

**Draft  
Comprehensive Risk Assessment  
Work Plan and Methodology**



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**APPENDICES**

- Appendix A – Ecological Soil PRG Calculation Process
- Appendix B – Accelerated Action Risk Analysis Process

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**ACRONYMS**

95UCL	upper confidence limit at a 95% level
AF	absorption factor
AI	adequate intake
AL	action level
ALF	Action Levels and Standards Framework for Surface Water, Ground Water, and Soils
AME	Actinide Migration Evaluation
ANOVA	analysis of variance
AOC	Area of Concern
AUF	area use factor
BAF	bioaccumulation factor
BD	building debris
BZ	Buffer Zone
BZSAP	Buffer Zone Sampling and Analysis Plan
CAD/ROD	Corrective Action Decision/Record of Decision
CAS	Chemical Abstract Service
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cm <sup>2</sup>	square centimeter
cm/hr	centimeter per hour
CMS	Corrective Measures Study
COC	contaminant of concern
CRA	Comprehensive Risk Assessment
CRAVE	Carcinogenic Risk Assessment Verification Endeavor
CRQL	contract-required quantitation limit
CSF	cancer slope factor
CSM	Conceptual Site Model
CHWA	Colorado Hazardous Waste Act

**ACRONYMS, cont**

CWQS	Colorado State Water Quality Standard
DBP	di-n-butyl phthalate
DCF	dose conversion factor
DOE	U S Department of Energy
DQF	Data Quality Filter
DQA	Data Quality Assessment
DQO	data quality objective
ECOC	ecological contaminant of concern
EcoSSL	ecological soil screening level
EG&G	EG&G Rocky Flats, Inc
Eh	reduction-oxidation potential
EPA	U S Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
ERAM	Ecological Risk Assessment Methodology
EU	exposure unit
FS	Feasibility Study
ft <sup>2</sup>	square foot
FY	fiscal year
GIS	Geographic Information System
h	hour
HEAST	Health Effects Assessment Summary Tables
HEC6-T	sedimentation instream networks
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IA	Industrial Area
IA Strategy	Industrial Area Characterization and Remediation Strategy
IAEA	International Atomic Energy Agency
IASAP	Industrial Area Sampling and Analysis Plan

ACRONYMS, cont

ICRP	International Commission on Radiological Protection
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action
IMP	Integrated Monitoring Plan
IR	ingestion rate
IRIS	Integrated Risk Information System
kg	kilogram
kg/mg	kilograms per milligram
K-H	Kaiser-Hill Company, L L C
km	kilometer
L/1,000 cm <sup>3</sup>	liters per 1,000 cubic centimeters
L/day	liters per day
LHSU	lower hydrostratigraphic unit
LOAEL	lowest observed adverse effect level
µg/kg	micrograms per kilogram
µm	micron
µg/m <sup>3</sup>	micrograms per cubic meter
m	meter
m <sup>2</sup>	square meter
m <sup>3</sup> /day	cubic meters per day
MDL	method detection limit
mg	milligram
mg/cm <sup>2</sup>	milligrams per square centimeter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mg/m <sup>3</sup>	milligrams per cubic meter
mg/vol	milligrams per volume
mrem	millirem
mrem/pCi	millirems per picocurie
mrem/pCi/g	millirems per picocurie per gram
NCP	National Oil and Hazardous Substances Pollution Contingency Plan

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**ACRONYMS, cont**

NCRP	National Council on Radiation Protection and Measurement
NFA	no further action
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no observed adverse effect level
NRC	Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
OU	Operable Unit
PAC	Potential Area of Concern
PARCC	precision, accuracy, representativeness, completeness, and comparability
PCB	polychlorinated biphenyl
pCi	picocuries
pCi/g	picocuries per gram
pCi/L	picocuries per liter
PCOC	potential contaminant of concern
PEC	probable effects level
pH	hydrogen ion activity
PMJM	Preble's meadow jumping mouse
PP	proposed plan
PPRG	programmatic preliminary remediation goal
PQL	practical quantitation limit
PRG	preliminary remediation goals
QA	quality assurance
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RDA	recommended daily allowance
RDI	recommended daily intake
RfC	Reference Concentration
RFCA	Rocky Flats Cleanup Agreement
RfD	reference dose
RFETS or Site	Rocky Flats Environmental Technology Site

ACRONYMS, cont

RFI/RI	RCRA Facility Investigation/Remedial Investigation
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RMA	Rocky Mountain Arsenal
RME	reasonable maximum exposure
ROC	receptor of concern
RPD	relative percent difference
RSAL	radionuclide soil action level
SAP	Sampling And Analysis Plan
SCM	Site Conceptual Model
SCMTM	Sitewide Conceptual Model Technical Memorandum
SLERA	screening-level ecological risk assessment
SMDP	scientific management decision point
SOP	standard operating procedure
SQG	sediment quality guideline
SQV	sediment quality values
SSV	soil screening value
SVOC	semivolatile organic compound
SWD	Soil/Water Database
TEC	threshold effects level
TM	Technical Memorandum
TRV	toxicity reference value
TSS	total suspended solids
UBC	Under Building Contamination
UCL	upper confidence limit
UHSU	upper hydrostratigraphic unit
UL	upper limit daily nutrient intake
USFW	U S Fish and Wildlife Service
UTL	upper tolerance limit
VOC	volatile organic compound
vol/day	volumes per day

**ACRONYMS, cont**

WEPP	Watershed Erosion Prediction Project
WRV	wildlife refuge visitor
WRW	wildlife refuge worker

## **1.0 INTRODUCTION**

This document was prepared under Task 8, Prepare the Comprehensive Risk Assessment Work Plan, of the Final Work Plan for the Development of the Remedial Investigation and Feasibility Study Report (K-H 2002). This document describes the scope, activities, and methodology for the Draft Comprehensive Risk Assessment (CRA). The Draft CRA is referred to hereafter as the CRA. The purpose of the CRA is to assess human health and ecological risks posed by chemicals, metals, and radionuclides remaining at the Rocky Flats Environmental Technology Site (RFETS or Site) following the completion of all accelerated actions. This document has been prepared pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Remedial Investigation/Feasibility Study (RI/FS) Report Work Plan (DOE 2001a). The CRA will support the RI/FS, Proposed Plan (PP), and Corrective Action Decision/Record of Decision (CAD/ROD) for the Site.

### **1.1 Background**

All accelerated actions will be completed by December 2006. The Site will then be transferred to the U.S. Fish and Wildlife Service (USFWS) for administration as a wildlife refuge, with possible maintenance of remediated areas and long-term surveillance and monitoring conducted by the U.S. Department of Energy (DOE).

The Rocky Flats Cleanup Agreement (RFCA) (DOE et al. 1996) is the Federal Facility Compliance Agreement and Consent Order negotiated pursuant to the CERCLA, the Resource Conservation and Recovery Act (RCRA), and the Colorado Hazardous Waste Act (CHWA). RFCA provides the regulatory framework for near- and intermediate-term cleanup objectives expressed in the Rocky Flats Vision and the RFCA Preamble. DOE is responsible for dispositioning all special nuclear material and regulated wastes, deactivating facility components, decontaminating and demolishing facilities and associated structures, and remediating remaining contamination in a risk-based approach to ensure the protection of future land, water, and resource use. The overriding goal for RFETS is to achieve accelerated cleanup in a manner that is safe to workers and the public, and protective of the environment.

After environmental restoration, decontamination, and decommissioning activities are completed, most of RFETS will be transferred to the jurisdiction of the USFWS and the future onsite land use will be a wildlife refuge, in accordance with the Rocky Flats National Wildlife Refuge Act of 2001. The federal government will be responsible for conducting future environmental monitoring activities at the Site. The refuge is currently envisioned to have minimal maintenance following remediation, however, refuge workers are assumed to be present on Site for most of the year and engaged in refuge maintenance and ecological work activities. A Comprehensive Conservation Plan is under development by the USFWS, in consultation with the stakeholders. Specific Site usage will be determined by this plan.

## 1.2 Comprehensive Risk Assessment Scope

**Scope:** The CRA will quantify and report risks posed by residual contamination at the Site to human and ecological receptors for the expected land use after completion of all accelerated actions

RFCA adopted an accelerated action cleanup approach to expedite remedial work and maximize early risk reduction at the Site, as described in RFCA paragraph 79 (DOE et al 1996). The completion of accelerated actions is intended to achieve the RFCA Intermediate Site Condition with no further actions required to satisfy RCRA/CHWA and CERCLA requirements pursuant to any final CAD/ROD. The need for further actions, if any, will be addressed in the RI/FS, where a detailed analysis of alternatives will be presented. The CRA will provide a basis for and support the decision that the requirements to achieve the Intermediate Site Condition have been met. The CRA will also support development and evaluation of the alternatives, if necessary. Risks to human and ecological receptors posed by residual contamination at the Site for the final preferred action presented in the CAD/ROD will be quantified and evaluated in the CRA.

The CRA will be prepared as part of the Sitewide RI/FS, concurrently with accelerated actions and will be incorporated into the RI/FS Report. The CRA will also provide support for completion of accelerated actions, and evaluation of remedial alternatives required to address existing risks. The CRA will be conducted in a progressive approach as remediation and environmental restoration information on the nature and extent of contamination is collected during the Sitewide RI/FS effort.

A primary task associated with the CRA is the development of the Final CRA Work Plan and Methodology hereafter referred to as the CRA Methodology. This methodology presents the approach and methods to be used in the CRA. The methodology also documents the Site Conceptual Model (SCM), exposure scenarios, exposure factors, toxicity assessment, and risk characterization. The CRA Methodology is a major revision to the previously circulated draft methodology (DOE 2000). The primary change is the recent Congressional designation of RFETS as a future wildlife refuge under the federal Rocky Flats National Wildlife Refuge Act of 2001 (HR2179). This designation has more precisely defined the future land use and has precluded the possibility of limited industrial, unrestricted open space, and onsite residential uses.

The CRA will evaluate long-term risks to human and ecological receptors following accelerated actions and environmental restoration. The CRA will not address risks to workers conducting remediation.

## 1.3 Technical Approach

The primary tasks required to complete the CRA and their interrelationships, are detailed in this section. Figure 1-1 depicts the overall technical approach and sequence of tasks, including the evaluation of additional data, if required. In general, the approach follows the methodology documented by the Draft CRA Methodology (DOE 2000).

Primary tasks include the following

- Generate the SCMs for both human health and ecological assessments with all defined exposure pathways, receptors, and scenarios,
- Identify exposure factors, and
- Develop exposure units (EUs), final Action Levels (ALs) and programmatic preliminary remediation goals (PPRGs) for contaminant of concern (COC) screening

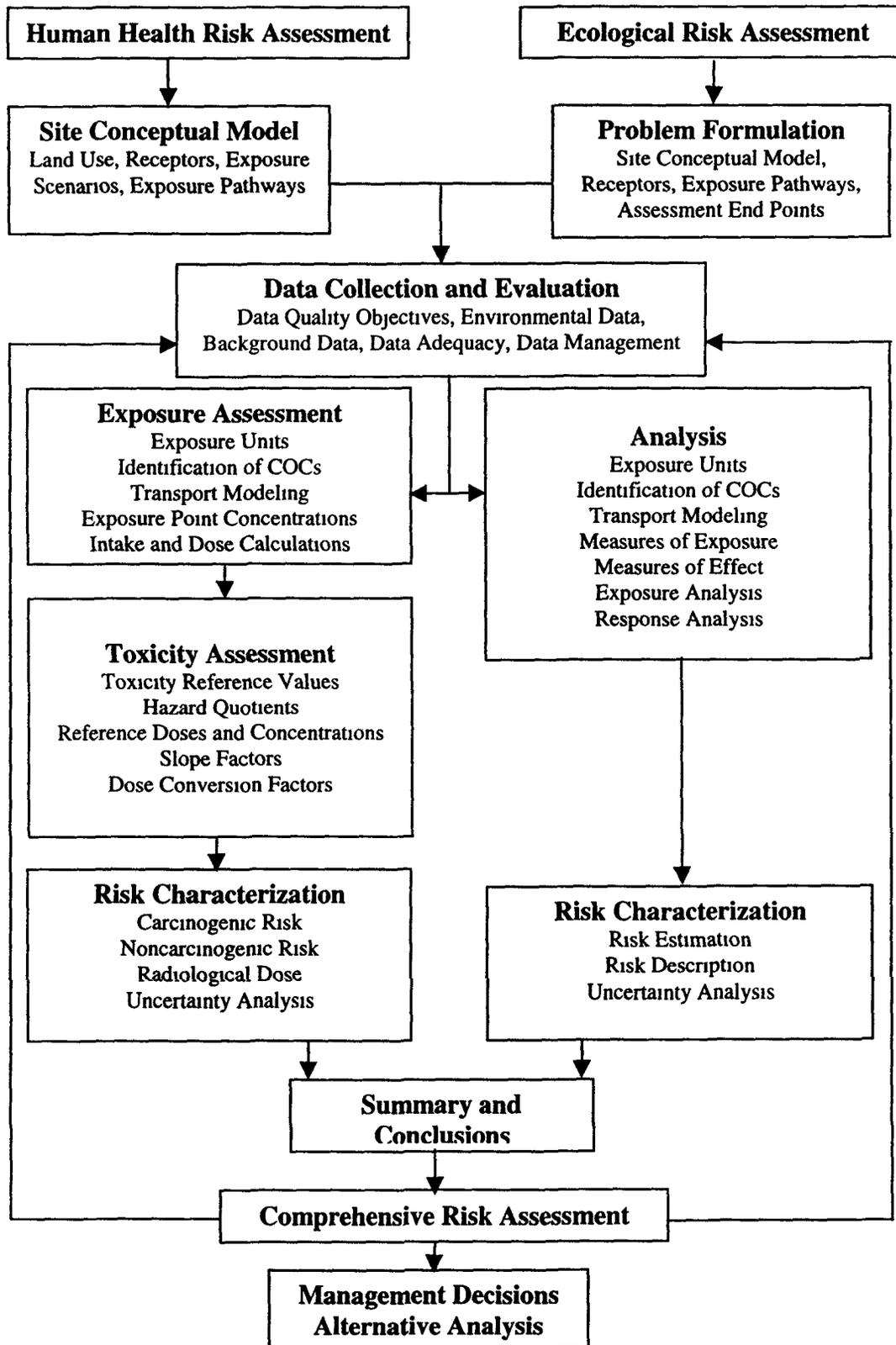
These tasks are considered critical and influence the resources and schedule necessary to complete the CRA

The human health risk assessment (HHRA) and the ecological risk assessment (ERA) will be conducted in parallel to ensure that Site remediation will adequately reduce both human health and ecological risk to all receptors. Evaluation of ecological and human health risks will be conducted to achieve risk-based cleanup of all contaminants. This risk-based remediation process will estimate risk to receptors, provide information for risk management decisions, and support the evaluation of remedial alternatives.

The CRA will be performed in accordance with this methodology. It will be conducted in a progressive manner as accelerated actions are completed. The need and extent of accelerated actions will primarily be based on direct comparison of aggregated COC concentration data at an Individual Hazardous Substance Site (IHSS) to media-specific ALs or approved PPRGs. ALs are presented in RFCA Attachment 5, "Action Levels and Standards Framework for Surface Water, Ground Water, and Soils" (ALF) (DOE et al 1996). Some PPRGs may be developed specifically for the CRA, in consultation with the U.S. Environmental Protection Agency (EPA) and Colorado Department of Public Health and Environment (CDPHE). Risks posed by residual contamination following completion of accelerated actions will be assessed by the CRA with confirmation sampling results. Specific risk assessments for accelerated actions may be conducted as part of the CRA and incorporated into the final CRA documentation demonstrating acceptable Site-wide residual risks to receptors.

A progressive approach will be used to complete the CRA as Site investigation and remediation is being conducted. Consequently, RI/FS data will be progressively accumulated and used to assess risk to receptors. Progressive refinement of risk estimates will then be utilized to guide collection of additional field data, as required, from EUs to ensure adequate remediation and estimation of residual risks.

Figure 1.1 CRA Process



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## 2.0 HUMAN HEALTH SITE CONCEPTUAL MODEL

**Action:** Develop SCM of receptors, exposure scenarios, and exposure pathways to guide the CRA process

After environmental restoration, decontamination, and decommissioning activities are completed most of RFETS will be transferred to the jurisdiction of the USFWS and the future onsite land use will be a wildlife refuge, in accordance with the Rocky Flats National Wildlife Refuge Act of 2001. The federal government will be responsible for conducting future environmental monitoring activities at the Site. The refuge is currently envisioned to have minimal maintenance following remediation, however, refuge workers are assumed to be present on site for most of the year and engaged in refuge maintenance and ecological work activities. A Comprehensive Conservation Plan is under development by the US Fish and Wildlife Service, in consultation with the stakeholders. Specific Site usage will be determined by this plan. Residential development is not considered a foreseeable or reasonable future land use scenario and was excluded from the risk assessment.

An exposure pathway describes a specific environmental route by which an individual receptor could be exposed to contaminants present at or originating from a site. After the primary source(s) and release mechanisms are identified for the Site, the resulting secondary sources and secondary release mechanisms are identified and described. Subsequent sources and release mechanisms are identified until the exposure pathways for each contaminant are fully delineated. A complete exposure pathway includes five necessary elements: a source, a mechanism of release, a transport medium, an exposure point, and an intake route. If any of these elements are missing, the pathway is incomplete.

Exposure pathways and exposure routes in the SCM have been categorized as significant, insignificant, or incomplete using best professional judgment in consultation with EPA and CDPHE. Significant and insignificant exposure pathways are considered complete exposure pathways. Significant exposure pathways contribute the major portion of risk or dose. An insignificant pathway is complete but will not contribute significantly to the total risk or dose. An incomplete exposure pathway will not contribute any risk or dose. All significant exposure pathways will be quantitatively assessed at RFETS, while insignificant and incomplete exposure pathways will be qualitatively addressed.

A comprehensive human health SCM, including all potentially viable exposure scenarios and pathways is presented on Figure 2.1. Receptors in the SCM are described in detail below. Possible release mechanisms for each exposure pathway and the potential for impact to receptors are discussed. Exposure factors for each significant pathway are presented in Section 4.0.

