**	0.1
UTL[a]	0.0155	13.3	159.1	0.0012	0.0001
UCL[a]	0.00480	13.3	159.1	0.0004	0.00003
Mean	16.3	13.3	159.1	1	0.10
Patch 3B					
MDC	92.8	13.3	159.1	**7**	0.6
UTL[a]	0.0155	13.3	159.1	0.0012	0.0001
UCL[a]	0.00480	13.3	159.1	0.0004	0.00003
Mean[a]	0.00375	13.3	159.1	0.0003	0.00002
Patch 5					
MDC	17.0	13.3	159.1	1	0.1
UTL[a]	0.0155	13.3	159.1	0.0012	0.0001
UCL[a]	0.00480	13.3	159.1	0.0004	0.00003
Mean	14.3	13.3	159.1	1	0.1
Patch 6					
MDC	13.0	13.3	159.1	0.97	0.08
UTL[a]	0.0155	13.3	159.1	0.0012	0.0001
UCL[a]	0.00480	13.3	159.1	0.0004	0.00003
Mean[a]	0.00375	13.3	159.1	0.0003	0.00002
Patch 7					
MDC	8.78	13.3	159.1	0.7	0.06
UTL[a]	0.0155	13.3	159.1	0.0012	0.0001
UCL[a]	0.00480	13.3	159.1	0.0004	0.00003
Mean[a]	0.00375	13.3	159.1	0.0003	0.00002
Patch 8					
MDC	23.8	13.3	159.1	**2**	0.1
UTL[a]	0.0155	13.3	159.1	0.0012	0.0001
UCL[a]	0.00480	13.3	159.1	0.0004	0.00003
Mean	17.0	13.3	159.1	1	0.1

[a] Intake and hazard quotients based on intake of surface water only because soil UTL, UCL, and/or Mean could not be calculated for use in food chain and incidental soil ingestion estimates

N/A = Not applicable.

Bold = Hazard quotients>1.

Table A4.2.3
PMJM Intake Estimates for Tin; Default Exposure Scenario

Soil to Plant	Soil to Invertebrate	Soil to Small Mammal				
0.03	1	0.21				
Media Concentrations (mg/kg)						
Patch	**Soil Concentration**	**Statistic**	**Plant**	**Earthworm**	**Small Mammal**	**Surface Water (mg/L)**
1	0.6	MDC	0.02	0.60	0.13	0.068
1	N/A	UTL	N/A	N/A	N/A	0.036
1	N/A	UCL	N/A	N/A	N/A	0.019
1	0.51	Mean	0.02	0.51	0.11	0.008
2	33	MDC	0.99	33.00	6.93	0.068
2	51.5	UTL	1.55	51.50	10.82	0.036
2	23.9	UCL	0.72	23.90	5.02	0.019
2	13.8	Mean	0.41	13.80	2.90	0.008
3A	28.1	MDC	0.84	28.10	5.90	0.068
3A	N/A	UTL	N/A	N/A	N/A	0.036
3A	N/A	UCL	N/A	N/A	N/A	0.019
3A	14.5	Mean	0.44	14.50	3.05	0.008
3B	31.2	MDC	0.94	31.20	6.55	0.068
3B	N/A	UTL	N/A	N/A	N/A	0.036
3B	N/A	UCL	N/A	N/A	N/A	0.019
3B	N/A	Mean	N/A	N/A	N/A	0.008
5	1.2	MDC	0.04	1.20	0.25	0.068
5	N/A	UTL	N/A	N/A	N/A	0.036
5	N/A	UCL	N/A	N/A	N/A	0.019
5	1.18	Mean	0.04	1.18	0.25	0.008
6	1.3	MDC	0.04	1.30	0.27	0.068
6	N/A	UTL	N/A	N/A	N/A	0.036
6	N/A	UCL	N/A	N/A	N/A	0.019
6	N/A	Mean	N/A	N/A	N/A	0.008
7	0.75	MDC	0.02	0.75	0.16	0.068
7	N/A	UTL	N/A	N/A	N/A	0.036
7	N/A	UCL	N/A	N/A	N/A	0.019
7	N/A	Mean	N/A	N/A	N/A	0.008
8	15	MDC	0.45	15.00	3.15	0.068
8	N/A	UTL	N/A	N/A	N/A	0.036
8	N/A	UCL	N/A	N/A	N/A	0.019
8	9.66	Mean	0.29	9.66	2.03	0.008