Figure 2.1 Human Health Site Conceptual Model

Primary Source	Primary Release Mechanism	Affected Media	Secondary Release Mechanism	Affected Media	Pathway Number	Wildlife Refuge Worker Pathways	Wildlife Refuge Visitor Pathways
Soil Subsoil Sediment Building Rubble	Stormwater Runoff (S)	Surface Water Streams / Seeps	Direct Contact		S-1	Oral (I) Dermal (I)	Oral (I) Dermal (I)
	Infiltration Percolation (I)	UHSU Groundwater	Biotte Uptake	Fish	S-2	Oral (IC)	Oral (IC)
			Ingestion	Deer/Grazing Animals	S-3	Oral (IC)	Oral (I)
			Percolation	LHSU Groundwater	I-1	Oral (IC) Dermal (IC)	Oral (IC) Dermal (IC)
	Volatilization (V)	Groundwater Subsurface Soil Surfacewater	Domestic Use		I-2	Oral (IC) Dermal (IC)	Oral (IC) Dermal (IC)
			Surface water		I-3	Oral (I) Dermal (I)	Oral (I) Dermal (I)
				Indoor Air	V-1	Inhalation (I)	Inhalation (IC)
	Resuspension (R)	Airborne Particulates		Outdoor Air	V-2	Inhalation (I)	Inhalation (I)
				Outdoor Air	V-3	Inhalation (I)	Inhalation (I)
				Indoor Air	R-1	Inhalation (S)*	Inhalation (IC)
Plant Uptake (P)	Surface Soil	Deposition	Deer/Grazing Animals	R-2	Inhalation (S)	Inhalation (S)	
			Deer/Grazing Animals	R-3	Oral (IC)	Oral (I)	
Direct Contact (D)		Surface Soil			P-1	Oral (IC)	Oral (I)
		Surface Soil (0 to 0.5 feet) <sup>b</sup>			D-1	Oral (S) Dermal (S')	Oral (S) Dermal (S')
		Subsurface Soil (0.5 to 3 feet) <sup>b</sup>			D-2	Oral (S) Dermal (S')	Oral (IC) Dermal (IC)
		Subsurface Soil (Below 3 feet)			D-3	Oral (IC) Dermal (IC)	Oral (IC) Dermal (IC)
		Sediment			D-4	Oral (S) Dermal (S')	Oral (I) Dermal (I)
Radioactive Decay (E)		Building Rubble			D-5	Oral (IC) Dermal (IC)	Oral (IC) Dermal (IC)
		Surface Soil			E-1	External Irradiation (S)	External Irradiation (S)
		Subsurface Soil			E-2	External Irradiation (I)	External Irradiation (I)
		Sediment			E-3	External Irradiation (S)	External Irradiation (I)
		Building Rubble			E-4	External Irradiation (I)	External Irradiation (I)

a. Indoor exposures to airborne particulates will not be assessed in the IA, no building will be built there (personal communication Mark Sattelburg)

b. Exposures to subsurface soil for the WRW will be combined with surface soil to a depth of 3 feet for an exposure frequency of 20 days/year

c. Dermal exposures will be assessed for organic COCs only

## **2.1 Receptors**

Two types of receptors are associated with the wildlife refuge land use the wildlife refuge worker (WRW) and the wildlife refuge visitor (WRV) These scenarios are evaluated in the SCM and will be assessed in the CRA The WRW is assumed to be exposed to outdoor contaminants for an average of one-half the workday Current planning by the USFWS does not include year-round offices or an onsite visitor center A seasonally staffed visitor contact station may be built on the western side of the Site (USFWS 2003) If an office/visitor center were built on Site, there could be exposures to indoor contaminants for one-half the day The WRV will have incidental exposures to outdoor contaminants

The offsite resident will not be assessed for the CRA because risks have been adequately assessed in the Operable Unit (OU) 3 RCRA Facility Investigation/Remedial Investigation (RI/RFI) Report (DOE 1996a), and risks due to air transport are assessed in the annual National Emission Standards for Hazardous Air Pollutants Report for Radionuclides and the Annual Dose Assessment Report The onsite resident will not be assessed because the designated land use does not allow residential usage

Ecological receptors will be identified and assessed within all EUs including the IA, BZ, and both the Walnut and Woman Creek watersheds Key ecoreceptors will be selected to adequately represent the local ecological community and quantify the range of potential impacts (see Section 7.0)

## **2.2 Human Health Exposure Scenarios**

The following exposure scenarios define the exposure pathways and assumptions for the WRW and WRV Insignificant and incomplete exposure pathways are also defined and discussed

### **2.2.1 Wildlife Refuge Worker Exposure Scenario**

The WRW scenario is very similar to that used for the radionuclide soil action levels (RSALs) development (EPA et al 2002) It has been altered following discussions with the USFWS, EPA, and CDPHE The latest Planning Update for the wildlife refuge (USFWS, 2003) does not include an onsite office One alternative (D) includes a seasonally staffed contact station Therefore, the WRW will be assessed in the appropriate EU for exposures at the contact station located on the west side of the BZ for an average of 50 percent of each day during a standard workweek of five days per week The remaining time will be spent outdoors on the Site Indoor exposure will not be assessed elsewhere on the Site It is assumed that following remediation, this receptor will be exposed to residual contaminants in the IA, as well as all other onsite locations The WRW will conduct some percentage of fieldwork that will result in limited exposure to contaminated soil, subsoil, sediment, and surface water It is assumed for the CRA that the WRW will spend 50 percent of the time in the field

The recently modified RFCA Attachment 5 shows a larger area in the center of the Site that may be subject to institutional controls The final area subject to institutional controls will be decided based partly on the results of the CRA These areas will be retained by DOE, but

will be seamlessly joined with the wildlife refuge Therefore, this area will be assessed using the WRW receptor

Long-term stewardship activities, including monitoring and maintenance, will occur on Site It is assumed that exposures due to these activities will be less than for the WRW scenario Therefore, the WRW scenario provides an upper bound for risks due to these activities, and a specific "stewardship receptor" will not be assessed in the CRA

***Complete Exposure Pathways***

Potentially complete exposure pathways for the WRW include

- Incidental ingestion of and dermal exposures to surface soil, subsurface soil, sediments, and surface water,
- Inhalation of volatiles and particulates, and
- External exposure to beta and gamma radiation from radionuclides present in soil, subsurface soil, sediment, and building rubble

***Complete and Significant Exposure Pathways***

The complete and significant exposure pathways for the WRW are

- Inhalation of surface and subsurface soil particulates,
- Incidental ingestion of surface soil, subsurface soil, and sediments,
- Incidental dermal exposure to surface and subsurface soil and sediments, and
- External irradiation exposure from surface soil

***Complete but Insignificant Pathways***

Best professional judgment has been used to designate exposure pathways that are considered complete, but are not anticipated to contribute significantly to Site risks to the WRW This is generally due to a variety of factors that lead to low intakes The following pathways are considered to be insignificant

- Incidental ingestion of surface water,
- Incidental dermal exposure to surface water,
- Inhalation of volatiles from groundwater,
- Inhalation of volatiles from surface soil and subsurface soil, and
- External irradiation exposure from subsurface soil and building rubble

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***Incomplete Exposure Pathways***

Best professional judgment has been used to designate exposure pathways that are considered incomplete and will not contribute to Site risks to the WRW. The following pathways are considered incomplete:

- Ingestion of fish or deer/grazing animals from the Site,
- Ingestion of groundwater,
- Inhalation of indoor air on Site,
- Ingestion of homegrown produce or animal tissue, and
- Incidental ingestion of building rubble

**2.2.2 Wildlife Refuge Visitor Exposure Scenario**

The WRV scenario is based on the open space scenario used in the RSAL report (EPA et al 2002). The WRV includes both a child and adult who visit the Site 100 days/year for 2.5 hours/day, for a total of 250 hours/year. The remaining time is spent offsite. Outdoors-recreational activities will primarily be on and near established hiking trails. Hunting may be allowed on a very limited basis, possibly by lottery. It is assumed that this receptor will be exposed to residual contaminants following remediation. It is assumed that the WRV will not conduct activities resulting in significant exposure to subsurface soils, surface water, or sediments.

***Complete Exposure Pathways***

Potentially complete exposure pathways for the WRV include:

- Incidental ingestion of and dermal exposures to surface soil, subsurface soil, sediments, and surface water,
- Ingestion of deer or grazing animals,
- Inhalation of volatiles and particulates, and
- External exposure to beta and gamma radiation from radionuclides present in soil, subsurface soil, sediment, and building rubble

***Complete and Significant Exposure Pathways***

The significant exposure pathways for the WRV are:

- Inhalation of surface soil particulates,
- Incidental ingestion of surface soil,
- Incidental dermal exposure to surface soil, and

- External irradiation exposure from surface soil

***Complete but Insignificant Exposure Pathways***

The following exposure pathways that are complete but are considered to contribute insignificant risk to the WRV are

- Incidental ingestion of surface water,
- Incidental dermal exposure to surface water,
- Ingestion of deer or grazing animals,
- Inhalation of outdoor air volatiles from surface water and groundwater,
- Inhalation of outdoor air volatiles from surface and subsurface soil,
- Inhalation of indoor air on Site,
- Incidental ingestion of sediments,
- Incidental dermal exposure to sediments, and
- External irradiation exposure from subsurface soil, sediments, and building rubble

***Incomplete Exposure Pathways***

The following exposure pathways are considered incomplete with respect to the WRV exposure scenario

- Ingestion of groundwater, and
- Incidental ingestion of subsurface soil and building rubble

**3.0 . DATA COLLECTION AND EVALUATION**

**Actions:** Identify data needs and data sources, assemble data, and evaluate data quality and adequacy

Data evaluation and aggregation will be performed on an EU and Area of Concern (AOC) basis for the HHRA. Methods are described below. The data quality objective (DQO) process specifies project decisions and techniques necessary to generate quality data and make associated conclusions (EPA 2000b). The DQO process will be utilized to

- Define stated objectives,

- Define appropriate data collection methods,
- Establish necessary data types, conduct data aggregation, and
- Specify acceptable levels of data quantity and quality necessary to support the risk assessment process

Nature and extent data that have been collected historically, and also progressively during RI/FS investigations and accelerated actions, will be identified and assembled. Verification and Data Quality Assessment (DQA) procedures will be used to verify the quality of collected data. COCs will be identified to support a comprehensive HHRA and ERA. Risks will be evaluated and quantified for receptors by exposure scenarios and pathways for established EUs and summarized accordingly.

Site data will be used to evaluate sources of contamination and determine contaminant distributions. Exposure parameters, such as inhalation and ingestion rate, exposure frequency, and exposure duration, have been determined for identified Site-specific receptors. Toxicity data will be collected to identify or derive dose limits to human and ecological receptors. Physical and chemical parameters for all viable COCs will also be collected, as necessary, to support a complete toxicity assessment, assessment of impacts to receptors, and determination of environmental fate and transport mechanisms. Radiological data for pertinent radionuclides, including plutonium-239, americium-241, uranium-235, and uranium-238 will be collected to determine recent dose conversion factors and radiological emission data. Ecological data will be collected from the ecological screening assessments for the BZ and IA, including receptor species, biological information, and Site habitat usage.

### **3.1 Human Health Risk Assessment Data Quality Objectives**

The CRA employs the EPA DQO process to ensure that the type, quantity, and quality of environmental data used in decisionmaking are appropriate for the intended purpose (EPA 2000b). The DQO process consists of seven steps that specify project decisions, the data quality required to support those decisions, specific data types needed, data collection requirements, and analytical techniques necessary to generate the specified data quality. During the first six steps of the DQO process, the planning team develops decision performance criteria (i.e., DQOs) for the data collection design. All decision rules need to be considered, as appropriate. The final step of the process involves developing the data collection design based on the DQOs.

#### **3.1.1 Step 1: State The Problem**

Human health risks from exposure to residual contaminants present in environmental media at RFETS must be quantified to determine whether end-state long-term land use is protective and within the range of acceptable risk. In order to quantify risk, the nature and extent of COCs must be adequately determined to quantify human health risks at RFETS and the methodology that calculated human health risks must be developed.

The problem

*“The risks to all human receptors exposed to residual contaminants present in environmental media following accelerated actions must be quantified in a technically sound and defensible manner ”*

### **3.1.2 Step 2: Identify The Decision**

The primary decision

*“Are risks to human receptors at RFETS following exposure to residual contamination acceptable based on the reasonably anticipated future land use?”*

In addition, resolution of the following key secondary decisions will be required to assure completion of all accelerated actions

- Is the CRA SCM adequate to define all viable exposure scenarios, exposure pathways, and receptors based on the reasonably anticipated future land use?
- Have all EUs been adequately defined and established?
- Have the nature and extent of inorganic, organic, and radionuclide analytes within EUs been identified with adequate confidence, based on evaluation of Site process knowledge and analytical data?
- Have adequate samples been collected within EUs to perform the risk assessment?
- Has a methodology been developed to adequately identify COCs?
- Has a methodology been developed to adequately assess human health risks?

### **3.1.3 Step 3: Identify the Inputs to the Decision**

Available historical information, sampling data, and risk assessment requirements will be used to determine adequate sampling locations and densities for IHSSs, Potential Areas Of Concern (PACs), and Under Building Contamination (UBC) sites

The CRA DQA methodology (Section 3.2) will be applied to all data used in the CRA. All data for use in the CRA will be screened through the COC selection process as prescribed in Section 4.4. All data will also be screened using professional judgment to ensure that data meet risk assessment needs. All selected COCs will be used to calculate risks to receptors.

### **3.1.4 Step 4: Define Study Boundaries**

Study boundaries are used to define the spatial and temporal boundaries for data collection in support of the decision to quantify risk to receptors. Environmental media analyte data will be assessed for surface soil and sediments to depth of 6 inches, and for subsurface soil from 6 inches to 3 feet. Existing environmental media data will be used when possible and additional sampling will be conducted if determined to be necessary. Sufficient samples will be collected to statistically evaluate the data, identify COCs, and quantify risk to receptors. Exposure to building rubble and buried pipeline materials will not be assessed and, therefore, samples of these materials will not be collected for the CRA.

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EUs will be established using a tiered approach. Functional EUs for the WRW and WRV receptors have been established based on watersheds, known patterns of contamination, and expected activity patterns. Known IHSSs and PACs of special interest will be grouped into AOCs based on preliminary remediation goal (PRG) screening (Section 4.2). Analyte data will be aggregated at both the EU and AOC levels to quantify risk to human receptors.

Statistical evaluation of environmental data will include standard descriptive calculations, precision, accuracy, representativeness, completeness, and comparability (PARCC) parameter analyses, distribution testing, population testing of Site data relative to background, nonparametric tests, and probabilistic resampling techniques, such as Bootstrapping and power calculations.

Data from environmental media will not be collected to support exposure pathways designated as insignificant.

### **3.1.5 Step 5: Identify the Data Adequacy Decision Rules**

This section presents the decision rules to determine data adequacy for the CRA. The nature and extent of inorganics, metals, and radionuclides must be determined with sufficient certainty to permit adequate quantification of statistical analyses and quantification of risk to receptors. Data adequacy criteria must, therefore, be met or additional sampling and analysis will have to be performed.

The following decision rules will be used to determine whether analyte data are adequate to support statistical and risk-based calculations.

#### *Data Sufficiency Assessment*

The sample data collected for each COC in an EU or AOC will be used to determine an upper confidence limit at a 95 percent level (95UCL) of statistical confidence for the COC. The 95UCL will then be used as the exposure point concentration (EPC) for the COC in the risk assessment. However, 95UCLs are only valid if sufficient numbers of sample data are available. While it is possible to calculate a 95UCL with only two or three samples, its validity is questionable. Therefore, it is necessary to determine how many samples are required to calculate a 95UCL for each COC.

Sampling power will be evaluated to statistically determine whether sufficient samples were collected to adequately determine COCs and calculate 95UCLs within the EUs and AOCs to support risk assessment. The decision to be made is

*“Given the estimate of the mean analyte concentration, the observed variance, and the calculated 95UCL, is the number of samples collected adequate to identify an exceedance of ALs for the WRW (at risk =  $10^{-6}$  or hazard quotient [HQ] = 0.1) with an alpha error of 0.1 and a beta error of 0.2?”*

All potential contaminants of concern (PCOCs) will be evaluated.

The CRA will use the nonparametric method as presented in the Multi-Agency Radiological Survey and Site Investigation Manual (MARSSIM) Report §5.5.2.3 (NRC 1997) for determining data sufficiency.

Estimates of the averages and variances will be derived as required to calculate the 95UCLs. Relative errors will be derived from the difference between the PRG or AL and the mean and 95UCL. Relative errors derived from average and 95UCLs will bound sampling errors due to inherent heterogeneity of analytes in environmental media to predict the number of samples required.

The results for all PCOCs detected in each EU or AOC will be summarized. The results of the data sufficiency calculations for each area will be evaluated collectively. At this point, other information on historical releases, Site usage, and process knowledge will also be reviewed. A decision will be made whether the data are sufficient or insufficient for the CRA. Results will be presented to the regulatory agencies for their concurrence.

#### ***PARCC Parameter Assessment***

Data quality and adequacy will also be assessed using a standard PARCC parameter analysis (EPA 2000c) for all data in each environmental media as follows:

- If the relative percent difference (RPD) between targets and duplicates, at concentrations five times their respective detection limits, is less than 35 percent for solids and 20 percent for liquids, the overall precision of the sample data is adequate (EPA 2000b). If these precision limits are exceeded, the data will be qualified and/or additional samples may be required.
- If the duplicate error ratio for radionuclides is less than 1/96, the sample data are adequate (EPA 2000c). If these precision limits are exceeded, the data will be qualified and/or additional samples may be required.
- If overall accuracy meets current laboratory statements of work, and complies with SW-846 (EPA 1994b) and specified limits in the Verification and Validation Guidelines (EPA 2000b), the data are accurate based on (1) calibrations, (2) laboratory control samples/spikes, (3) laboratory matrix spikes, (4) relative standard deviation, (5) laboratory blanks, (6) chemical yield, (7) counting time, and (8) sensor efficiency. If these accuracy limits are not met, the data will be qualified and/or additional samples may be required.
- If data representativeness, in terms of numbers, types, and locations of samples, is achieved as dictated by established Sampling and Analysis Plans (SAPs) and approved by the regulatory agencies, the data are representative (EPA 2000c). If data are determined not to be representative, the data will be qualified and/or additional samples may be required.
- If the overall completeness of the data in each EU is at least 90 percent, the data are adequate. If the completeness goal of 90 percent is not achieved, the data must be qualified and/or additional samples may be required (EPA 2000c).
- If comparability of the data is met based on criteria documented in SW-846 (EPA 1994b) (including systematic quality controls, standardized units of measure, and thorough documentation of the planning, sampling, and analysis process), the data are comparable.

If data are not comparable, the data will be qualified and/or additional samples may be required (EPA 2000c)

### **3.1.6 Step 6: Specify Tolerable Limits on Decision Errors**

Sources of uncertainties in the risk assessments will be identified, minimized, and documented in the CRA. This may include use of upper-bound numbers or ranges of values, as applicable, for various parameters considered, concentration term estimates, contaminant transport, data distribution assumptions, and EU use assumptions.

Where alpha and beta errors are applicable in statistical hypothesis testing, these errors will also be documented. Alpha error will not exceed 10 percent in sample power calculations. Likewise, beta error will not exceed 20 percent in sample power calculations. Relative errors will be determined based on the differences between the AL for an analyte and the upper 95UCL or the estimate of the average analyte concentration (EPA 2002a).

### **3.1.7 Step 7: Optimize the Design**

Based on the iterative nature of the DQO process, any decision that is not consistent with project goals will result in a reinitiation of the DQO process. If determination of the nature and extent of analytes is found to be inadequate, further sampling will be initiated. If sampling power is determined to be inadequate for any given scenario and set of analyte data, more samples will be collected and the sampling power will be re-calculated.

## **4.0 EXPOSURE ASSESSMENT**

**Actions:** Identify potential land use, identify exposed populations, develop the SCM, exposure factors for each pathway, and EUs for data aggregation, identify COCs, determine whether transport modeling is necessary, estimate COC EPCs, and quantify intake to receptors

The CRA human health exposure assessment will quantitatively and qualitatively evaluate contact between human receptors and COCs. The exposure assessment will estimate the total dose or intake for a receptor in an EU or AOC for a particular land use and exposure scenario. The calculated dose is then combined with chemical-specific dose-response data to estimate risk (EPA 1992a). The exposure assessment methods for the HHRA are described in detail in the following sections.

### **4.1 Exposure Factors**

This section presents the exposure factors for the HHRA.

#### **4.1.1 Exposure Pathway Assessment**

Exposure pathways determined to be significant in the SCM (Figure 2.1) will be assessed for the CRA.

Direct contact with surface soil, subsurface soil (less than 3 feet in depth), and sediments, the inhalation of airborne contaminants, and exposure to penetrating radiation are the primary exposure pathways of concern. Contact with subsurface soil is considered for the WRW, but is limited in both exposure frequency and exposure duration. Ingestion of and dermal contact with surface water, and volatilization of contaminants are considered insignificant pathways. Ingestion of animal tissues is incomplete for the WRW, but is considered insignificant for the WRV due to possible limited hunting activity. All other exposure pathways are considered incomplete and will not be addressed, including ingestion of groundwater and fish.

#### ***Inhalation Pathway***

The inhalation pathway will be assessed for resuspension of airborne contaminants present in surface soil transported to human and ecological receptors. The receptors will be assessed for this exposure pathway using the contaminant concentration in the soil and the mass loading variable developed for the RSALs. The potential volatilization of contaminants from soil and shallow groundwater to receptor locations is considered an insignificant pathway. Volatilization into office space will not be assessed due to the location of WRW offices in the Western Area EU (Section 4.2), which is upgradient of any potential subsurface contamination.

#### ***Ingestion Pathway***

The ingestion pathway will be assessed for direct incidental ingestion of contaminants present in surface soil and sediments for the WRW and WRV receptors. Direct ingestion of surface water will not be assessed for the WRW and WRV receptors. Contamination and transport of groundwater in the upper hydrostratigraphic unit (UHSU) to surface water will also not be assessed. Ingestion of deep aquifer groundwater will not be assessed as a viable exposure pathway.

Runoff from contaminated soil to nearby surface water could result in direct ingestion of contaminated surface water by all receptors and contribute to possible contamination of aquatic species. However, direct ingestion of surface water and contaminated fish collected from the area are considered insignificant, or incomplete pathways, respectively, and will not be assessed. Collection of meat from hunting activities and subsequent ingestion is also considered insignificant and will not be assessed.

#### ***Dermal Exposure***

Dermal exposure due to contact with contaminated soil and sediments will be assessed for the WRW and WRV receptors. Dermal exposure to incidental contact with surface water will not be assessed for either receptor.

#### ***External Exposure***

External exposure will be assessed for both receptors to determine impacts to human receptors resulting from exposure to external penetrating radiation emanating from radionuclides present in contaminated environmental media and associated contamination. This pathway will not be assessed for subsurface soil or building rubble due to the inability of radionuclide emissions to penetrate soil and expose any receptor.

#### **4.1.2 WRW Scenario Exposure Factors**

The exposure factors for the WRW are presented in Table 4 1 Most factors are taken from the RSALs Task 3 Report (EPA et al 2002) The sediment pathway was not assessed in the RSALs report

#### **4.1.3 WRV Scenario Exposure Factors**

Current plans for the wildlife refuge include public uses similar to open space usage, with trails for wildlife observation, hiking and biking (USFWS, 2003) Therefore, the open space user scenario previously developed for RFETS has been adopted for the WRV scenario The exposure time and duration factors for the WRV receptor, presented in Table 4 2, are based on a survey conducted by Jefferson County of open space users (Jefferson County 1996) The values were first used in the Open Space PPRG calculations for the Site and were adapted for the RSALs report

#### **4.2 Functional EUs and AOCs**

Sources of contamination will be determined using available Site data to assess the spatial and temporal distribution of all classes of contaminants This information will be used to support the selection of COCs and AOCs The AOCs will be identified and illustrated on Site maps, source terms will be defined to the extent possible with available information Significant data gaps for contaminant sources and distributions will also be identified and resolved

EUs have been established across the Site based on anticipated activity patterns of the potential receptors that have been selected for known or potential land uses The AOCs will be defined during the PRG comparison stage of the COC selection process

Table 4.1 CRA Exposure Factors for the On-Site Wildlife Refuge Worker Receptor

Exposure Factor	Abbreviation	Units	Value	Source
Chemical concentration in medium	Cs	mg/kg \ pCi/g mg/L \ pCi/L	chemical-specific	
Adult body weight	BWa	kg	70	EPA 1991
Surface soil/sediment exposure frequency <sup>a</sup>	EFwss	day/yr	230	EPA et al 2002
Surface-subsurface soil/sediment exposure frequency <sup>a</sup>	EFwsub	day/yr	20	DOE 2003
Exposure duration	EDw	yr	18.7	EPA et al 2002
Exposure time	ETw	hr/day	8	EPA et al 2002
Exposure time fraction, outdoor	Eto_w	--	0.5	EPA et al 2002
Exposure time fraction, indoor	Eti_w	--	0.5	EPA et al 2002
Averaging time - noncarcinogenic	ATnc	day	6826	CALC
Averaging time - carcinogenic	ATc	day	25550	CALC
Soil/sediment ingestion rate	IRwss	mg/day	100	EPA et al 2002
Skin-soil adherence factor	AFw	mg/cm <sup>2</sup> -event	0.12 <sup>b</sup>	EPA 2001a
Event frequency	EVw	events/day	1	EPA 2001a
Skin surface area (exposed)	SAw	cm <sup>2</sup>	3300 <sup>c</sup>	EPA 2001a
Soil dermal absorption fraction	ABS	--	chemical-specific	EPA 2001a
Inhalation rate	IRaw	m <sup>3</sup> /hr	1.3	EPA et al 2002
Dilution factor, indoor inhalation	DFi	--	0.7	EPA et al 2002
Mass loading, (PM10) for inhalation	MLF	kg/m <sup>3</sup>	6.7E-08 <sup>d</sup>	EPA et al 2002
Area correction factor	ACF	--	0.9	EPA et al 2002
Gamma shielding factor (1-Se)	GSF	--	0.4	EPA et al 2002
Gamma exposure factor (annual) = (EF / 365 day/yr)	Te_A	--	0.7	CALC
Gamma exposure factor (daily) = (8 hr/day / 24 hr/day)	Te_D	--	0.3	CALC
Conversion factor-nonradionuclides	CFn	kg/mg	0.000001	
Conversion factor-radionuclides	CFr	g/mg	0.001	

- a The total yearly exposure frequency is 250 days. This has been divided into 230 days for surface soil exposures and 20 days for combined surface soil, subsurface soil, and sediment exposures.
- b The skin soil adherence factor is the geometric mean for farmers. This value is recommended by CDPHE for use in the WRW PRGs.
- c The skin surface area value is the EPA default for commercial/industrial exposures and is the average of the 50<sup>th</sup> percentile for men and women >18 years old wearing a short-sleeved shirt, long pants, and shoes. The value was recommended by CDPHE for use in the WRW PRGs.
- d ML value is the 95<sup>th</sup> percentile of the estimated ML distribution estimated in the RSALs Task 3 Report (EPA et al 2002).

Table 4.2 CRA Exposure Factors for the Wildlife Refuge Visitor Receptor

Exposure Factor	Abbreviation	Units	Value	Source
Concentration in medium	Cs	mg/kg	chemical-specific	
Adult body weight	BWa	kg	70	EPA 1991
Child body weight	BWc	kg	15	EPA 1991
Exposure frequency	EFv	day/yr	100	EPA et al 2002 <sup>a</sup>
Exposure duration-adult	EDav	yr	24	EPA 1991
Exposure duration-child	EDcv	yr	6	EPA 1991
Exposure time	ETv	hr/day	2.5	EPA et al 2002 <sup>b</sup>
Adult averaging time - noncarcinogenic	Atancv	day	8760	CALC
Child averaging time - noncarcinogenic	Atcncv	day	2190	CALC
Averaging time - carcinogenic	ATc	day	25550	EPA 1991
Adult soil ingestion rate	SIRav	mg/day	50	EPA et al 2002
Child soil ingestion rate	SIRcv	mg/day	100	EPA et al 2002
Age-adjusted soil ingestion rate for non-radionuclides	SIRageav	mg-yr/kg-day	57	CALC
Age-adjusted soil ingestion rate for radionuclides	SIRagav_r	mg/day	60	CALC
Adult Skin-soil adherence factor	AFav	mg/cm <sup>2</sup> -event	0.07 <sup>c</sup>	EPA 2001a
Child Skin-soil adherence factor	AFcv	mg/cm <sup>2</sup> -event	0.2 <sup>d</sup>	EPA 2001a
Event frequency	EVv	events/day	1	EPA 2001a
Adult skin-surface area (exposed)	SAav	cm <sup>2</sup>	5700 <sup>e</sup>	EPA 2001a
Child skin-surface area (exposed)	SACv	cm <sup>2</sup>	2800 <sup>f</sup>	EPA 2001a
Age-averaged surface area/adherence factor	SFSagav	mgyr/kg-event	361	EPA 2001a
Dermal absorption fraction	ABS	--	chemical-specific	EPA 2001a
Outdoor inhalation rate - adult	IRov	m <sup>3</sup> /hr	2.4	EPA et al 2002
Outdoor inhalation rate - child	IRcov	m <sup>3</sup> /hr	1.6	EPA et al 2002
Age-averaged inhalation factor (non-radionuclides)	IRagav	m <sup>3</sup> yr/kgday	3.7	EPA et al 2002
Age-averaged inhalation rate (radionuclides)	Iragav_r	m <sup>3</sup> /hr	2.2	EPA et al 2002
Mass loading, (PM10) for inhalation	MLF	kg/m <sup>3</sup>	6.7 E-8 <sup>g</sup>	EPA et al 2002
Area correction factor	ACF	--	0.9	EPA et al 2002
Gamma exposure factor (annual) = (EF / 365 day/yr)	Te_A	--	0.3	CALC
Gamma exposure factor (daily) = (2.5 hr/day / 24 hr/day)	Te_D	--	0.1	CALC
Conversion factor 1	CF1	kg/mg	0.000001	
Conversion factor 2	CF2	g/kg	1000	
Conversion factor 3	CF3	g/mg	1000	

- a Value is the 95<sup>th</sup> percentile of visitation frequency for open space users (Jefferson County 1996)
- b Value is the 50<sup>th</sup> percentile of time spent for open space users (Jefferson County 1996)
- c The adult skin-soil adherence factor is the EPA residential default and the 50<sup>th</sup> percentile for gardeners  
This is the value recommended by CDPHE for use in the WRW PRGs
- d The child skin-soil adherence factor is the EPA residential default and the 95<sup>th</sup> percentile for children playing in wet soil This is the value recommended by CDPHE for use in the open space user PRGs
- e The adult skin-surface area value is the EPA default for residential exposures and the average of the 50<sup>th</sup> percentile for males and females >18 years old wearing short-sleeved shirts, shorts, and shoes The value was recommended by CDPHE for use in the WRW PRGs
- f The child skin-surface area value is the EPA default for residential exposures and the average of the 50<sup>th</sup> percentile for males and females from <1 to <6 years old wearing short-sleeved shirts, shorts and no shoes The value was recommended by CDPHE for use in the WRW PRGs,
- g ML value is the 95<sup>th</sup> percentile of the estimated ML distribution estimated in the RSALs Task 3 Report (EPA et al 2002)

#### **4.2.1 EU Development**

Human health risks and health hazards will be assessed in three ways at RFETS to support the CRA These risk assessments include

- An onsite WRW will be assessed based on exposure to COCs developed on the basis of the EU
- An onsite WRW will be assessed based on exposure to COCs developed on an AOC basis
- An onsite WRV will be assessed based on exposure to COCs developed on the basis of the EU The same EUs will be used for the WRV as for the WRW assessment

The EUs for the wildlife refuge worker and the wildlife refuge visitor are illustrated in Figure 4 1 AOCs will then be established to define those areas that represent distinct potential impacts to receptors from the perspective of source terms, observed COCs, nature and extent of contaminant transport, and spatial locations

Sources of contamination will be determined using Site data to assess the spatial and temporal distribution of all classes of contaminants This information will be used to support the selection of COCs Primary areas of contamination will be identified and depicted on Site maps to define AOCs Data sufficiency will be assessed

#### **4.2.2 Defining and Assessing EUs**

Risk assessments evaluate the long-term threats to human health and the environment An EU is the area over which long-term risks to the chosen receptors are assessed The EU is an embodiment of the exposure scenario and its size varies with the land use and receptor activities Recreational or open space EUs are generally large, depend on the recreational activities envisioned for the Site, and represent the area over which a receptor ranges during recreational activities The activities of a WRW are even more extensive and varied, and the area over which the worker will be exposed during a career is quite large

The EUs integrate the above factors and also

- Consider Site contaminant release patterns and distinct areas of contamination,
- Aggregate data on a watershed basis,
- Support future land use planning,
- Facilitate assessment of risk in functional areas,
- Comply with RFCA/CERCLA requirements, and
- Interface with the ecological assessment

The EUs represent long-term activity areas in which the WRW and WRV will be exposed to residual contamination. The importance and relationship to assessment of long-term risks of the previous bullets are discussed below.

#### ***Contaminant Release Patterns***

Contaminant release patterns and known sources were incorporated in the delineation of the EUs, as shown on Figures 4.2 and 4.3. The objective is to assess areas with similar types of contamination on a collective basis. For example:

- The IA EU has the most IHSSs and PACs and is the area most affected by industrial activities at the Site.
- The Wind Blown Area EU includes surface soil affected by the 903 Pad release that are characterized by elevated plutonium and americium activities.
- The Upper Walnut Drainage EU includes the A- and B-Series ponds, which have elevated levels of radionuclides in sediments.
- The No Name Gulch Drainage EU encompasses the Present Landfill and down-gradient areas.
- The Lower Walnut Drainage EU stream sediments are affected by surface water flows from the ponds and erosion from the Wind Blown Area.
- The Woman Drainage EU is affected by the 903 Pad, the Original Landfill, and other IHSSs and PACs.
- The remaining four EUs are not significantly affected by releases from the Site.

**Figure 4.3 Exposure Unit Map with PACs**

Map is currently under construction

***Watersheds and Ecological Habitats***

The EUs were designed on a watershed basis. This was done to account for similar long-term fate and transport processes for residual contaminants in soil and sediments. The major transport process for contaminants in soil is overland flow and transport of eroded soil. The EUs also represent distinctive types of ecological habitats. The EUs, therefore, represent distinct areas affected by the potential transport of residual contamination from well-defined sources and activity areas for the WRW and WRV receptors based on similar landscapes and habitats.

***Future Land Use Planning***

The EUs are designed to support future land use planning by assessing risks for areas aggregated by similar geography, ecology, and expected usage. This will enable planners and managers to use the results of the CRA to determine areas of the Site to target for more intensive recreational development or other uses, such as ranger offices or a visitor center for the refuge.

***Assessment of Functional Areas***

The EUs are representative of expected activity areas for the WRW or WRV receptors. The areas of the EUs vary from 398 to 1,069 acres as shown in Table 4.3. Time-weighted activity areas for refuge personnel calculated from survey data collected for the Rocky Mountain Arsenal (RMA) are in the same size range, according to Table 4.4. The areas were calculated using the estimated time spent in each area size class, using the following formula:

$$\text{Time-Weighted Area} = \sum_{i=1 \text{ to } 3} (t_i/t_t * A_i) \quad \text{Equation 4-1}$$

Where

$t_t$  = the total time spent in all area size classes by all workers

$t_i$  = the time spent in the  $i^{\text{th}}$  area size class by all workers

$A_i$  = the  $i^{\text{th}}$  area (midpoint or maximum of size range)

**Table 4.3. Areas of the RFETS EUs.**

Name	Area (acres)
Industrial Area	428
Woman Drainage	977
South Buffer Zone Area	1,069
Windblown Area	720
Upper Walnut Drainage	403
Lower Walnut Drainage	398
No Name Gulch Drainage	425
Inter-Drainage	591
Rock Creek Drainage	765
West Area	471

The EU areas are very similar to those calculated from the survey and are good estimates of the areas over which an average WRW will range in doing his or her work. They are also indicative of different functional areas. Activities performed in the drainages will vary from those performed in the upland areas due to variation in topography, vegetation, and habitat. The combination of the assessment of risks in the EUs and AOCs, which represent areas of intensive activity, will result in a complete assessment of the potential range in risks from residual contamination at the Site.

**Compliance with RFCA/CERCLA Requirements**

Under CERCLA, it must be shown that risks for expected land uses at the Site fall within the acceptable range of  $1 \times 10^{-6}$  to  $1 \times 10^{-4}$ . The assessments for the EUs will present a comprehensive evaluation of long-term risks to the designated receptors across the Site. The coupling of these results with assessments of the targeted AOCs will provide the range of expected and high-end residual risks from the Site following the completion of all accelerated actions.

**Table 4.4. Time Weighted Average Activity Areas for Wildlife Refuge Workers<sup>a</sup>**

Receptors	Parameter	Small Areas	Medium areas	Large areas
		(0-10 acres)	(10-500 acres)	(500-6,000 acres)
	Midpoint size of area (acres)	5	255	3,250
	max size of area (acres)	10	500	6,000
<b>All workers</b>	Midpoint time weighted area (acres)	2	126	332
	Midpoint EU size (time-weighted) (acres)	<b>460</b>		
	Max time-weighted area (acres)	4	248	613
	Max EU size (time-weighted) (acres)	<b>865</b>		
<b>Workers spending at least 50% of time Outdoors</b>	Midpoint time weighted area (acres)	19	132	319
	Midpoint EU size (time-weighted) (acres)	<b>453</b>		
	Max Time weighted area (acres)	38	260	589
	Max EU size (time-weighted) (acres)	<b>852</b>		
<b>Workers spending at Least 30% Time Outdoors and on Site 100% of Time</b>	Midpoint time weighted area (acres)	2	133	425
	Midpoint EU size (time-weighted) (acres)	<b>560</b>		
	Max Time weighted area (acres)	3	261	784
	Max EU size (time-weighted) (acres)	<b>1,048</b>		
<b>All workers spending at least 30% Time Outdoors</b>	Midpoint time weighted area (acres)	18	132	421
	Midpoint EU size (time-weighted) (acres)	<b>555</b>		
	Max Time weighted area (acres)	35	260	777
	Max EU size (time-weighted) (acres)	<b>1,040</b>		

a Calculated from original survey data from Table B 2-14 (RMA IEA/RC Appendix B, 8/93) (reported times at middle and higher activities, outdoors) and from Table B 2att2-1,2,3,4,5,& 6 (RMA IEA/RC Appendix B, 2/15/94) (reported times doing specific tasks) Survey was performed by Shell for the Army's Baseline Risk Assessment for the RMA WRW from Malheur, OR (M), Minnesota Valley, MN (MV), and Crab Orchard, IL (CO) WRW were included in the survey Carl Spreng and Diane Niedzwiecki of CDPHE then exercised professional judgment to decide land area for each task

### ***Interface with the Ecological Risk Assessment***

Potential activity patterns and areas for the WRW and WRV receptors were considered in delineating the EUs, based on similar landscapes and habitats The EUs are representative of distinctive types of ecological habitats, generally either drainage or upland habitats Therefore, the chosen ecological receptors can be associated with specific EUs

#### **4.2.3 EUs for the Wildlife Refuge Worker**

As discussed above, EUs for the WRW, shown in Figure 4 1, incorporate information on contaminant releases, and watershed and drainage features, and are based on anticipated activity patterns These EUs form the basis for the assessment of risks to the anticipated major receptor in the CRA, recognize distinct areas of contamination, and support land use planning The EU assessment will be augmented with the AOC analysis and assessments Together, they will provide a complete assessment of risks to the WRW

The assessments for the EUs represent the risks the worker will encounter in discharging his duties across the Site The nature of the work involves movement over the entire Site Therefore, relatively small EUs do not represent true estimates of long-term risks to the worker However, due to the nature of the distribution of residual contamination across the Site, some areas represent a greater risk to the worker The combination of the EU assessments with the AOC assessments addresses this concern The EU assessments will provide a realistic evaluation of long-term risks at the Site, while the AOC assessments will characterize areas that may need to be managed more carefully

The risk assessment flow for each WRW EU is given below

- 1 The process described above predetermines the areas of the EUs
- 2 All surface soil, sediment, and subsurface soil sampling locations to a depth of 3 feet will be assessed at each EU for the WRW scenario
- 3 A DQA will be performed on the samples in each EU to ensure that the data within each are of sufficient quantity and quality to perform a risk assessment
- 4 The COC selection process will be applied to surface soil, sediments, and subsurface soil to a depth of 3 feet
- 5 Data from the COC selection process will be used to determine AOCs to be assessed (Section 4 2 5)
- 6 Data will be aggregated by EU and risks will be characterized

This approach will support future land use planning, comply with RFCA/CERCLA requirements, and interface with the ERA

#### **4.2.4 EUs for the Wildlife Refuge Visitor**

The refuge visitor is envisioned as participating in activities at the wildlife refuge. The visitor may be under the guidance and oversight of a WRW. Therefore, the same EUs will be applied to assess risks to the WRV as for the WRW. Due to the less intensive usage of the Site by the visitor, an assessment by AOC will not be performed.

The risk assessment flow for each WRV EU is given below:

- 1 The process described above predetermines the areas of the EUs
- 2 All surface soil and sediment sampling locations in each EU will be assessed for the WRV scenario
- 3 Surface soil and sediments will be combined for the COC selection process
- 4 A DQA will be performed on the samples in each EU to ensure that the data within each are of sufficient quantity and quality to perform a risk assessment
- 5 Data will be aggregated by EU and risks will be characterized

This approach will support future land use planning, and provide valuable estimates of the risks due to incidental usage of the Site by visitors. The visitor assessment will comply with RFCA/CERCLA requirements.

#### **4.2.5 Defining and Assessing AOCs**

The following section outlines how the AOCs will be developed for the onsite WRW. Developing AOCs in this manner will focus efforts on those areas with the highest contamination while minimizing efforts in areas where risks are known to be low. This evaluation also examines the environmental samples available to support the AOC determination.

##### ***AOCs for the Wildlife Refuge Worker***

The onsite WRW exposure scenario will be assessed across all areas at RFETS on an AOC basis. The AOC for the WRW will be smaller than the EUs because a wildlife refuge worker may be exposed across a smaller area. Therefore, COC concentrations will be averaged over a smaller area for this exposure scenario. The areal extent of an AOC for the WRW will be less than the EU and will be determined by the results of the PRG screen.

A risk assessment includes a number of phases: data evaluation, exposure assessment, toxicity assessment, and risk characterization. The data evaluation and exposure assessment phases provide the information for deriving the AOCs. These phases include a DQA and PRG screen. The DQA determines whether the data are of sufficient quantity and quality for use in the risk assessment. The PRG screen removes all contaminants from consideration that have such a low risk that they can be dropped from the risk assessment.