Table A4.2.3
PMJM Intake Estimates for Tin; Default Exposure Scenario

Intake Parameters						
	$IR_{(food)}$ (kg/kg BW day)	$IR_{(water)}$ (kg/kg BW day)	$IR_{(soil)}$ (kg/kg BW day)	P_{plant}	P_{invert}	P_{mammal}
PMJM	0.17	0.15	0.004	0.7	0.3	0
Intake Estimates (mg/kg BW day)						
	Plant Tissue	**Invertebrate Tissue**	**Mammal Tissue**	**Soil**	**Surface Water**	**Total**
Patch 1						
MDC	2.14E-03	3.06E-02	N/A	2.45E-03	1.02E-02	4.54E-02
UTL	N/A	N/A	N/A	N/A	5.40E-03	5.40E-03
UCL	N/A	N/A	N/A	N/A	2.85E-03	2.85E-03
Mean	1.82E-03	2.60E-02	N/A	2.08E-03	1.20E-03	3.11E-02
Patch 2						
MDC	1.18E-01	1.68E+00	N/A	1.35E-01	1.02E-02	1.95E+00
UTL	1.18E-01	1.68E+00	N/A	1.35E-01	1.02E-02	1.95E+00
UCL	8.53E-02	1.22E+00	N/A	9.75E-02	2.85E-03	1.40E+00
Mean	4.93E-02	7.04E-01	N/A	5.63E-02	1.20E-03	8.11E-01
Patch 3A						
MDC	1.00E-01	1.43E+00	N/A	1.15E-01	1.02E-02	1.66E+00
UTL	N/A	N/A	N/A	N/A	5.40E-03	5.40E-03
UCL	N/A	N/A	N/A	N/A	2.85E-03	2.85E-03
Mean	5.18E-02	7.40E-01	N/A	5.92E-02	1.20E-03	8.52E-01
Patch 3B						
MDC	1.11E-01	1.59E+00	N/A	1.27E-01	1.02E-02	1.84E+00
UTL	N/A	N/A	N/A	N/A	5.40E-03	5.40E-03
UCL	N/A	N/A	N/A	N/A	2.85E-03	2.85E-03
Mean	N/A	N/A	N/A	N/A	1.20E-03	1.20E-03
Patch 5						
MDC	4.28E-03	6.12E-02	N/A	4.90E-03	1.02E-02	8.06E-02
UTL	N/A	N/A	N/A	N/A	5.40E-03	5.40E-03
UCL	N/A	N/A	N/A	N/A	2.85E-03	2.85E-03
Mean	4.21E-03	6.02E-02	N/A	4.81E-03	1.20E-03	7.04E-02
Patch 6						
MDC	4.64E-03	6.63E-02	N/A	5.30E-03	1.02E-02	8.64E-02
UTL	N/A	N/A	N/A	N/A	5.40E-03	5.40E-03
UCL	N/A	N/A	N/A	N/A	2.85E-03	2.85E-03
Mean	N/A	N/A	N/A	N/A	1.20E-03	1.20E-03
Patch 7						
MDC	2.68E-03	3.83E-02	N/A	3.06E-03	1.02E-02	5.42E-02

Table A4.2.3
PMJM Intake Estimates for Tin; Default Exposure Scenario

UTL	N/A	N/A	N/A	N/A	5.40E-03	5.40E-03
UCL	N/A	N/A	N/A	N/A	2.85E-03	2.85E-03
Mean	N/A	N/A	N/A	N/A	1.20E-03	1.20E-03
Patch 8						
MDC	5.36E-02	7.65E-01	N/A	6.12E-02	1.02E-02	8.90E-01
UTL	N/A	N/A	N/A	N/A	5.40E-03	5.40E-03
UCL	N/A	N/A	N/A	N/A	2.85E-03	2.85E-03
Mean	3.45E-02	4.93E-01	N/A	3.94E-02	1.20E-03	5.68E-01