The areal extent of the AOC for the WRW will be defined using the following steps:

- 1 All surface soil and sediment sampling locations at RFETS will be assessed for the WRW exposure scenario

- 2 Surface soils and sediments will be compared with the onsite WRW PRGs for a risk =  $10^{-6}$  and a Hazard Index (HI) = 0.1
- 3 The AOC will be defined as the area surrounding the location(s) above the WRW PRG where organics are present above the detection limit and metals/radionuclides are found above background for each COC
- 4 The remaining steps of the COC selection process will then be applied to the AOC. If COCs exist, a risk assessment will be performed
- 5 A DQA will be performed on the samples in each AOC to ensure that the data within each AOC are of sufficient quantity and quality to perform a risk assessment
- 6 Human health risks will be developed for COCs within each AOC

#### **4.3 Data Aggregation for Risk Assessment**

Sampling and modeling contaminant data for onsite environmental media that meet the DQO and DQA requirements will be used to estimate human health and ecological risks on an EU/AOC basis (Section 4.2). The types of data aggregation to be performed for the HHRA are outlined in Table 4.5 below. Data for surface soil, subsurface soil, and sediments will be aggregated on an EU and AOC basis to estimate exposure concentrations and intakes to perform the CRA.

**Table 4.5 Data Aggregation for the CRA**

<b>Exposure Scenario</b>	<b>Functional EU</b>	<b>Area of Concern</b>
Wildlife Refuge Worker	Yes	Yes
Wildlife Refuge Visitor	Yes	No

#### **4.4 COC Identification and Selection**

The COCs will be selected for each media (e.g., surface soil/sediment and subsurface soil) and will be identified on an EU and AOC basis. COCs will be determined for each individual EU and AOC because historical use of chemicals varied across the Site. The COC lists will be developed using the WRW AL/PRGs. These COCs will also be used for the WRV scenario.

##### **4.4.1 Selection of EU and AOC COCs**

The selection of EU and AOC COCs will follow the process outlined on Figure 4.4. The process will be repeated for each EU and AOC. Environmental media that will be included in the COC selection process are surface soil, sediment, and subsurface soil.

#### **4.4.2 Data Quality Assessment**

Data will be extracted and the DQA will be conducted to assess the quality of reported data as described in Section 3.0. Outliers will also be assessed using standard statistical testing and eliminated, if appropriate.

#### **4.4.3 Data Aggregation**

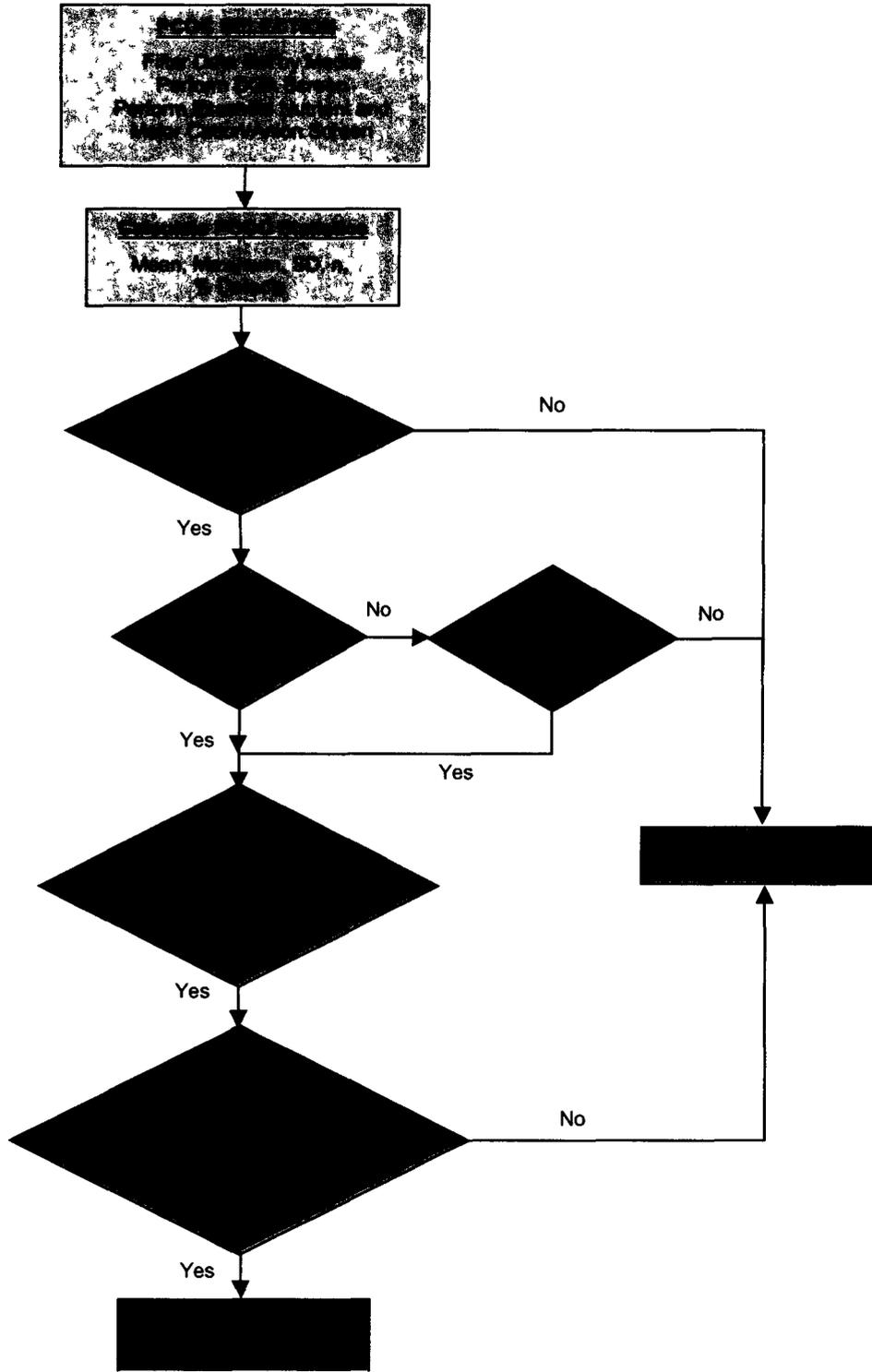
Data will then be aggregated on an EU basis by medium and analyte prior to initiation of the COC screening process. A value of one-half the reported value will be used for all U-qualified (aka nondetections) inorganic and organic data (EPA 1989). This does not apply to radionuclides, for which reported values will be used in all cases. A summary presentation of the data will include chemical name, Chemical Abstract Service (CAS) number, chemical-specific, contract-required quantitation limit (CRQL), reported detection limit, number of samples, frequency of detection, minimum detected concentration, maximum detected concentration, arithmetic mean concentration, and standard deviation.

#### **4.4.4 Elimination of Essential Nutrients/Major Cations and Anions**

Intakes calculated based on maximum concentrations of all essential nutrients in soil and sediment samples will be compared to recommended daily allowances (RDAs), recommended daily intakes (RDIs), adequate intakes (AIs) or upper limit daily nutrient intakes (ULs) in accordance with EPA guidance (1989). All essential nutrients that fall within the range of recommended or maximum daily intakes will be eliminated from further consideration in the CRA.

Nitrate, nitrite, ammonium, and fluoride have oral toxicological factors and will be assessed. Sulfide, bicarbonate, bromide, carbonate, chloride, orthophosphate, and sulfate have no toxicological factors and will be eliminated from assessments in soil and sediments.

**Figure 4.4 EU/AOC COC Selection Process**



#### **4.4.5 AL/PPRG Screen**

All remaining PCOCs identified in RFCA will be screened against the WRW AL/PPRGs for the appropriate media using an HQ of 0.1 or risk of 1E-06. All PCOCs below the WRW AL/PPRG will be eliminated for the EU and any AOC within the EU. The WRW AL/PPRGs for each medium used in this screen are presented in RFCA Appendix A (DOE et al. 1996). The PPRG ratios for each PCOC will be presented in tables.

#### **4.4.6 Detection Frequency Filter**

Compounds detected at a frequency of 5 percent or greater will be carried through the COC selection process. Compounds detected at less than 5 percent frequency are not considered characteristic of Site contamination and the potential for exposure is low.

All chemicals with less than 5 percent detection frequency will be compared to Site PPRGs set to an HQ of 3 or risk of 3E-05 as a health-protective precaution to ensure that hot spot contaminants are not eliminated as PCOCs. If the maximum detected value of an infrequently detected contaminant (less than 5%) exceeds the hot spot screening value, it will be carried on in the COC screening process.

#### **4.4.7 Data Distribution Testing**

Data distribution testing will be performed for all PCOCs retained following the AL/PPRG and frequency screens to aid in deciding the statistical test to use for comparison to background. Testing will be conducted following EPA guidance (2002b) and EPA QA/G-9 methods (2000b). The statistical tests to be used for determining data distributions are:

- Shapiro-Wilk Test (S-W, test limited to  $n > \text{or} = 30$  and  $< \text{or} = 50$ ), and
- D'Agostino's Test (D'Agostino,  $n > 50$ )

The test will be chosen based on sample size as recommended by EPA (2002b). Data sets with less than 30 samples will be considered to be lognormally distributed. If the chosen test identifies the distribution as normal, testing will stop and the data will be considered normally distributed. If not, the data will be log-transformed and tested again. The data will then be assigned a lognormal or nonparametric distribution, depending on the results. The assigned distribution will then be used to determine the appropriate test for the background comparison and estimate an appropriate upper 95UCL concentration.

#### **4.4.8 Background Analysis**

Following the determination of data distributions, inorganic and radionuclide PCOCs will be compared statistically to background data sets to determine whether the PCOCs are present at concentrations above background.

The background comparison is used to distinguish between contamination associated with Site activities and nonanthropogenic (naturally occurring) background conditions. The Geochemical Characterization of Background Surface Soils Background Soils Characterization Program, Final Report (DOE 1995a) will be used for the surface soil background data. The Background Geochemical Characterization Report (DOE 1993a) will

be used for the remaining media types. Background comparisons will be performed in accordance with current EPA guidance (2002b).

The statistical test chosen for a particular PCOC depends on the distributions of the PCOC and background data. Either parametric or nonparametric tests can be used, although neither work well with small data sets of less than 25 samples (EPA 2002b). Therefore, it is important that a combination of statistical testing be used to supplement the information from the statistical tests to compare the populations and other comparison methods including graphical, 95UCLs, outlier testing, and comparison of maximum values. The Wilcoxon (aka Mann-Whitney) Rank Sum Test is useful when Site and background data have different assigned distributions or are both nonparametric (i.e., not normally or lognormally distributed). If Site and background data have the same normal or lognormal distributions, a Student's T-Test can be used to compare PCOCs to background. Lognormal data are logtransformed prior to conducting a standard T-Test. Evaluation of 95 percent confidence intervals for Site and background data can also be useful. Overlap of 95 percent confidence intervals indicates that the Site data are within the range of natural background.

If the concentrations for a particular PCOC are found to be significantly greater than background levels, the PCOC will be retained for further consideration. Following the background comparison, professional judgment will be applied and the final list of COCs will be determined.

#### **4.4.9 Professional Judgment**

Professional judgment is also used to include or exclude a PCOC from the final COC list. A PCOC that has been previously eliminated may be included because of a preponderance of historical data suggesting the chemical may have been released in significant quantities to the environment. Professional judgment can also be applied to develop a weight of evidence argument to exclude a PCOC based on data assessment, spatial, temporal, or pattern-recognition concepts.

Data assessment includes an evaluation of laboratory and validation qualifiers. Spatial analysis requires that concentrations of each PCOC be plotted on a map, assessment of the plotted data should indicate their presence (or absence), or any trends in concentration, and assist in delimiting hot spots.

Temporal analysis is particularly relevant for groundwater data, where repeated sampling at a well offers the opportunity to evaluate changes in analyte concentrations over time. Time-series plots are used for this evaluation. Temporal analysis of data for sediment or other geologic materials is less useful and may not even be applicable.

Pattern recognition includes

- Inter-element correlations,
- Similarities in geochemical behavior,
- Geochemical modeling to determine solubility controls on element concentrations,
- Correlations, between elemental concentrations and certain parameters (total suspended solids [TSS], the negative logarithm of the hydrogen ion activity [pH], reduction-



transport of contaminants in groundwater to surface water, and estimate future maximum exposure concentrations to potential onsite receptors. A subsurface water flow and transport model will be developed to estimate spatial and temporal contaminant distributions, if the COC screening procedure, using PRGs developed for WRW and ecological receptors exposures to surface water, and the pathway assessment determines surface water exposures to be significant. The modeling results will be used to estimate potential human health or ecological effects from surface water concentrations resulting from the transport of contaminants currently in groundwater. The transport model will be calibrated using available information on contaminant sources, current contaminant distributions, and historical concentrations over time. DQOs for the modeling effort will be completed if modeling is determined to be necessary.

#### **4.6 Exposure Point Concentrations**

The EPC of a COC in a sampled medium is quantified using the 95UCL on the arithmetic mean. The arithmetic mean is a statistically robust estimator, even when normality assumptions are not met (Gilbert 1987). The 95UCL on the mean is a conservative estimate of the average concentration to which receptors would be exposed over time in the exposure area. If the maximum detected COC value is below the 95UCL, the maximum concentration is used as the EPC. When data distributions are demonstrated to be lognormal, an arithmetic mean and 95UCL will be calculated using log-transformed data. When distributions are found to be neither normal nor lognormal, a nonparametric 95UCL will be calculated.

Guidance and literature for calculating EPCs were reviewed. A Bootstrap nonparametric, probabilistic resampling methodology will be used to determine the 95UCL when observed data are not normally or lognormally distributed. A normal Bootstrap program was used to derive all mean and variance estimates. The Bootstrap method has been used to calculate concentration terms for estimating risk, as presented in EPA guidance (2002a). This nonparametric method will be selected when data sets have unknown distributions. In addition, lognormal distributions for radionuclides have inherent technical difficulties due to zero and negative concentrations and large variances.

Bootstrap calculations of the 95UCL avoid difficulties associated with empirically determining the shape of the observed distribution because it has no distributional assumptions. Resampling techniques provide estimates of the mean and variance for any distribution regardless of the specific shape. A discussion of the method in Appendix D of EPA's Process for Conducting Probabilistic Risk Assessment (1997) states that it has been shown that Bootstrap methods "perform substantially better, sometimes orders of magnitude better, in estimating the 95UCL of the mean from positively skewed data sets" than other methods (EPA 1997). Estimates derived for the CRA will be developed using 2,000 or more resampling events. Use of 1,000 iterations has been demonstrated to be sufficient for estimating the mean and associated variance (DOE 2003).

EPCs will be estimated at human receptor locations for all pertinent environmental media, including surface and subsurface soils, and sediment. The physical, chemical, and hydrogeologic characteristics of the Site must therefore be adequately studied and understood. Steady-state conditions will be assumed to EPCs based on direct environmental monitoring data. Effects of dilution, dispersion, source-term depletion, erosion, biodegradation, and sorption on quantification of the EPCs will be addressed in the

uncertainty section of the CRA EPCs will be estimated to realistically predict long-term averages and impacts to receptors

EPCs for human receptors will be determined using measured environmental monitoring data for surface, sediments. Subsurface soil concentrations will be utilized to estimate source terms for the possible transport of contaminants to groundwater and surface water locations and subsequent direct ingestion by human receptors

EPCs will be determined for ecological receptors using existing monitoring data for soils, sediments, surface water, and biotic compartments. Data for plant and animal tissues will be used to estimate direct impacts to sampled receptors and secondary exposure to food chain receptors consuming such contaminated materials. Air concentrations will be determined at specified receptor locations to assess inhalation impacts to primary species in the IA, BZ, and watershed ecosystems

#### **4.6.1 Intake Calculations**

Intake to receptors will be quantified for each screened COC, exposure pathway, and exposure scenario. Exposure factors reported in Section 4.1 will be used in the CRA. Intake in units of milligrams per kilograms per day (mg/kg-day) will be calculated for all receptors exposed to ingestion, dermal, and inhalation pathways using the general formulas below. Radiological intake in units of picocuries (pCi) will be assessed using the standard EPA formulas. External radionuclide exposure is calculated in units of yr/pCi/g.

The equations for calculating intakes for the WRW and WRV are given in Table 4.7. The abbreviations and specific values used for the exposure factors are defined in Tables 4.1 and 4.2.

Intakes are averaged over different time periods for carcinogenic and noncarcinogenic chemicals. For carcinogens, intakes are calculated by averaging the total cumulative dose during the exposure period over a lifetime, yielding a "lifetime average daily intake" (EPA 1989). For noncarcinogenic chemicals, intakes are calculated by averaging over the period of exposure to yield an average daily intake. For carcinogens, intakes are calculated by averaging the total cumulative dose during the exposure period over a lifetime, yielding a "lifetime average daily intake" (EPA 1989). Different averaging times are used for carcinogens and noncarcinogens because their effects occur by different mechanisms. The approach for carcinogens is based on the hypothesis that a high dose received over a short period of time is equivalent to a corresponding low dose spread over a lifetime. The intake of a carcinogen is averaged over a 70-year lifetime regardless of exposure duration.

**Table 4.7 Intake Equations for the WRW and WRV for the CRA<sup>1</sup>.**

<b>Wildlife Refuge Worker</b>
<b>Intake Equation for WRW Incidental Ingestion of Soil and Sediments</b>
Nonradionuclide Intake (mg/kg-day) = $\frac{(Cs \times IR_{wss} \times EF_{wss} \times Ed_w \times ETo \times CF1)}{(BW_a \times AT^*)}$
Radionuclide Intake (pCi) = $Cs \times IR_{wss} \times EF_{wss} \times ED_w \times ETo \times CF3$
<b>Intake Equation for WRW Dermal Contact with Soils and Sediments</b>
Nonradionuclide Intake (mg/kg-day) = $\frac{(Cs \times EF_{wss} \times ED_w \times EV_w \times SA_w \times AF_w \times ABS \times CF1)}{(BW_a \times AT)}$
<b>Intake Equation for WRW Inhalation of Suspended Particulates</b>
Nonradionuclide Intake (mg/kg-day) = $\frac{(Cs \times IR_{aw} \times EF_{w1} \times ED_w \times ET_w \times Eto \times MLF)}{(BW_a \times AT)}$
Radionuclides Intake (pCi) = $Cs \times IR_{aw} \times EF_{w1} \times ED_w \times ET_w \times ETo \times MLF \times CF2$
<b>Exposure Equation for WRW External Radiation from Surface Soil</b>
Radionuclide Exposure (yr/pCi/g) = $Cs \times (ET_w \times Eto) / 24 \text{ hr/day} \times EF_{w1} / 365 \text{ day/yr} \times ED_w \times ACF \times GFS$
<b>Wildlife Refuge Visitor</b>
<b>Intake Equations for WRV Incidental Ingestion of Soil</b>
Nonradionuclide Intake (mg/kg-day) = $\frac{(Cs \times SIR_{ageav} \times EF_v \times CF1)}{AT}$
Radionuclide Intake (pCi) = $Cs \times SIR_{agav\_r} \times EF_v \times ED_t \times CF2$
<b>Intake Equation for WRV Dermal Contact with Soil</b>
Nonradionuclide Intake (mg/kg-day) = $\frac{(Cs \times EF_v \times EV_v \times SFS_{agav} \times ABS \times CF1)}{AT}$
<b>Intake Equations for WRV Inhalation of Surface Soil</b>
Nonradionuclide Intake (mg/kg-day) = $\frac{(Cs \times IR_{agav} \times EF_v \times MLF)}{AT}$
Radionuclide Intake (pCi) = $Cs \times IR_{agav\_r} \times EF_v \times (ED_{av} + E_{dcv}) \times ET_v \times MLF \times CF3$
<b>Exposure Equation for WRV External Radiation from Surface Soil</b>
Radionuclide Intake (yr/pCi/g) = $Cs \times ET_v / 365 \text{ day/yr} \times ED_t \times ET_v / 24 \text{ hr/day} \times AFC \times GFS$

<sup>1</sup> Equations are given for surface soil and sediment. For WRW subsurface soil exposures, substitute the appropriate exposure frequency (EF<sub>sub</sub>)

When calculating intakes of radionuclides, the denominator (BW x AT) is excluded from the calculation. For calculation of radionuclide intakes, the exposure concentration is expressed in pCi/L, and the expression is not divided by body weight and averaging time. The resulting intake for radionuclides is expressed in pCi.

## 5.0 HUMAN HEALTH TOXICITY ASSESSMENT FOR CHEMICALS OF CONCERN

**Action:** Determine toxicity values and modes of action and end points for PCOCs

Toxicity values are used to characterize risk, while toxicity profiles summarize toxicological information for radioactive and nonradioactive COCs. Toxicity information is summarized for two categories of potential effects: noncarcinogenic and carcinogenic. These two categories have slightly differing methodologies for estimating potential health risks associated with exposures to carcinogens and noncarcinogens.

In general, toxicity profiles are obtained from EPA's *Integrated Risk Information System* (IRIS). IRIS contains only the toxicity values that have been verified by EPA's Reference Dose or Carcinogenic Risk Assessment Verification Endeavor (CRAVE) Work Groups. The IRIS database is updated monthly and supercedes all other sources of toxicity information.

If the necessary data are not available in IRIS, EPA's most recent issue of *Health Effects Assessment Summary Tables* (HEAST) will be used. It contains a comprehensive listing of provisional risk assessment information that has undergone review and has the concurrence of individual EPA Program Offices, but has not had enough review to be recognized agency-wide as consensus information. Values that have been withdrawn will not be used quantitatively unless the agency toxicologists (CDPHE and EPA) concur with their use for the CRA. Provisional values for toxicity factors are often available from the EPA's National Center for Environmental Assessment. These will be used with the concurrence of EPA and CDPHE toxicologists. EPA's HEAST for Radionuclides will be used as guidance for calculating radionuclide-specific cancer risk (EPA 2001b). Route-to-route extrapolation of toxicity values will not be performed at RFETS except where oral criteria are used for dermal exposures.

Secondary sources of information will be used qualitatively in the HHRA. EPA toxicologists, both regional and national, may also serve as information sources. All information sources will be documented in the toxicity assessment. In general, the toxicity factors used for the Site ALs and PPRGs will be used, unless updates have become available.

### 5.1 Identification of Toxicity Values for Carcinogenic Effects

Potential carcinogenic risks will be expressed as an estimated probability that an individual might develop cancer from lifetime exposure. This probability is based on projected intakes and chemical-specific dose-response data called cancer slope factors (CSFs). CSFs and the estimated daily intake of a compound, averaged over a lifetime, are used to estimate the incremental risk that an individual exposed to that compound may develop cancer. There are two classes of potential carcinogens: chemical carcinogens and radionuclides. Each of these two classes of elements or compounds are discussed separately below.

### 5.1.1 Chemical Carcinogens

Evidence of chemical carcinogenicity originates primarily from two sources: lifetime studies with laboratory animals, and human (epidemiological) studies. Animal data from laboratory experiments represent the primary basis for the extrapolation, for most chemical carcinogens. Experimental results are extrapolated across species (i.e., from laboratory animals to humans), from high-dose regions (i.e., levels to which laboratory animals are exposed) to low-dose regions (i.e., levels to which humans are likely to be exposed in the environment), and across routes of administration (e.g., inhalation versus ingestion).

The EPA estimates human cancer risks associated with exposure to chemical carcinogens on the administered-dose basis. The EPA assumes a small number of molecular events can evoke changes in a single cell that can lead to uncontrolled cellular proliferation and tumor induction. This mechanism for carcinogenesis means there is theoretically no level of exposure to a given chemical carcinogen that does not pose a small, but finite, probability of generating a carcinogenic response.

The CSFs are estimated using the linearized multistage model. The basis of this model is that multiple events may be needed to yield tumor induction (Crump et al. 1977) reflecting the biological variability in tumor frequencies observed in animal and human studies. The dose-response relationship predicted by this model at low doses is essentially linear. The CSFs calculated for nonradiological carcinogens using the multistage model represent the 95UCL of the probability of a carcinogenic response. Consequently, risk estimates based on these CSFs are conservative estimates representing upper-bound estimates of risk.

Uncertainties in the toxicity assessment for chemical carcinogens are dealt with by classifying each chemical into one of several groups, according to the EPA-defined, weight-of-evidence from epidemiological studies and animal studies. These groups are listed in Table 5.1.

**Table 5.1 Carcinogen Groups**

Weight-of-Evidence	Description
A	Human carcinogen (sufficient evidence of carcinogenicity in humans)
B	Probable human carcinogen (B1 - limited evidence of carcinogenicity in humans, B2 - sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans)
C	Possible human carcinogen (limited evidence of carcinogenicity in animals and inadequate or lack of human data)
D	Not classifiable as to human carcinogenicity (inadequate or no evidence)
E	Evidence of noncarcinogenicity for humans (no evidence of carcinogenicity in adequate studies)

The oral and inhalation CSFs for the COCs will be compiled in a table. Table 5.2 presents the current CSFs used for calculation of the PRGs. These values will be updated as necessary for the CRA. A similar table of values will be included in the CRA.

### **5.1.2 Radionuclides**

A series of federal guidance documents have been issued by EPA for the purpose of providing federal and state agencies with technical information to assist their implementation of radiation protection programs. The HEAST for Radionuclides (EPA 2001b) provide numerical factors, called "risk coefficients," for estimating risks to health from exposure to radionuclides. This federal guidance will be used to calculate risk from radionuclides. It applies state-of-the-art methods and models that take into account age and gender dependence of intake, metabolism, dosimetry, radiogenic risk, and competing causes of death in estimating the risks to health from internal or external exposure to radionuclides.

For a given radionuclide and exposure mode, both a "mortality risk coefficient" and "morbidity risk coefficient" are provided. A mortality risk coefficient is an estimate of the risk to an average member of the U.S. population, per unit activity inhaled or ingested for internal exposures or per unit time-integrated activity concentration in air or soil for external exposures, of dying from cancer as a result of intake of the radionuclide or external exposure to its emitted radiations. A morbidity risk coefficient is a comparable estimate of the average total risk of experiencing a radiogenic cancer, regardless of whether the cancer is fatal. For conservatism, the risk coefficient associated with morbidity will be used to characterize human health risks. Current values used are shown in Table 5.2.

### **5.2 Identification of Toxicity Values for NonCarcinogenic Effects**

Potential noncarcinogenic effects will be evaluated in the risk characterization by comparing daily intakes (calculated in the exposure assessment) with chronic reference doses (RfDs) developed by EPA. A chronic RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of the daily exposure that can be incurred during a lifetime, without an appreciable risk of a noncancer effect being incurred in human populations, including sensitive subgroups (EPA 1989). The RfD is based on the assumption that thresholds exist for noncarcinogenic toxic effects (e.g., liver or kidney damage). Adverse effects are not expected to occur with chronic daily intakes below the RfD value. Conversely, if chronic daily intakes exceed this threshold level, there is a potential that some adverse noncarcinogenic health effects might be observed in exposed individuals.

Table 5.2 lists the current values used for calculation of PRGs. This table will be updated as necessary for the CRA.

Table 5.2 Toxicity Constants for COCs for Carcinogenic Effects

Target Analyte List Chemical	CAS Number	Oral RfDw (mg/kg-day)	Oral/Ingestion Slope Factor <sup>2</sup> (mg/kg-day) <sup>-1</sup>	Inhalation RfD (mg/kg-day)	Inhalation Slope Factor (mg/kg-day) <sup>-1</sup>	Dermal ABS <sup>2</sup> Fraction Absorbed
Acenaphthene	(V) 83-32-9	0.06	I			0.13
Acetone	(V) 67-64-1	0.1	I			
Aldrin	309-00-2	0.0003	I	17	I	0.1
Aluminum	7429-90-5	1	E	0.001	E	0.13
Anthracene	(V) 120-12-7	0.3	I			
Antimony	7440-36-0	0.0004	I			
Aroclor-1016	12674-11-2	0.0007	I	0.07	Ia	0.14
Aroclor-1221	11104-28-2		2		Ia	0.14
Aroclor-1232	11141-16-5		2		Ia	0.14
Aroclor-1242	53469-21-9		2		Ia	0.14
Aroclor-1248	12672-29-6		2		Ia	0.14
Aroclor-1254	11097-69-1	0.0002	I	0.4	Ia	0.14
Aroclor-1260	11096-82-5		2		Ia	0.14
Arsenic	7440-38-2	0.0003	I	15	I	0.03
Barium	7440-39-3	0.07	I	0.0001429	A	
Benzene	(V) 71-43-2	0.003	E	0.055	E	
alpha-BHC	319-84-6		6.3		I	0.04
beta-BHC	319-85-7		1.8		I	0.04
delta-BHC	319-86-8					0.04
gamma-BHC (Lindane)	58-89-9	0.0003	I	1.3	H	0.04
Benzo(a)anthracene	56-55-3		0.73		E	0.13
Benzo(a)pyrene	50-32-8		7.3		I	0.13
Benzo(b)fluoranthene	205-99-2		0.73		E	0.13
Benzo(k)fluoranthene	207-08-9		0.073		E	0.13
Benzoic Acid (at pH 7)	65-85-0	4	I			
Benzyl Alcohol	100-51-6	0.3	H			
Beryllium	7440-41-7	0.002	I	5.71E-06	I	8.4
bis(2-chloroethyl)ether	(V) 111-44-4		1.1		I	1.1
bis(2-chloroisopropyl)ether	(V) 39638-32-9	0.04	I	0.07	H	0.035

Table 5.2 Toxicity Constants for COCs for Carcinogenic Effects

Target Analyte List Chemical	CAS Number	Oral RfDw (mg/kg-day)	Oral/Ingestion Slope Factor <sup>2</sup> (mg/kg-day) <sup>-1</sup>	Inhalation RfD (mg/kg-day)	Inhalation Slope Factor (mg/kg-day) <sup>-1</sup>	Dermal ABS <sup>2</sup> Fraction Absorbed
bis(2-ethylhexyl)phthalate	117-81-7	0.02	I 0.014	I	0.014	E 0.1
Bromodichloromethane	(V) 75-27-4	0.02	I 0.062	I		
Bromoform	(V) 75-25-2	0.02	I 0.0079	I	0.0039	I
Bromomethane (methyl bromide)	(V) 74-83-9	0.0014	I	0.0014286	I	
2-Butanone (methyl ethyl ketone)	(V) 78-93-3	0.6	I	0.2857143	I	
Butylbenzylphthalate	85-68-7	0.2	I			0.1
Cadmium (water)	7440-43-9	0.0005	I		6.3	I
Cadmium (food)	7440-43-9	0.001	I	0.000057	6.3	I 0.001
Carbon disulfide	(V) 75-15-0	0.1	I	0.2		
Carbon tetrachloride	(V) 56-23-5	0.0007	I 0.13	I 0.000571	E 0.053	I
alpha-Chlordane	5103-71-9	0.0005	I 0.35	I 0.0002	b 0.35	b 0.04
beta-Chlordane	5103-74-2	0.0005	I 0.35	I 0.0002	b 0.35	b 0.04
gamma-Chlordane	12789-03-6	0.0005	I 0.35	I 0.0002	b 0.35	b 0.04
4-Chloroaniline	106-47-8	0.004	I			0.1
Chlorobenzene	(V) 108-90-7	0.02	I	0.017		
Chloroethane (ethyl chloride)	(V) 75-00-3	0.4	E 0.0029	E 2.8571429	I	
Chloroform	(V) 67-66-3	0.01	I	0.000086	E 0.0805	I
Chloromethane (methyl chloride)	(V) 74-87-3		0.013	H 0.026	I 0.0035	E
2-Chloronaphthalene	(V) 91-58-7	0.08	I			
2-Chlorophenol	(V) 95-57-8	0.005	I			
Chromium III	16065-83-1	1.5	I			
Chromium VI	18540-29-9	0.003	I	0.00003	H 41	H
Chrysene	218-01-9		0.0073	E	0.0031	E 0.13
Cobalt	7440-48-4	0.02	E	0.0000057		
Copper	7440-50-8	0.04	H			
Cyanide	57-12-5	0.02	I			
4,4-DDD	72-54-8		0.24	I		0.03
4,4-DDE	72-55-9		0.34	I		0.03
4,4-DDT	50-29-3	0.0005	I 0.34	I	0.3395	I 0.03

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Table 5.2 Toxicity Constants for COCs for Carcinogenic Effects

Target Analyte List Chemical	CAS Number	Oral RfDw (mg/kg-day)	Oral/Ingestion Slope Factor <sup>2</sup> (mg/kg-day) <sup>-1</sup>	Inhalation RfD (mg/kg-day)	Inhalation Slope Factor (mg/kg-day) <sup>-1</sup>	Dermal ABS <sup>2</sup> Fraction Absorbed
Dibenz(a,h)anthracene	53-70-3		7.3		3.1	0.13
Dibenzofuran	132-64-9	0.004				0.1
Dibromochloromethane	124-48-1	0.02	0.084			0.1
Di-n-butylphthalate	84-74-2	0.1				0.1
1,2-Dichlorobenzene (o-)	95-50-1	0.09		0.04	H	
1,4-Dichlorobenzene (p-)	106-46-7	0.03	0.024	0.23	I	E
3,3-Dichlorobenzidine	91-94-1		0.45			0.1
1,1-Dichloroethane	75-34-3	0.1		0.1428571	A	
1,2-Dichloroethane	107-06-2	0.03	0.091	0.0014	E	I
1,1-Dichloroethene	75-35-4	0.009	0.6		0.175	I
1,2-Dichloroethene (total)	540-59-0	0.009				
2,4-Dichlorophenol (at pH 6.8)	120-83-2	0.003				
1,2-Dichloropropane	78-87-5		0.068			
cis-1,3-Dichloropropene	10061-01-5	0.03	0.1	0.0057143	Ic	Ic
trans-1,3-Dichloropropene	10061-02-6	0.03	0.1	0.0057143	Ic	Ic
Dieldrin	60-57-1	0.00005	16		16	I
Diethylphthalate	84-66-2	0.8				0.1
2,4-Dimethylphenol	105-67-9	0.02				
Dimethylphthalate	131-11-3	10				0.1
4,6-Dinitro-2-methylphenol (4,6-dinitro-o-cresol)	534-52-1	0.001				
2,4-Dinitrophenol	51-28-5	0.002				
2,4-Dinitrotoluene	121-14-2	0.002	0.68			
2,6-Dinitrotoluene	606-20-2	0.001	0.68			
Di-n-octylphthalate	117-84-0	0.02				0.1
Endosulfan I	959-98-8	0.006			0.014	0.1
Endosulfan II	33213-65-9	0.006				0.1
Endosulfan sulfate	1031-07-8	0.006				0.1
Endosulfan (technical)	115-29-7	0.006				0.1

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Table 5.2 Toxicity Constants for COCs for Carcinogenic Effects

Target Analyte List Chemical	CAS Number	Oral RfDw (mg/kg-day)	Oral/Ingestion Slope Factor <sup>2</sup> (mg/kg-day) <sup>-1</sup>	Inhalation RfD (mg/kg-day)	Inhalation Slope Factor (mg/kg-day) <sup>-1</sup>	Dermal ABS <sup>2</sup> Fraction Absorbed
Endrin (technical)	72-20-8	0.0003	I			0.1
Ethylbenzene	(V) 100-41-4	0.1	I	0.2857143	I 0.00385	E
Fluoranthene	206-44-0	0.04	I			0.13
Fluorene	(V) 86-73-7	0.06	I			0.13
Heptachlor	76-44-8	0.0005	I		4.5	I 0.1
Heptachlor epoxide	1024-57-3	0.000013	I		9.1	I 0.1
Hexachlorobenzene	118-74-1	0.0008	I		1.6	I 0.1
Hexachlorobutadiene	87-68-3	0.0002	H		0.078	I 0.1
Hexachlorocyclopentadiene	77-47-4	0.006	I	0.000057	I	0.1
Hexachloroethane	67-72-1	0.001	I		0.014	I 0.1
Indeno(1,2,3-cd)pyrene	193-39-5				0.73	E
Iron	7439-89-6	0.3	E			
Isophorone	78-59-1	0.2	I		0.00095	I
Lead	7439-92-1					
Lithium	7439-93-2	0.02	E			
Magnesium	7439-95-4					
Manganese (Nonfood)	7439-96-5	0.02	I	1.429E-05	I	
Mercury (elemental)	7439-97-6			0.000086	I	
Methoxychlor	72-43-5	0.005	I			
Methylene chloride (dichloromethane)	(V) 75-09-2	0.06	I	0.8571429	H 0.001645	I
2-Methylnaphthalene	(V) 91-57-6	0.02	E			
4-Methyl-2-pentanone (methyl isobutyl ketone)	(V) 108-10-1	0.08	H	0.0229	H	
2-Methylphenol (o-cresol)	95-48-7	0.05	I			0.1
4-Methylphenol (p-cresol)	106-44-5	0.005	H			0.1
Molybdenum	7439-98-7	0.005	I			
Naphthalene	(V) 91-20-3	0.02	I	0.0009	I	0.1
Nickel (soluble)	7440-02-0	0.02	I			
2-Nitroaniline	88-74-4			0.0000571	H	

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Table 5.2 Toxicity Constants for COCs for Carcinogenic Effects

Target Analyte List Chemical	CAS Number	Oral RfDw (mg/kg-day)	Oral/Ingestion Slope Factor <sup>2</sup> (mg/kg-day) <sup>-1</sup>	Inhalation RfD (mg/kg-day)	Inhalation Slope Factor (mg/kg-day) <sup>-1</sup>	Dermal ABS <sup>2</sup> Fraction Absorbed
Nitrobenzene	98-95-3	0.0005	I	0.0004	A	
4-Nitrophenol	100-02-7	0.008	E			
n-Nitrosodiphenylamine	86-30-6		0.0049		I	
n-Nitrosodipropylamine	621-64-7		7		I	
Pentachlorophenol	87-86-5	0.03	I	0.12	I	0.25
Phenol	108-95-2	0.6	I			
Pyrene	129-00-0	0.03	I			0.1
Selenium	7782-49-2	0.005	I			
Silver	7440-22-4	0.005	I			
Strontium	7440-24-6	0.6	I			
Styrene	100-42-5	0.2	I	0.2857143	I	
1,1,2,2-Tetrachloroethane	79-34-5	0.06	E	0.2	I	
Tetrachloroethene	127-18-4	0.01	I	0.052	E	0.00203
Tin	7440-31-5	0.6	H			
Toluene	108-88-3	0.2	I	0.1142857	I	
Toxaphene	8001-35-2		1.1		I	0.1
1,2,4-Trichlorobenzene	120-82-1	0.01	I	0.0571	H	
1,1,1-Trichloroethane	71-55-6	0.28	E	0.63	E	
1,1,2-Trichloroethane	79-00-5	0.004	I	0.057	I	0.056
Trichloroethene	79-01-6	0.0003	E	0.01	E	0.4
2,4,5-Trichlorophenol	95-95-4	0.1	I			
2,4,6-Trichlorophenol	88-06-2		0.011		I	0.01
Uranium (soluble salts)	No CASN	0.003	I			
Vanadium	7440-62-2	0.007	H			
Vinyl acetate	108-05-4	1	H	0.0571429	I	
Vinyl chloride	75-01-4	0.003	I	0.028	I	0.0154
Xylene (total)	1330-20-7	2	I			
Zinc	7440-66-6	0.3	I			

Table 5.2 Toxicity Constants for COCs for Carcinogenic Effects

Target Analyte List Chemical	CAS Number	Oral RfDw (mg/kg-day)	Oral/Ingestion Slope Factor <sup>2</sup> (mg/kg-day) <sup>-1</sup>	Inhalation RfD (mg/kg-day)	Inhalation Slope Factor (mg/kg-day) <sup>-1</sup>	Dermal ABS <sup>2</sup> Fraction Absorbed
Nitrate	14797-55-8	1.6	I			
Nitrite	14797-65-0	0.1	I			
Ammonium (as Ammonia)	7664-41-7			0.0286	I	
Fluoride (as fluoride)	7782-41-4	0.06	I			

Notes

1 Only those constituents in ALF are included

2 Source EPA 2001a

I = IRIS (EPA 2002) H = HEAST (EPA 1997a) A = HEAST Alternate W = Withdrawn from IRIS or HEAST

E = EPA-NCEA provisional value O = other

(V) = Chemicals listed are volatile

a = Values given are for PCBs

b = Values given are for chlordane (CAS No 12789-03-6)

c = Values given are for 1,3-dichloropropene

### **5.3 Identification of Radionuclide Dose Conversion Factors**

Dose coefficients will be delineated according to federal guidance (EPA 1988a, 1993) These documents will be used to tabulate dose coefficients for the committed effective dose equivalent to tissues of the body per unit activity of inhaled or ingested radionuclides The reports set forth derived guides consistent with current federal radiation protection guidance The guides are intended to serve as the basis for regulations setting upper bounds on the inhalation and ingestion of, and submersion in, radioactive materials in the workplace The reports also include tables of exposure-to-dose conversion factors for general use in assessing average individual committed doses in any population adequately characterized by Reference Man (ICRP 1975)

The dose coefficients for external exposure to radionuclides distributed in air, water, and soil will be tabulated in accordance with Federal Guidance Reports Nos 11 and 12 (EPA 1988a, 1993) The dose coefficients are based on dosimetric methodologies and include the results of calculations of the energy and angular distributions of the radiations incident upon the body and transport of these radiations within the body Particular effort was devoted to expanding the information available for the assessment of the radiation dose from radionuclides distributed on or below the ground surface

Generally, dose coefficients for external exposure relate the doses to organs and tissues of the body to the concentrations of radionuclides in environmental media Because the radiations arise outside the body, this is referred to as "external exposure" This situation is in contrast to the intake of radionuclides by inhalation or ingestion, where the radiations are emitted inside the body In either case, the dosimetric quantities of interest are the radiation dose received by the more radiosensitive organs and tissues of the body For external exposures, the kinds of radiation of concern are those sufficiently penetrating to traverse the overlying tissues of the body and deposit ionizing energy in radiosensitive organs and tissues Penetrating radiations are limited to photons, including bremsstrahlung, and electrons The radiation dose depends strongly on the temporal and spatial distributions of the radionuclide to which a human is exposed The mode considered for the CRA for external exposure is exposure to contamination on or in the ground (i e , ground exposure)

### **6.0 HUMAN HEALTH RISK CHARACTERIZATION PERFORMED ON AN EU AND AOC BASIS**

**Action:** Characterize risks for the CRA in three ways

- 1 An on-site WRW will be assessed based on exposure to COCs developed on the basis of the EUs, as discussed in Section 4 2
- 2 An on-site WRW will be assessed based on exposure to COCs for AOCs determined by the methods discussed in Section 4 2
- 3 An on-site (WRV) will be assessed based on exposure to COCs developed on the basis of the EUs

To characterize risks, the chemical-specific intakes calculated in the exposure assessment are multiplied by the applicable chemical-specific, dose-response factors to compute estimates of the cancer risk for an individual over a lifetime of exposure, or the intakes are compared with RfDs (chronic, subchronic, or acute) for noncarcinogenic health effects. The nature, weight-of-evidence, and magnitude of uncertainty for the potential critical health effects are considered. The process of quantifying health risks includes the following:

- Calculating and characterizing carcinogenic effects for each COC, receptor, pathway, and exposure scenario,
- Calculating and characterizing noncarcinogenic effects for each COC, receptor, pathway, and exposure scenario,
- Calculating and characterizing radiation dose for each radionuclide COC, receptor, pathway, and exposure scenario, and
- Conducting qualitative (or quantitative, if necessary) uncertainty analysis

### 6.1 Calculating and Characterizing Carcinogenic Effects

The following calculations will be used to determine carcinogenic effects by obtaining numeric estimates (i.e., unitless probability) of lifetime cancer risks:

$$Risk = Intake \times CSF \quad \text{(Equation 6-1)}$$

Where

*Risk* = potential lifetime excess cancer risk (unitless probability)

*CSF* = cancer slope factor (mg/kg-day<sup>-1</sup> or pCi<sup>-1</sup>)

*Intake* = chronic daily lifetime intake (mg/kg-day or pCi) from equations in Table 4.7

CSFs will be used as provided in IRIS. Inhalation and oral ingestion CSFs are used with respective inhalation and ingestion intakes to estimate potential carcinogenic health risks. The CSFs used are presented and discussed in the toxicity assessment (Section 5.1).