NA = Not applicable or not available

Table A4.2.4
PMJM Hazard Quotients for Tin

Patch/ EPC Statistic	Total Intake (mg/kg BW day)	TRV (mg/kg BW day) NOAEL	TRV (mg/kg BW day) LOAEL	Hazard Quotients NOAEL	Hazard Quotients LOAEL
Manganese (Default Exposure)					
Patch 1					
MDC	0.0454	0.25	15	0.2	0.003
UTL[a]	0.00540	0.25	15	0.02	0.0004
UCL[a]	0.00285	0.25	15	0.01	0.0002
Mean	0.0311	0.25	15	0.1	0.0021
Patch 2					
MDC	1.95	0.25	15	**8**	0.1
UTL	3.03	0.25	15	**8**	0.1
UCL	1.40	0.25	15	**6**	0.09
Mean	0.811	0.25	15	**3**	0.05
Patch 3A					
MDC	1.66	0.25	15	**7**	0.1
UTL[a]	0.00540	0.25	15	0.02	0.0004
UCL[a]	0.00285	0.25	15	0.01	0.0002
Mean	0.852	0.25	15	**3**	0.06
Patch 3B					
MDC	1.84	0.25	15	**7**	0.1
UTL[a]	0.00540	0.25	15	0.02	0.0004
UCL[a]	0.00285	0.25	15	0.01	0.0002
Mean[a]	0.00120	0.25	15	0.005	0.0001
Patch 5					
MDC	0.081	0.25	15	0.3	0.005
UTL[a]	0.00540	0.25	15	0.02	0.0004
UCL[a]	0.00285	0.25	15	0.01	0.0002
Mean	0.070	0.25	15	0.3	0.005
Patch 6					
MDC	0.086	0.25	15	0.3	0.006
UTL[a]	0.00540	0.25	15	0.02	0.0004
UCL[a]	0.00285	0.25	15	0.01	0.0002
Mean[a]	0.00120	0.25	15	0.005	0.0001
Patch 7					
MDC	0.054	0.25	15	0.2	0.004
UTL[a]	0.00540	0.25	15	0.02	0.0004
UCL[a]	0.00285	0.25	15	0.01	0.0002
Mean[a]	0.00120	0.25	15	0.005	0.0001
Patch 8					
MDC	0.890	0.25	15	**4**	0.06
UTL[a]	0.00540	0.25	15	0.02	0.0004
UCL[a]	0.00285	0.25	15	0.01	0.0002
Mean	0.568	0.25	15	**2**	0.04

[a] Intake and hazard quotients based on intake of surface water only because soil UTL, UCL, and/or Mean could not be calculated for use in food chain and incidental soil ingestion estimates
N/A = Not applicable.
Bold = Hazard quotients>1.

COMPREHENSIVE RISK ASSESSMENT

ROCK CREEK DRAINAGE EXPOSURE UNIT

VOLUME 4: ATTACHMENT 5

Chemical-Specific Uncertainty Analysis

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS

BAF	bioaccumulation factor
CRA	Comprehensive Risk Assessment
DOE	U.S. Department of Energy
ECOPC	ecological contaminant of potential concern
EcoSSL	Ecological Soil Screening Level
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
HQ	hazard quotient
LOAEL	lowest observed adverse effect level
NOAEL	No observed adverse effect level
ORNL	Oak Ridge National Laboratory
PMJM	Preble’s meadow jumping mouse
RCRA	Resource Conservation and Recovery Act
RFETS	Rocky Flats Environmental Technology Site
RI/FS	Remedial Investigation/Feasibility Study
TRV	toxicity reference value
UCL	upper confidence limit
UTL	upper tolerance limit

1.0 INTRODUCTION

One potential limitation of the hazard quotient (HQ) approach is that calculated HQ values may sometimes be uncertain due to simplifications and assumptions in the underlying exposure and toxicity data used to derive the HQs. Where possible, this risk assessment provides information on two potential sources of uncertainty, described below.