Cancer risks are summed separately across all potential chemical carcinogens and radionuclides considered in the risk assessment using the following equations:

$$Risk_{Tc} = \sum Risk_{ic} \quad \text{(Equation 6-2)}$$

$$Risk_{Tr} = \sum Risk_{ir} \quad \text{(Equation 6-3)}$$

Where

*Risk<sub>Tc</sub>* = total chemical cancer risk (unitless probability)

*Risk<sub>ic</sub>* = risk estimate for the *i*th chemical contaminant (unitless probability)

*Risk<sub>Tr</sub>* = total radionuclide cancer risk (unitless probability)

*Risk<sub>ir</sub>* = risk estimate for the *i*th radionuclide contaminant (unitless probability)

These equations are an approximation of the precise equation for combining risks to account for the probability of the same individual developing cancer as a consequence of exposure to two or more carcinogens. The difference between the precise equation and this approximation is negligible for total cancer risks less than 0.1 ( $10^{-1}$ ). The risk summation assumes independence of action by the compounds (i.e., no synergistic or antagonistic actions). The limitations of this approach include conservative risk estimates due to the use of multiple upper-bound estimates of CSFs, increased uncertainty when adding potential carcinogenic risk across weight-of-evidence cancer classes (A through C), and uncertainty due to possible interactions among carcinogens.

A table of risks for each exposure scenario will be presented to show contaminant- and pathway-specific risk, with contaminants presented by rows and pathways presented by columns. Risks will be subtotaled across pathways for each contaminant.

A total carcinogenic risk will also be summed across weight-of-evidence classifications as an aid in the discussion of the uncertainty of the estimates. In accordance with EPA guidance, only one significant digit is retained when summarizing calculated risks (EPA 1989).

The CRA will discuss risks that exceed the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) risk range of  $10^{-4}$  to  $10^{-6}$  (EPA 1990). The pathways and contaminants driving the risk will be noted and accompanied by a discussion of any qualifying information.

In addition to presenting the incremental cancer risks due to contaminants at the Site, perspective may be provided by giving examples of typical background sources of risk, such as for arsenic or uranium. The text will note assumptions associated with the calculations, and discuss the importance of background risks associated with each exposure scenario. The CRA summary section will present risks for each scenario.

## 6.2 Calculating and Characterizing Noncarcinogenic Effects

Health risks associated with exposure to individual noncarcinogenic compounds are determined by calculating HQs and HIs. The noncarcinogenic HQ is the ratio of the intake or exposure level to the RfD, as follows:

$$HQ_i = \text{Intake}_i / \text{RfD}_i \quad (\text{Equation 6-4})$$

Where

$HQ_i$  = noncarcinogenic HQ for  $i^{\text{th}}$  substance

$\text{Intake}_i$  = intake for  $i^{\text{th}}$  substance (mg/kg-day) for appropriate exposure period

$\text{RfD}_i$  = reference dose for  $i^{\text{th}}$  substance (mg/kg-day) for appropriate exposure duration

Inhalation and oral ingestion RfDs are used with respective inhalation and ingestion intakes to estimate potential noncarcinogenic health effects. Intake and RfD are expressed in the same units and represent the same exposure period. The RfDs used are presented and discussed in the toxicity assessment of the CRA. COCs that have been determined to have subchronic (two-week to seven-year exposure) or acute (less than two-week exposure)

effects in the toxicity assessment will be characterized using subchronic or acute RfDs, or other dose-response information, as available

HIs are the summed HQs for each chemical across an exposure pathway. A HI is calculated using the following equation

$$HI_{pw} = \sum HQ_i \quad (\text{Equation 6-5})$$

Where

$HI_{pw}$  = HI for an exposure pathway

$HQ_i$  = HQ for the  $i^{\text{th}}$  COC

The  $HI_{pw}$  values are not statistical probabilities of a potential effect. If the  $HI_{pw}$  exceeds one, there is a concern for potential noncarcinogenic health effects. In general, the greater the HI above one, the greater the level of concern. However, the level of concern does not increase linearly as the HI approaches or exceeds one.

Noncarcinogenic effects will be presented in the CRA tables similar to those used in the presentation of carcinogenic risk. Each table will show contaminant- and pathway-specific effects with contaminants presented in rows, and pathways presented by columns.  $HI_{pw}$ s will be subtotaled across pathways to develop an HI for the exposure scenario ( $HI_{es}$ ), if the same individuals would consistently be exposed to more than one pathway for each contaminant.

HQs approaching or exceeding one will be segregated and summed by mode of action or target organ to calculate the total HI by target organ ( $HI_{to}$ ). A total  $HI_{to}$  will also be summed across all pathways and contaminants for a specific receptor scenario. Both of these procedures are subject to limitations. One significant digit is retained when summarizing the calculated indices.

The CRA will discuss HQs and HIs that exceed one. The pathways and contaminants driving the risk will be noted and discussed. A summary table presenting  $HI_{es}$  subtotals for all scenarios will be created for presentation in the CRA risk summary section. This may be presented by placing the results for each scenario in rows, and providing information on HIs, dominant COCs, and dominant pathways in columns.

### 6.3 Calculating and Characterizing Radiation Dose

The following calculation will be used to determine the radiation dose (NCRP 1985)

$$Dose = Intake \times DCF \quad (\text{Equation 6-6})$$

Where

$DCF$  = dose conversion factor (millirems per picocurie [mrem/pCi] or millirems per picocurie per gram [mrem/pCi/g])

$Intake$  = radionuclide intake or media concentration (pCi or pCi/gram)

Inhalation and oral ingestion DCFs are used with respective inhalation and ingestion intakes to estimate radiation dose. For external irradiation, external DCFs are used with respective

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soil concentrations to estimate radiation dose DCFs are calculated using mathematical extrapolation models based on human epidemiological studies

Radiation dose is summed separately across all potential radionuclides considered in the dose assessment using the following equation

$$Dose_T = \sum Dose_i \quad \text{(Equation 6-7)}$$

Where

$Dose_T$  = total radiation dose, expressed in millirem (mrem)

$Dose_i$  = radiation dose estimate for the  $i^{\text{th}}$  radionuclide

A table of radiation doses for each exposure scenario will be created to show contaminant- and pathway-specific dose, with radionuclides presented by rows and pathways presented by columns Reasonable exposure pathway combinations will be identified and the likelihood that the same individuals would consistently be exposed by more than one pathway will be evaluated In most situations, a receptor could be exposed by several pathways in combination For these situations, dose will be subtotaled across pathways for each radionuclide

In addition to presenting the incremental radiation dose due to radionuclides at the Site, perspective may be provided by giving examples of typical background sources of dose from anthropogenic and terrestrial sources Assumptions associated with the calculations will be noted and discussed The CRA summary section will present doses for each exposure scenario and present a brief discussion of the uncertainty of the risk estimates

#### **6.4 Conducting Uncertainty Analysis**

The uncertainty analysis characterizes the various sources and their contributions to uncertainty in the CRA These uncertainties are driven by uncertainty in the Site investigation data, likelihood of hypothetical exposure scenarios, transport modes used to estimate concentrations at receptor locations, receptor intake parameters, and toxicity values used to characterize risk Additionally, uncertainties are introduced in the risk assessment when exposures to several substances across multiple pathways are summed

The concept of uncertainty can be more fully defined by distinguishing between variability and knowledge uncertainty Variable parameters are those that reflect heterogeneity in a well-characterized population, for which the distributions would not generally be narrowed through further measurement or study Certain parameters reflect a lack of information about properties that are invariant and whose single, true value could be known exactly by the use of a perfect measuring device Where appropriate, qualitative uncertainty analysis may distinguish between variability and uncertainty This type of uncertainty analysis will identify each key source of uncertainty, present an estimate of the relative impact of the uncertainty on the CRA, and include any clarifying remarks

There are four stages of analysis applied in the risk assessment process that can introduce uncertainties

- Data collection and evaluation,

- Exposure assessment,
- Toxicity assessment, and
- Risk characterization

The discussion of uncertainty is an important component of the risk assessment process. Point estimates of risk do not fully convey the range of information considered and used in developing the assessment (EPA 1992b). To provide information about the uncertainties associated with the reasonable maximum exposure (RME) estimate, uncertainties identified during the CRA process will be discussed qualitatively. In some cases, the effects on risks of the variability in some factors may be calculated quantitatively to show potential risk ranges.

## 7.0 ECOLOGICAL RISK ASSESSMENT

**Scope:** Develop and document the methodology for the ERA portion of the CRA and for support of accelerated actions

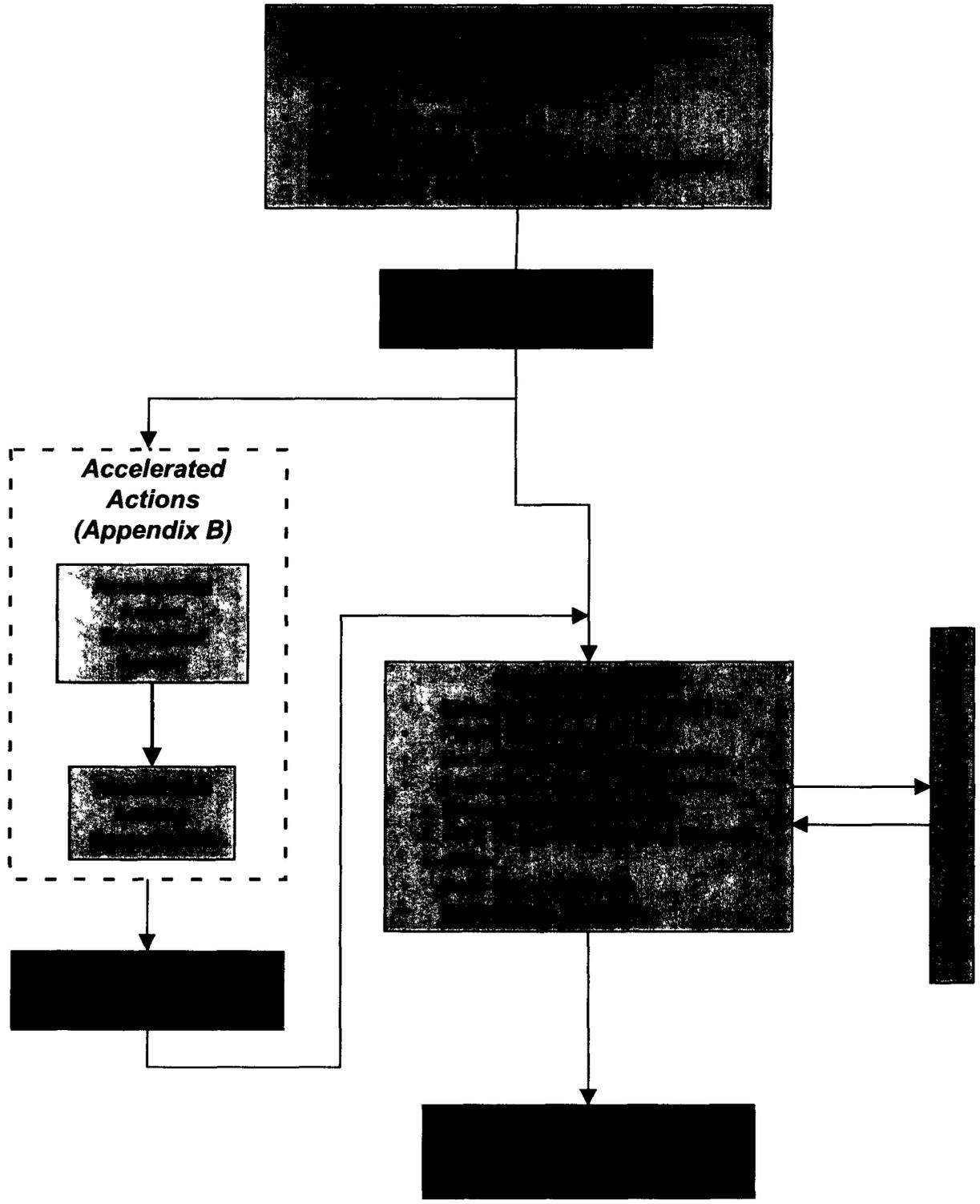
This section provides the methodology for the ERA in support of the CRA. The methodology utilizes previous RFETS Ecological Risk Assessment methodologies (DOE 1996b, 1996c) and more recent EPA guidance on performing ERAs at Superfund sites (EPA 1997, 1999, 2000b).

The existing RFETS methodologies were used to perform ERAs for the Woman and Walnut Creek watersheds. The results of these ERAs were presented in the *Draft Final Phase I RFI/RI Report Appendix N, Woman Creek Priority Drainage Operable Unit No. 5* (DOE 1995b). Hereafter this ERA will be referred to as the Watershed ERA.

The BZ includes approximately 6,000 acres, or approximately 93 percent of the Site. The Industrial Area (IA) covers approximately 400 acres and contains the most developed parts of the Site, where industrial and office facilities for the Rocky Flats Site are located. An ERA has not been performed for areas within the IA. Buildings, parking lots, or other developed areas currently cover much of the IA. As a result, the IA does not currently represent a significant ecological resource. However, after completion of all accelerated actions, land use for the IA will be wildlife habitat and an ERA is needed to characterize the potential exposure and ecological risk due to residual contamination in soils or other media.

An overview of the CRA process is depicted in Figure 7.1. The CRA analysis is intended to document residual risks after remedial activities have been completed. The analysis will include two main phases. First, data on potential chemicals of concern (PCOCs) in abiotic media from the Site will be compared to PRGs that have been developed for abiotic media and a range of ecological receptor types. For areas affected by accelerated action, this analysis will be conducted using post-remedy data.

**Figure 7.1 Sequence of Activities for Ecological Risk Assessment**



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For other areas, the analysis will be conducted with data from previous investigations such as the RFI/RIs or Sitewide soil sampling. The PRG comparisons will be used to identify receptor of concern (ROC)/PCOC pairs for which PCOC concentrations exceed receptor-appropriate benchmarks, and to map the locations at which the PRGs are exceeded.

Second, for areas identified in the above analyses, further analyses will be conducted based on additional lines of evidence. Results of the Watershed ERA (DOE1995b) will be reviewed in context of information that has been developed since the risk assessment, such as mapping of Preble's meadow jumping mouse (PMJM) habitat. On the basis of this review, data or information gaps will be identified and will be addressed in the CRA.

Development of PRGs will be specific to the ROCs and the level of protectiveness needed. For ROCs that are not protected by state or federal statute (e.g., threatened or endangered species), PRGs will be developed to represent exposures equal to the Lowest Observed Adverse Effects Levels (LOAELs). PRGs for PMJM will be developed at a more protective level since it is a rare species with legal protection. PMJM PRGs will be based on No Observed Adverse Effects Levels (NOAELs). PRGs are being developed to accompany human health ALs in RFCA (Appendix N) (DOE et al 1996). Application of the RFCA process will result in remediation of accelerated action to levels that will prevent adverse ecological effects from exposure to Site-related contaminants.

The CRA will characterize Sitewide residual risk from exposures after Site remediation actions, including the accelerated actions. Data used for the PRG comparison process will be data from abiotic media (soil, surface water, sediment). For accelerated action areas, data will be from post-remedy confirmation sampling. In addition, the ERA may use the results of any Sitewide surface water and groundwater transport modeling efforts to predict exposure of aquatic and terrestrial species at points of potential discharge, such as hillside seeps (terrestrial) and streams (terrestrial and aquatic).

The following sections describe the available information from the Watershed ERAs or other information sources, and the approach proposed for the CRA. The sections are organized as follows:

- Section 7.1 describes the Watershed ERA analysis and approach, and summarizes the results.
- Section 7.2 describes the background information for the CRA including the Site conceptual model (SCM). This section also presents the DQO analysis for the CRA, and an overview of the PRG development process. (Note: Appendix A details the PRG development process.)
- Section 7.3 describes the Sitewide ECOC identification process that will be used to identify the chemicals for which additional risk analyses are needed.
- Section 7.4 describes the overall CRA risk analysis approach to be implemented after accelerated action results data are available.
- Appendix A details the PRG development process.
- Appendix B describes the analysis process for the accelerated actions in the IA and BZ (includes analysis approach for PMJM and non-PMJM ROCs).

## 7.1 Summary of Existing Watershed ERA Results

**Purpose:** Summarize results of previously completed Watershed ERAs to be used to support current assessment of ecological risks from residual contamination at the Site

This section presents the methods and results for the ERAs conducted for the BZ in the Walnut Creek and Woman Creek watersheds (DOE 1995b). The Watershed ERAs represented the ecological portions of the baseline risk assessments associated with the RCRA RFI/RI for OUs 1, 2, 4 (in part), 5, 6, 7, 10 (in part), and 11. As noted above, the Watershed ERAs were conducted based on agreements among EPA, CDPHE, and the DOE. ERAs were formerly planned for each OU, and preliminary field investigations were conducted on that basis. The regulatory agencies agreed that it was more appropriate to conduct the ERAs for each watershed, because the watershed scale is more relevant to ecological receptors than administrative boundaries.

### 7.1.1 Use in CRA

Results of the Watershed ERAs will be an important line of evidence in the risk analysis process. The Watershed ERAs represent a comprehensive exposure and risk calculation process conducted specifically for the RFI/RI process at RFETS. The results will be used on several levels. For example, PRG calculations include assumptions about extent to which ECOCs are accumulated from abiotic media to biota in the food chain. The literature-based bioaccumulation factors (BAFs) used in developing the PRGs analysis are typically conservative and will tend to overestimate the ECOC concentrations in forage and prey which, in turn, tend to overestimate risk. BAFs are notoriously Site-specific and the assumptions used in the PRG calculations may not match reality at the Site. The Watershed ERA contains data on ECOC concentrations in biota throughout the active areas of the Site. These data were used in exposure and risk calculations, eliminating the need for use of BAFs. Therefore, results of the exposure analyses will be used to determine whether the PRGs are overestimating risk for the Site.

Data from the Watershed ERAs and or RFI/RI reports may be used in a data gaps analysis to help determine whether additional data are needed to assess risks in specific areas. This may be especially applicable to PMJM habitats along the creeks where soil and biota data were collected. The results of the Watershed ERAs can be used to determine whether additional data are needed to fill spatial data gaps along the drainages.

### 7.1.2 Background

The approach used was consistent with a screening-level risk assessment appropriate for sites where ecological effects have not been observed, but contaminant levels have been measured and can be compared with concentrations considered protective of ecological receptors.

The RFETS ERA methodology drew information from DOE and EPA guidance and ERA tools developed at Oak Ridge National Laboratory (ORNL) (Efroymsen et al , 1997) and the Savannah River Site (DOE 1993b, EPA 1992d, 1994a, Norton et al 1992, Opresko et al 1994) The Watershed ERAs included three phases identified in EPA guidance (1) preliminary risk calculations and problem formulation, (2) analysis, and (3) risk characterization

As noted above, preliminary field investigations were performed for each OU prior to the integration of ERAs into watersheds However, Interagency Agreement (IAG) schedules for individual RFI/RI did not allow evaluation of contaminant distribution prior to ecological field investigations Therefore, in most cases, collection of data on specific effects of individual contaminants was not possible As a result, the Watershed ERA focused primarily on estimation of exposure from available contaminant distribution data in abiotic and biotic media A large and comprehensive database of RFI/RI data was available for evaluating contaminant distribution in abiotic media In addition, biological tissue samples from each OU were analyzed for metals and radionuclides, and these data were used to document exposures

### **7.1.3 General Methodology**

A SCM was developed to identify all viable exposure pathways for onsite receptors The Ecological Contaminants of Concern (ECOC) Screening Methodology Technical Memorandum (DOE 1996b) describes the methodology used to identify ECOCs for use in the RFETS Watershed ERAs Data on chemical distributions in biotic and abiotic media associated with potential contaminant source areas (IHSSs) were screened using a three-tiered approach The first tier identified Site-specific contaminants for the ERAs The evaluation included statistical analyses and professional judgment and resulted in a list of PCOCs that was then used to determine the ECOCs for the ERA

The potential ecotoxicity of PCOCs was evaluated in the second and third tiers Evaluations were conducted only for complete exposure pathways The second and third tier screens each required estimates for exposure of representative or key receptors to Site contaminants Representative species of birds, small mammals, large mammals, and fish were selected based on their abundance at RFETS, special legal status, and position in local food webs Information on life history, body size, diet, and other parameters needed to estimate exposure were also presented in the Sitewide Conceptual Model Technical Memoranda (SCMTM) (DOE 1996c)

The potential toxicity of exposures to PCOCs was assessed in the Watershed ERAs This information was then used to identify ECOCs for which exposure analysis was conducted Screening-level assumptions were adopted to minimize the chance of underestimating risk from a given PCOC

The Tier 2 screen was equivalent to preliminary exposure and risk calculations included in Step 2 of the most recent EPA ERA guidance (1997) Estimation of exposure and comparison to benchmarks for this tier involved a limited number of species The screen conservatively assumed that receptors are continuously exposed to the highest concentrations detected

Tier 3 included a more accurate method for estimating exposure than Tier 2 because it incorporated the distribution of chemicals in the environment and spatial and temporal aspects of receptor behavior. Factors such as diet, home-range size, seasonal migration, and body size affect the frequency, duration, and intensity of contact with contaminated media. The adjustment of exposure parameters in Tier 3 to account for these factors is important in obtaining more objective estimates.

Potential ecotoxicity of contaminants was evaluated by comparing Site-specific exposures to ecotoxicological benchmarks developed for various receptor species from established databases or scientific literature. The comparison was expressed as a HQ or the ratio of a Site-specific exposure estimate to the benchmark (EPA 1994a). The approach and methods for risk characterization were described in a problem formulation step designed to be consistent with EPA guidance on conducting ERAs (EPA 1994a). However, in contrast with EPA guidance, risk characterization was performed using existing data and toxicity information. Data were available on concentrations of metals, radionuclides, and certain organic chemicals (pesticides and polychlorinated biphenyls [PCBs]) in aquatic and terrestrial biota. These data were reliable indicators of exposure and were collected to evaluate exposure of upper level consumers to chemicals accumulated in forage or prey (Suter 1993).

Ecotoxicological benchmarks values for the Watershed ERAs were based on a database developed at Oak Ridge National Laboratory (ORNL 1994). In most cases, benchmarks were derived from data on the toxicity to laboratory test animals and extrapolated to wildlife species by scaling to body size and applying uncertainty factors to account for variability among species and data types (ORNL 1994). The ORNL method was used to develop benchmarks for key receptor species at RFETS.

#### **7.1.4 Watershed Results**

The results for the previous work conducted in the BZ (DOE 1995b) are summarized by watershed, receptor group, ECOG, and ERA source areas in Tables 7.1 and 7.2. More specific results can be found in DOE (1995b).

Table 7.1. Summary of Ecological Risks for Walnut Creek Watershed

Receptor Group	ECOCs	ERA Source Area	Media/Exposure Point	Conclusions
Wide-Ranging Wildlife	None	Not Applicable	Not Applicable	The Tier 3 ECOC screen did not identify ECOCs
Aquatic Life	Metals and Organics in Sediments	OU 6 A-Ponds OU 6 B-Ponds	Sediments	Risks are primarily due to PAHs in sediments. However, no toxicity was detected in sediment toxicity tests with <i>Hyalella azteca</i> . Importance of sediment contamination is unclear but does not appear to be the primary factor controlling benthic community structure.
Aquatic-Feeding Birds	Aroclor 1254	OU 6 A-Ponds OU 6 B-Ponds	Pond Sediments	Aroclor 1254 concentrations in sediment exceeded risk based criteria for Ponds B 1, B-2, and B-3 only if top aquatic predators were present. Ponds currently do not support this type of community.
	Mercury	OU 6 A-Ponds OU 6 B-Ponds	Fish Tissue	Mercury was detected in 75% of fish from B-ponds. However, the maximum concentration was detected in B-5, which has the lowest contaminant content. The maximum HQ was 2. Mercury does not appear to represent risk to herons.
	Di-N-butyl phthalate	OU 6 A-Ponds OU 6 B-Ponds	Sediments	All samples with detectable DBP concentrations were "J" qualified. Only one sample corresponds to an HQ of 2, all other HQs are $\leq 1$ . DBP does not appear to represent risk to herons or mallards.
Terrestrial-Feeding Raptors	Chromium	OU 2 903 Pad OU 2 East Trenches	Terrestrial Arthropods	Mean chromium concentration in soil was not greater than the background mean. No clear contaminant source exists. Chromium is not a risk to the kestrel population at RFETS.
	Chromium, Lead	OU 4 Downgradient OU 6 A-Ponds OU 6 B-Ponds	Small Mammals	Chromium and lead were elevated in small mammals from pond areas. The source is unclear because soil and sediments contain low levels. Risks are possible to individual birds feeding in the area, but effects to RFETS population are minimal.
	Mercury, Vanadium	OU 4 Downgradient OU 6 A-Ponds OU 6 B-Ponds	Small Mammals	Mercury and vanadium were detected at low frequency and some concentrations were "J" qualified. Risks appear to be minimal.
Small Mammals	Plutonium-239/240 Americium 241	OU 2 903 Pad OU 2 East Trenches	Soil	Radionuclides do not present significant risk to terrestrial receptors. Maximum tissue concentrations do not result in dose rates that exceed the TRV (0.1 rad/day).
	Barium	OU 6 North Spray Field	Vegetation	The barium HQ of 1.05 indicates exposures are very close to the NOAEL. Risks to small mammal populations are negligible. Some individual jumping mice might be exposed, but adverse effects would be minimal.
	Selenium	OU 7 Downgradient	Vegetation	Selenium exposure exists in a small area but includes habitat for jumping mice. The source of selenium is not clear. Levels in vegetation were twice that of background. Possible adverse effects to individuals exist, but population effects were negligible due to the small area.
Vegetation	Metals and Organics	Most Source Areas	Soil, Sediments	Nitrates in OU 7 and OU 4, and silver in B-ponds have the highest risk estimates. However, ecological risk is unclear because vegetation in these areas does not appear stressed.

Table 7.2. Summary of Ecological Risks for Woman Creek Watershed

Receptor Group	ECOCs	ERA Source Area	Media/Exposure Point	Conclusions
Wide-Ranging Wildlife	None	Not Applicable	Not Applicable	The Tier 3 ECOC screen did not identify ECOCs
Aquatic Life	Metals and Organics in Sediments	OU 2 903 Pad OU 5 C-Ponds OU 5 Old Landfill	Sediments	Risks are primarily due to PAHs in sediments. However, no toxicity was detected in sediment toxicity tests with <i>Hyalella azteca</i> . The importance of sediment contamination is unclear but does not appear to be the primary factor controlling benthic community structure.
Aquatic-Feeding Birds	Aroclor-1254	OU 5 C-Ponds	Sediments of SID	Aroclor-1254 concentrations in sediment did not exceed risk-based criteria developed for sediment at RFETS
	Mercury	OU 5 Old Landfill OU 5 C-Ponds	Fish Tissue	Mercury was detected in 2 of 24 fish from C-ponds. Mercury was not detected in other fish. Risks are significant only if birds obtain all food from C-1
	Antimony	OU 5 Old Landfill	Sediments	The screening estimate assumes 100% site use. Actual use is much less because the stream supports a small fish population. Risks were not significant when adjusted for realistic site use factor.
Terrestrial-Feeding Raptors	Chromium	OU 2 903 Pad OU 2 East Trenches	Terrestrial Arthropods	The mean chromium concentration in soil was not greater than background mean. No clear contaminant source exists. Chromium was not a risk to the kestrel population at RFETS.
Small Mammals	Plutonium-239/240 Americium-241 Uranium-233/234 Uranium-238	OU 2 903 Pad OU 2 East Trenches OU 5 Old Landfill	Soil Soil	Radionuclides do not present significant risk to terrestrial receptors. Maximum tissue concentrations do not result in dose rates that exceed TRVs (0.1 rad/day). See text for plutonium and americium conclusions.
Vegetation	Metals	Most Source Areas	Soil, Sediments	Soils of Ash Pits contained several metals with HQs >1. The highest HQ (7.9) was for chromium. Ecological risk to vegetation communities is minimal because each of the Ash Pits involves relatively small areas. Sediments of C-ponds contain mercury at concentrations that exceed TRVs for wetland vegetation. However, growth of vegetation in littoral zone appears normal.

## **7.2 CRA Background, Conceptual Site Model and Data Quality Objectives (DQOs)**

### **Actions:**

Specify information needed on physical setting, develop SCM of ecological receptors and exposure pathways to guide the ERA process, specify risk management goals and assessment endpoints, and develop DQOs to guide the ERA process

### **7.2.1 Environmental Setting**

The description of the environmental setting at RFETS will include the physical characteristics of the Site such as topography, geology, and hydrology, and the types and extent of plant and animal communities present

After accelerated actions have been completed, species diversity, abundance, and habitats may significantly change. Therefore, it will be important to determine the following

- Extent of wetlands habitat onsite,
- Sensitive/protected plant species habitat (i.e., Ute Ladies'-Tresses) onsite,
- PMJM habitat locations onsite,
- Other Protected or Special Status species sightings or habitats on Site (e.g., bald eagles, and peregrine falcons), and
- Vegetation/habitat types to be introduced in the IA

Much of the above information is available from ecological characterization and monitoring activities for the Site. Site physical characteristics are well characterized. Surface water and groundwater flow patterns have been modeled through the Site-wide Water Balance, Actinide Migration Evaluation, and the Land Configuration Design Projects. Results of these studies will be used in conjunction with data on nature and extent of contamination, selected assessment endpoints, and ECOC screening methodologies to complete the Problem Formulation phase of the ERA.

### **7.2.2 Site Conceptual Model**

Development of the SCM is the first step in the problem formulation, or planning phase of ERAs (EPA 1997). The purpose of the SCM is to help identify environmental stressors and the potential pathways by which ecological receptors may be exposed to them. This step allows investigators to identify the potentially complete pathways that will become the focus of the ERA. The SCM also aids in the selection of measurement endpoints for use in evaluation of assessment endpoints (Suter 1993).

An SCM for the Watershed ERAs was described and approved. The SCMTM (DOE 1996c) established the relationships among the key components of the RFETS ecosystem. The following information was included in the SCMTM:

- Description of the environmental setting at RFETS, including the natural physical and biological systems and a brief description of the primary contaminant source areas or IHSSs,
- Description of the important contaminant fate and transport pathways in abiotic media,
- Description of the important exposure pathways, including primary exposure media, exposure points, receptor guilds, and exposure routes,
- Description of receptor guilds and identification of key species in each guild to be used in representative exposure estimates at RFETS,
- Species-specific exposure parameters to be used in estimating exposure to key receptors,
- Measurement endpoints for which data have been collected, and
- Existing environmental data, data sources, and ongoing monitoring programs are also summarized

The SCM has been updated to reflect the most appropriate ecological receptors for the Site as a wild life refuge (Figure 7.2). The purpose of the SCM is to help identify potential pathways by which ecological receptors may be exposed to PCOCs. The identified pathways become the focus of the CRA. The SCM will also be used to identify measurement endpoints for use in evaluation of assessment endpoints (Suter 1993).

Specifically, the CRA will provide the following:

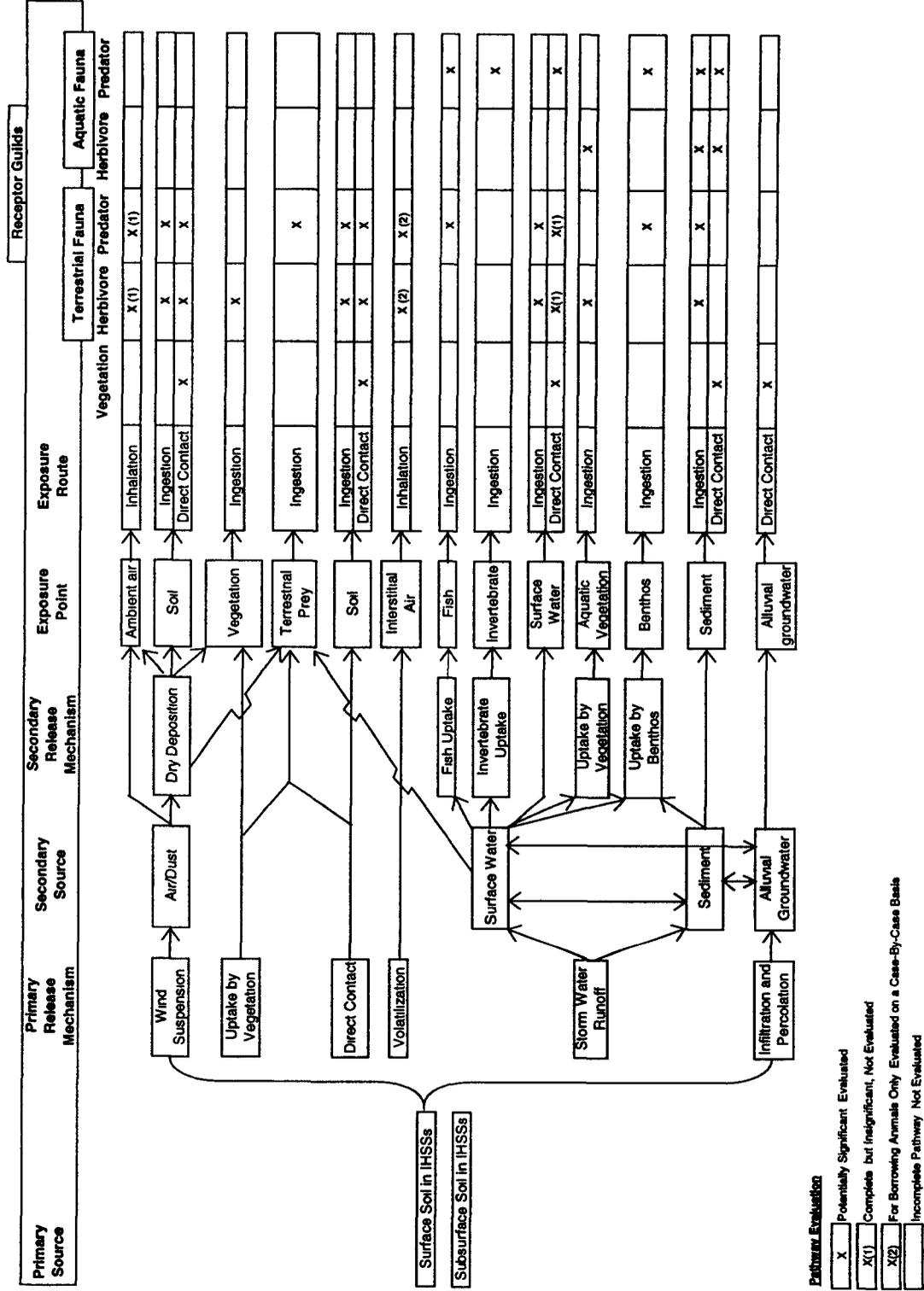
- Description of the important contaminant fate and transport pathways in abiotic media,
- Description of the important exposure pathways, including primary exposure media, exposure points, receptor guilds, and exposure routes,
- Description of receptor guilds and identification of key species in each guild to be used in representative exposure estimates at RFETS,
- Species-specific exposure parameters to be used in estimating exposure to key receptors, and
- Measurement endpoints for which data have been collected

### **7.2.3 Ecological Risk Management Goals and Assessment Endpoints**

In order to focus the ERAs, EPA (1997) recommends identifying overall Site management goals, and assessment endpoints on which the analysis of risk should focus. Assessment endpoints are the explicit description of the ecological values to be protected as a result of management actions at a Site. The overall risk management goal identified for use in developing the CRA is:

- Site conditions after completion of accelerated actions that do not represent significant adverse ecological effects due to exposure to Site-related residual contamination

Figure 7.2 Ecological Site Conceptual Model



Significant adverse ecological effects means toxicity that results in reductions in survivorship or reproductive capability that threatens populations or communities at RFETS. For relatively rare and legally protected species with small populations, such as PMJM, significant adverse effects can occur even if individuals are affected. Therefore, the assessment for PMJM will address the potential for individual mice to be adversely affected by contact with PCOCs. For non-protected species, the assessment will focus population-level effects where some individuals may suffer adverse effects, but the effects are not ecologically significant because the overall Site population is not affected.

For PMJM, the overall risk management goal and assessment endpoint are as follows:

- Goal: Prevent adverse effects on individual PMJM due to lethal, mutagenic, reproductive, systemic, or general toxic effects of contact with PCOCs from the Site.
- Assessment Endpoint: Survival, growth, and reproduction of individual PMJM at the Site.

For non-protected ecological receptors the risk management goal and assessment endpoint are as follows:

- Goal: Prevent adverse effects on populations due to lethal, mutagenic, reproductive, systemic, or general toxic effects of contact with PCOCs from the Site.
- Assessment Endpoint: Survival, growth, and reproduction adequate to sustain populations at the Site.

The non-protected receptors to be included as assessment endpoints for the Site are shown below. The receptors were identified based on ecological functional groups, then representative species identified to focus the analysis.

Functional Group	Representative Species
Burrowing Small Mammal	Black-tailed Prairie Dog
Herbivorous or Omnivorous Small Mammal	Deer Mouse
Insectivorous Small Mammal	Deer Mouse
Herbivorous or Omnivorous Bird	Mourning Dove
Mammalian Predator	Coyote
Avian Predator	American Kestrel

#### 7.2.4 Data Quality Objectives

As with the HHRA process, the approach to the ERA is presented in the format of DQOs. This process can be viewed as parallel to the PPRG process as described in EPA guidance (1997).

**Step 1: State the Problem**

Potentially toxic substances have been released at the Site. Ecological receptors could be exposed to the substances. To date, ecotoxicological risks have been characterized only for portions of the BZ in the Woman Creek and Walnut Creek watersheds. Results of the Watershed ERAs (DOE 1995b) indicate minimal or negligible risks for most of the area evaluated (Section 7.2). Some minimal risks to individual organisms were identified for PCB exposures in pond sediments, and some potential hot spots of soil contamination. The analyses suggest little or no risk to populations of receptors in the area.

The problem to be addressed by the ERA is

*“Site ecological conditions following accelerated actions are intended to comply with RFCA Intermediate Site Condition, and no further actions are anticipated to satisfy RCRA/CHWA and CERCLA requirements pursuant to any final CAD/ROD.”*

**Step 2: Identify the Decision**

The CRA is will characterize what is known about the exposures, and whether they have resulted, or could result in significant adverse effects to ecological receptors. The overall Site management question to be addressed by the CRA is

*“Are residual long-term ecological risks from Site-specific contaminants acceptable for the long-term Site use and management goals?”*

In order to address this general decision, additional decisions to be addressed include

- Have the nature and extent of contaminants within IHSSs, PACs, and UBC sites been identified with adequate confidence, based on Site history (process knowledge) and analytical data?
- Is further risk characterization necessary to make remedial decisions at the Site?