- **Bioaccumulation Factors (BAFs).** For wildlife receptors, concentrations of contaminants in dietary items were estimated from surface soil using uptake equations. When the uptake equation was based on a simple linear model (e.g., C_{tissue} = BAF * C_{soil}), the default exposure scenario used a high-end estimate of the BAF (the 90th percentile BAF). However, the use of high-end BAFs may tend to overestimate tissue concentrations in some dietary items. In order to estimate more typical tissue concentrations, where necessary, an alternative exposure scenario calculated total chemical intake using a 50th percentile (median) BAF and HQs were calculated. The use of the median BAF is consistent with the approach used in the U.S. Environmental Protection Agency (EPA) ecological soil screening level (Eco-SSL) guidance (EPA 2005).
- **Toxicity Reference Values (TRVs).** The Comprehensive Risk Assessment (CRA) Methodology (U.S. Department of Energy [DOE] 2005), used an established hierarchy to identify the most appropriate default TRVs for use in the ecological contaminant of potential concern (ECOPC) selection. However, in some instances, the default TRV selected may be overly conservative with regard to characterizing population-level risks. The determination of whether the default TRVs are thought to yield overly conservative estimates of risk is addressed in the uncertainty sections below on a chemical-by-chemical basis in the following subsections. When an alternative TRV is identified, the chemical-specific subsections provide a discussion of why the alternative TRV is thought to be appropriate to provide an alternative estimate of toxicity (e.g., endpoint relevance, species relevance, data quality, chemical form, etc.), and HQs were calculated using both default and alternative TRVs where necessary.

The influences of each of these uncertainties on the calculated HQs are discussed for each ECOPC in the following subsections.

1.1 Manganese

Bioaccumulation Factors

There are several important uncertainties associated with the intake and HQ calculations for vertebrate receptors. Manganese has two types of bioaccumulation factors used in the intake calculations. For the soil-to-invertebrate BAF, a regression equation was used to estimate tissue concentrations. Confidence placed in this value is high; however, uncertainty is unavoidable when using even high-quality models to predict tissue concentrations. In cases without available measurements of tissue concentrations, regression-based models are generally the best available predictor of tissue concentrations. However, the regression-based BAFs may still overestimate or underestimate invertebrate tissue concentrations of manganese to an unknown degree.

The soil-to-plant and soil-to-small mammal BAFs used to estimate tissue concentrations are based on screening-level, upper-bound (90th percentile) BAFs presented in ORNL (1998) and Sample et al. (1998). These values provide conservative estimates of uptake from soils to tissues. This conservative estimate may serve to overestimate manganese concentrations in plant and small mammal tissues. For this reason, the median BAFs presented in the same document were used as alternative BAFs to estimate tissue concentrations. It is unclear whether the use of median BAFs reduces the uncertainty involved in the estimation of plant and small mammal tissue concentrations, but the likelihood of overestimation of risks is reduced. In addition, the conservative nature of the upper-bound soil-to-plant BAF directly affects the conservatisms in the soil-to-small mammal BAF that uses both the soil-to-plant and soil-to-invertebrate BAFs in its calculation. It is unclear to what degree and direction that uncertainty can be estimated for the soil-to-small mammal BAF, but the uncertainty associated with the estimated small mammal tissue concentrations is high.

Toxicity Reference Values

The no observed adverse effect level (NOAEL) and lowest observed adverse effect level (LOAEL) TRVs for mammalian receptors were obtained from PRC (1994), a CRA Methodology-approved source of TRVs. The LOAEL TRV represents an intake rate at which a decrease in testical weight in mice was noted. The NOAEL TRV was taken from the same study and represents an intake rate at which no effects on testicular weight were noted. No threshold TRV was identified in the CRA Methodology, so it is unknown where the threshold for effects lies at intake rates lower than the LOAEL TRV. In addition, no relationship appears to have been identified between decreased testicular weight to reductions in reproductive success. This introduces some uncertainty into the risk assessment. However, because the endpoint for the LOAEL TRV is based on potential reproductive effects, the uncertainty is likely to be limited. Risks predicted by the LOAEL TRV may be overestimated, but the degree of uncertainty is low.

Background Risks

Manganese was detected in Rocky Flats Environmental Technology Site (RFETS) background surface soils. Because risks are generally not expected at naturally occurring background levels, it is important to calculate the risks that would be predicted at naturally occurring concentrations using the same assumptions and models as used in the CRA. This provides information necessary to gauge the predictive ability of the risk assessment models used in the CRA. In addition, risks calculated using background data can provide additional information on the magnitude of potentially site-related risks.

Risks to the PMJM were calculated using both the upper confidence limit (UCL) and upper tolerance limit (UTL) of background soils. NOAEL HQs of 1 were calculated for the PMJM using either the UCL or UTL. HQs less than 1 were calculated using LOAEL TRVs.

1.2 Tin

Bioaccumulation Factors

The primary source of uncertainty in the risk estimation for tin is in the estimation of tissue concentrations. No high-quality regression models or BAF data were available for any of the three soil-to-tissue pathways. As a result, plant tissue concentrations are estimated using a biotransfer factor from soil-to-plant tissue from Baes et al. (1984). The values presented in Baes et al. (1984) were the lowest tier for data quality in the CRA Methodology and represent the most uncertain BAF available. It is unclear whether these BAFs overestimate or underestimate uptake into plant tissues, and the magnitude of uncertainty is also unknown but could be high.

No data were available to estimate invertebrate concentrations from soil. As a result, a default value of 1 was used. This value assumes that the concentration in invertebrate tissues is equal to the surface soil concentration. There is a large degree of uncertainty in this assumption. Because tin is not expected to bioaccumulate in the food chain, invertebrate tissue concentrations are likely to be overestimated to an unknown degree using this BAF. The lack of quality soil-to-plant and soil-to-invertebrate BAFs directly affects the quality of the soil-to-small mammal BAF that uses the previous two values in its calculation. Compounding the uncertainty for this BAF is a food-to-tissue BAF, again from Baes et al. (1984). It is unclear to what degree and direction that uncertainty can be estimated for the soil-to-small mammal BAF, but the uncertainty associated with the estimated small mammal tissue concentrations is high.

Toxicity Reference Values

The NOAEL and LOAEL TRVs for mammalian receptors were obtained from PRC (1994). The selected NOAEL TRV is protective of systemic effects in mice. These effects are not associated with the assessment endpoints for mammalian receptors at RFETS and, therefore, are overly conservative for use in the CRA. However, the LOAEL TRV selected by PRC (1994) is from a proper endpoint for use in the CRA and is described by PRC (1994) as predictive of a mid-range of effects less than mortality. Therefore, while the uncertainty related to the NOAEL TRV for mammals is high, the uncertainty for the LOAEL TRV is considerably lower. For this reason, no alternative TRVs are recommended in the uncertainty analysis.

All of the TRVs used for tin were based on toxicity to tributyl tin. Tributyl tin compounds are commonly regarded as the most toxic forms of tin while inorganic tins are likely to be among the least toxic forms. In terrestrial environments, organic forms of tin, such as tributyl tin, on which the TRVs are based are not generally found in elevated concentrations unless a source of them is nearby. No known source of organic tin is present at RFETs. It is likely that much of the tin detected in soil samples is either inorganic tin or in compounds less toxic than tributytin. The use of tributyltin TRVs likely overestimates risks from tin to an unknown degree.

Background Risk Calculations

Tin was not detected in background surface soils, therefore, background risks were not calculated for tin in Appendix A, Volume 2, Attachment 9 of the Remedial Investigation/Feasibility Study (RI/FS) Report.

2.0 REFERENCES

Baes, C.F., R.D. Sharp, A.L. Sjoreen, and R.W. Shor, 1984, A review and analysis of parameters for assessing transport of environmentally released radionuclides through agriculture. Oak Ridge National Laboratory. USDOE> ORNL-5786. September 1984.

U.S. Department of Energy (DOE), 2005. Final Comprehensive Risk Assessment Work Plan and Methodology, Rocky Flats Environmental Technology Site, Golden, Colorado. Revision 1. September.

EPA, 2003. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs). OSWER 9285.7-55. Office of Solid Waste and Emergency Response. December.

EPA, 2005. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs). Attachment 4-1 Update. Office of Solid Waste and Emergency Response, February.

ORNL, 1998, Empirical Models for the Uptake of Inorganic Chemicals from Soil by Plants, Bechtel Jacobs Company L.L.C., Oak Ridge, Tennessee, BJC/OR-133.

PRC, 1994. Draft Technical Memorandum: Development of Toxicity Reference Values, as Part of a Regional Approach for Conducting Ecological Risk Assessment at Naval Facilities in California. PRC Environmental Management, Inc. Prepared for the U.S. Department of Navy.

Sample, B.E., J. Beauchamp, R. Efroymson, and G.W. Suter, II, 1998, Development and Validation of Bioaccumulation Models for Small Mammals, ES/ER/TM-219, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

COMPREHENSIVE RISK ASSESSMENT

ROCK CREEK DRAINAGE EXPOSURE UNIT

VOLUME 4: ATTACHMENT 6

CRA Analytical Data Set