**Step 3: Identify the Inputs to the Decision**

The information needed to resolve the CRA decision statements is listed below

- Data and results from the previous ERAs conducted at RFETS,
- Ecological data that have become available since the completion of the previous ERAs (e.g., the Integrated Ecological Monitoring program), and
- Existing data for areas under consideration,
- A DQA screen will be applied for each type of environmental medium as prescribed in this CRA Methodology. This will ensure the reliability of the data used in the risk assessment, and
- The data for abiotic environmental media passing the DQA will be screened against ecotoxicologically based screening levels

**Step 4: Define the Study Boundaries**

Study boundaries are used to determine the areas from which data will be used, and identify where future sampling will occur. These study boundaries are listed below

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- Only data from characterization and remediation activities will be used. In no event will the assessment area extend beyond the current RFETS boundary.
- The ERA portion of the CRA will consider ECOCs in surface water. As indicated in Section 4.5, modeling the transport of groundwater to surface water may be conducted if ECOC concentrations in groundwater exceed PRGs for aquatic life. The contaminant load to surface water includes COC transport from surface soil, unsaturated and saturated zone soil, and sediments.
- Soil will be assessed generally from the land surface to a maximum of 6 feet below ground surface. This depth was identified to protect burrowing mammals, and was used in developing PRGs.

### **Step 5: Develop a Decision Rule**

In addition to the decision rules cited for data adequacy in Section 3, decision rules that describe how the data will be evaluated for the ERA are listed below.

- If maximum concentrations Sitewide are greater than the NOAEL, then further evaluation is needed,
- If the maximum is greater than the NOAEL and located in PMJM habitat, then the analyte is a PMJM ECOC (Figure 7.3)
- If the maximum is greater than the NOAEL, the detection frequency is greater than 5 percent or the analyte presents a specific risk, it is above background (inorganics and radionuclides), and the 95 UCL is greater than the LOAEL or the maximum is three times the LOAEL the analyte is a non-PMJM habitat ECOC (Figure 7.3)
- Non-PMJM Habitat (Figure 7.4) if the ECOC in non-PMJM habitat has a detection frequency greater than five percent or the ECOC presents a specific risk, and the 95UCL exceeds the LOAEL-PRG or the maximum in the patch is three times the LOAEL-PRG, then, locations will be mapped and risks assessed
- PMJM Habitat (Figure 7.5) if the ECOC in a particular habitat patch has a detection frequency greater than five percent and the 95UCL exceeds the NOAEL-PRG, or detection frequency less than five percent and the maximum in the patch is three times the NOAEL or the ECOC presents a specific risk, then, data will be aggregated, 95UCLs calculated, Thiessen polygon mapping will be done, and risks assessed

Decision rules for accelerated actions follow

#### **Non-PMJM Habitat (Figure B.1)**

- If the non-PMJM ECOC 95UCL for the area is greater than the LOAEL PRG and the frequency of detection is greater than five percent or the ECOC presents a specific risk, evaluate using best professional judgement and consult with agencies to determine if removal is needed
- If the maximum ECOC value is greater than three times the LOAEL PRG, then evaluate using best professional judgement, consult with agencies, and remediate the area if necessary

PMJM Habitat (Figure B 2)

- If an AOC is in PMJM habitat and the maximum concentration of a PMJM ECOC is greater than the NOAEL PRG, then evaluate using best professional judgement and consult with agencies to determine if removal is needed
- If the maximum is greater than three times the NOAEL PRG, then evaluate using best professional judgement, consult with agencies, and remediate the area if necessary

**Step 6: Specify Tolerable Limits on Decision Errors**

Several sources potentially contribute uncertainty to the CRA. As indicated in the CRA process described in later sections, best professional judgment and input from the regulatory agencies is needed for decisions regarding data gaps and risk management actions. Exposure point concentrations for non-protected species are often represented by the 95UCL limit of the mean for a data population. As a screening step for non-protected species, this metric is compared to a specific PRGs. Although not a formal hypothesis test, the implied Type 1 error rate (i.e., alpha) for this comparison is 5%, since use of the 95UCL implies that the mean exposure is not expected to exceed the metric with more than 5% frequency.

**Step 7: Optimize the Design**

The nature and extent of COCs in IHSSs, PACs, and UBC sites will be assessed to support the CRA. The nature and extent of COCs in the IA and BZ will be determined according to the IA and BZ SAPs (DOE 2001b, 2002b).

**7.2.5 Data Types and Adequacy**

The SCM suggests that ecological receptors may be exposed to PCOCs in abiotic and biological media. Site data on PCOC concentrations in soil, surface water, and sediment will be evaluated to support the CRA. The inhalation exposure route will be considered insignificant compared to ingestion pathways for terrestrial wildlife (EPA, 2000a). Biological tissue analysis results will not be used in the initial phase of the IA and CRA assessments. However, potential uptake of PCOCs into prey and forage species will be considered in development of the screening levels.

Additional soil sampling will be conducted in accelerated action areas to support the remediation and risk assessments. PCOC concentrations in soil and sediment will be expressed as "total recoverable" (e.g., sample prepared for analysis by EPA Method 3050 or equivalent). PCOC concentrations in surface water that are to be compared to water quality standards for protection of aquatic life should be expressed as "dissolved" (i.e., filtered with a 0.45 µm filter prior to analysis). This is because water quality standards are based on the dissolved fraction. Surface water data used to assess risks to wildlife drinking the surface water will be based on "total recoverable" (i.e., unfiltered) analyses.

The IA and BZ SAPs (DOE 2001b, 2002b) identify laboratory analytical methods to provide data with adequately low method detection limits (MDLs), and practical quantitation limits (PQLs) to allow meaningful comparison to ecological screening levels in abiotic media.

In addition to the comparison of screening levels directly to analytical data, potential future exposures may be estimated by modeling contaminant fate and transport. In particular,

models may be used to estimate PCOC concentration in storm water runoff from potentially contaminated soils and groundwater that may surface at seeps downgradient of the IA. Both sources of water could contact aquatic biota or wildlife.

Adhering to the specifications of the DQOs as outlined above will ensure the adequacy of data for use in the ERA. In addition, the DQA will help ensure that the quality of data is consistent with RFETS standards.

### **7.2.6 PRG Development**

The Watershed ERA estimated exposure of wildlife receptors to PCOCs by estimating intake of the chemicals in abiotic media (soils, sediment, water), as well as forage, and prey. The biota data were collected specifically for conducting the ERA during implementation of the RFI/RIs. As noted earlier, data on biota are not available from all parts of the Site, especially from the IA. RFCA (DOE et al. 1996) identifies an 'extension' of the ERA methodology from the buffer zone to the IA. However, the same methodology is not appropriate for the IA because

1. Data on COC concentrations in biota are lacking for the IA. Therefore, direct assessment of the intake of COCs through ingestion of forage and prey is not currently possible.
2. The area within the IA is mostly developed for industrial uses including extensive parking lots, roadways, and buildings. Because these structures will be removed, any biota data collected from the area would not be representative of conditions following completion of accelerated actions.

DOE proposed the development of PRGs for assessing ecological risk similar to those currently included in RFCA for assessing human health. The PRGs are expressed as PCOC concentrations in abiotic media that can be compared directly to data from the locations of interest at RFETS. The PRGs will be developed for various types of receptors (omnivorous mammals, birds, etc.) and will represent ecotoxicologically 'safe' exposures for each of the PCOCs to each receptor group. This approach is similar to development of PRGs for HHRA (EPA 1991), and allows streamlined evaluation of environmental data for possible risk of toxic exposures. However, the approach requires application of assumptions about PCOC concentrations in biota, increasing uncertainties about the risk conclusions. Conservative assumptions were used to avoid underestimating risk. PRGs are being developed for soil, sediment, and surface water. Ecotoxicological information is not available for all PCOCs in RFCA Appendix N, Table 3, and information gaps in the PRGs is expected. DOE and regulatory agencies will review the list of PCOCs without PRGs and determine whether more extensive effort is necessary to develop benchmarks.

#### Soil

EPA's Eco Soil Screening Levels (EcoSSLs) (EPA 2000a) process was used as a general guidance for developing the PRGs. Acquisition of primary literature, followed by extensive review and scoring of the documents was not done. Instead, extensive use was made of existing databases and compilations of ecotoxicity information, especially those from other DOE facilities such as ORNL and Los Alamos National Laboratories.

The EcoSSL document provided general equations and procedures for developing PRGs from toxicological research, receptor-specific exposure parameters (e.g., food ingestion rate, diet, etc), and bioaccumulation factors (BAFs) that describe uptake of PCOCs from soils into forage or prey species. The EcoSSL document lists the following steps:

- 1 **Identify the Wildlife Risk Model:** Develop a SCM with receptors, exposure pathways, and exposure scenarios. Quantify an equation that relates the contaminant concentration in soil to an acceptable threshold based on an exposure model. Selected equation(s) should reflect general features of conceptual exposure models.
- 2 **Select Surrogate Wildlife Species:** Identify species that are representative of the functional groups for which risk is to be evaluated. Data for representative species will then be used for parameterizing the exposure model.
- 3 **Estimate Exposure Dose:** Determine exposure parameters and quantify dose for each selected contaminant.
- 4 **Derive the Toxicity Reference Values (TRVs):** Identification of an acceptable dose or exposure.
- 5 **Calculate the Eco-SSL:** Calculation of the Eco-SSLs by solving the exposure equation for PCOC concentrations in soil that result in exposure equal to the TRV.

Both NOAEL and LOAEL-based PRGs will be developed utilizing the above outlined process for small mammals, ground-feeding birds, terrestrial invertebrates, and avian predators. The complete PRG development process is included as Appendix A. PRGs will be developed for a list of Sitewide PCOCs that will be identified based on existing information and soil data from the Site as is outlined in the following sections:

### *Sediments*

For sediments, Sediment Quality Values (SQVs) have been developed for many chemicals are available from several sources. SQVs are generally expressed as concentration terms and, therefore, require no calculations or assumptions. However, the assumptions underlying the development of SQVs will be evaluated to determine consistency with uses at RFETS.

### *Surface Water*

For surface water, ecotoxicologically based water quality criteria are available from several sources. Only criteria appropriate for selected on-Site receptors will be used. PRGs will be taken from State of Colorado water quality standards, federal Ambient Water Quality Criteria, and other data bases such as that from Oak Ridge National Laboratories.

### *Radionuclides*

Soil benchmarks for radionuclides were developed for RFETS during the Watershed ERAs (Higley and Kuperman 1994). Since then, DOE's Biological Dose Assessment Committee has developed additional procedures for assessing exposure and risk to terrestrial and aquatic biota (DOE 2002a). These additional processes will be used to verify protectiveness of the earlier soil benchmarks, and to evaluate protectiveness of available surface water criteria.

### 7.3 Sitewide ECOC Identification Process

**Actions:** Identify ECOCs for the ERA and for support of accelerated actions

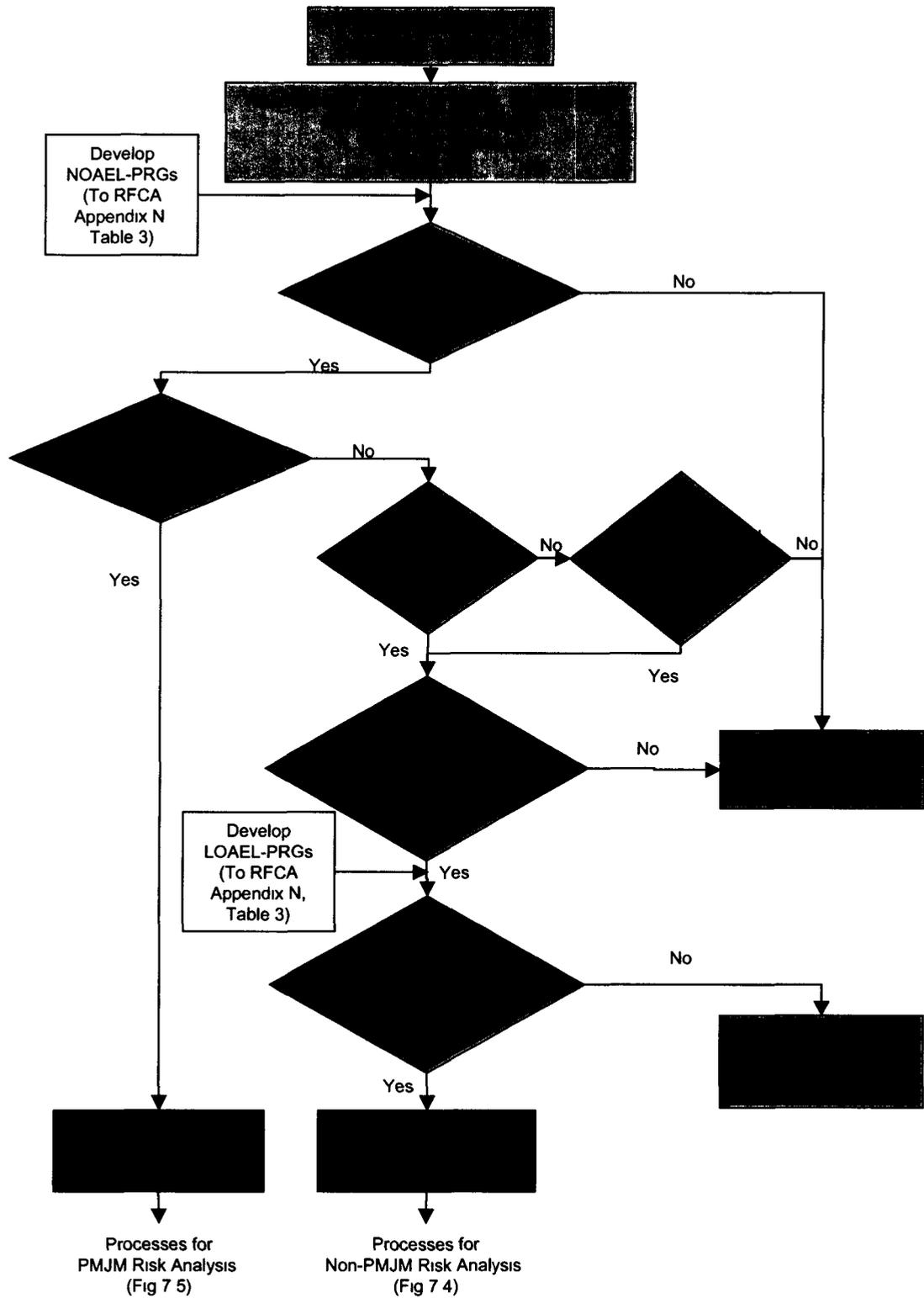
A comprehensive list of Sitewide ECOCs will be developed as part of the CRA based on data representing conditions after accelerated actions have been completed in the IA and BZ PCOCs identified in RFCA (RFCA Appendix N, Table 3 (DOE et al 1996) will form the starting point for the ECOC identification process shown in Figure 7 3

The entire database will be queried, filtered by media and subjected to a DQA screen to identify which data meet the needs of the DQOs discussed in the previous section Data from the DQA screen will be used in both the human health and ecological risk assessments Following the DQA screen, "U" qualified nondetects will have one-half the reported result concentration substituted, basic descriptive statistics will then be calculated, such as number of samples, percent detections, maximum detections, mean detection, standard deviation, variance, etc

Soils data will be compared to NOAEL-based PRGs (Appendix A) If the maximum detected concentration of the PCOC does not exceed the NOAEL-based PRG, the PCOC will be dropped from further analysis in the CRA and the rationale for removing it from further analysis will be recorded and presented in the CRA screening-level risk analysis If the maximum detected PCOC concentration exceeds the NOAEL-based PRG, it will be retained as a PCOC for further evaluation of risks to PMJM (see Figure 7 4), and will be included in PCOCs for further screening for non-protected species

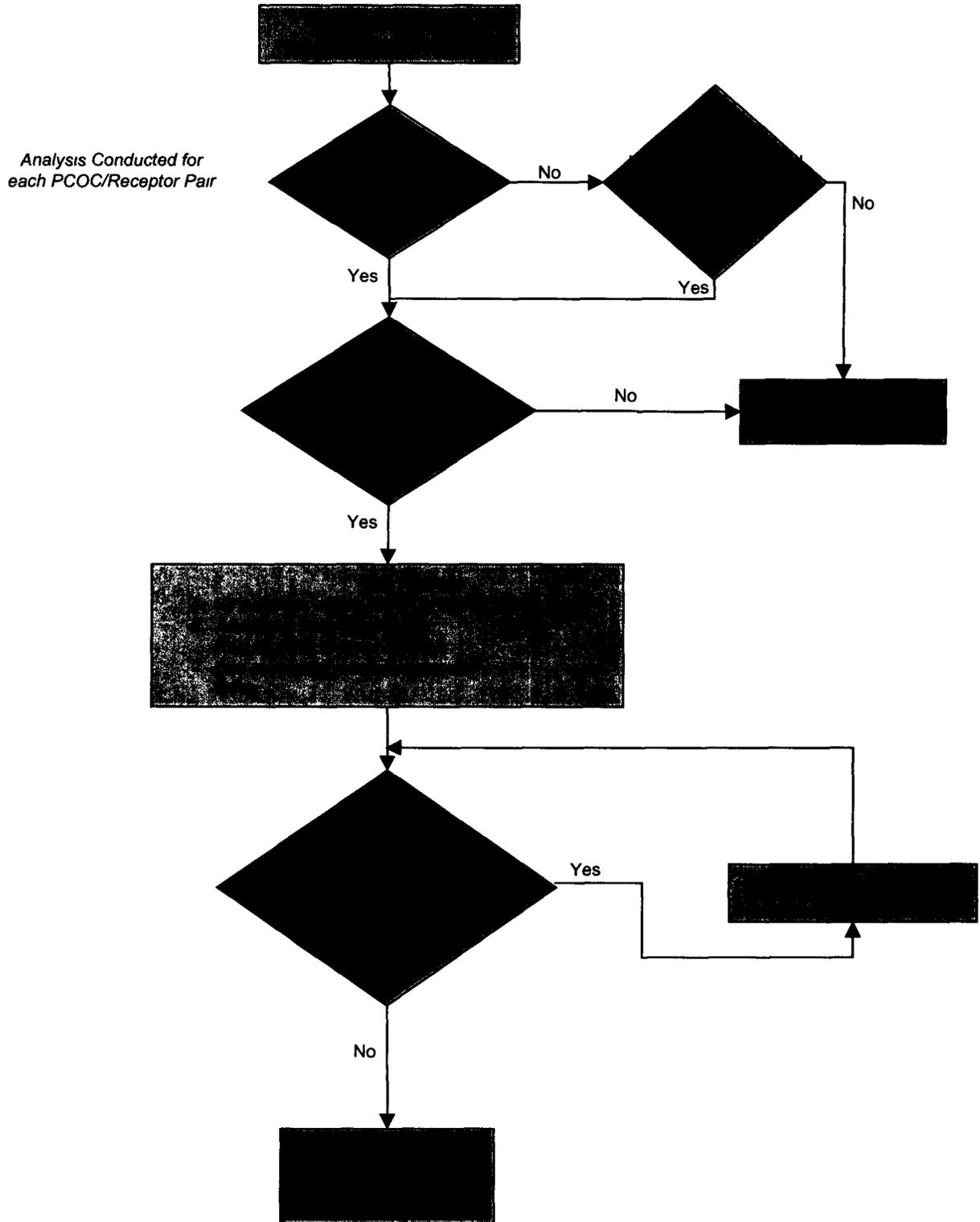
PCOCs that have detected concentrations greater than the NOAEL-based PRG in areas that are potential current or future habitat for the PMJM will be carried forward as protected species ECOCs For those PCOCs that have detected concentrations greater than the NOAEL-based PRG in areas that are not identified as potential current or future habitat for the PMJM, further analyses will be conducted to determine their status as ECOCs

Figure 7.3 Sitewide ECOC Screening Process



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Figure 7.4. Risk Analysis Process for Non-PMJM Habitat



If the PCOC was detected in less than 5% of the samples, the PCOC will be evaluated using best professional judgment as to its potential to cause risk to wildlife receptors at the Site. This decision, or Scientific Management Decision Point (SMDP), will be made in cooperation with regulatory agency personnel. The determination will consider process knowledge, spatial and temporal factors, as well as the physical and chemical properties of the PCOC as they pertain to the potential for risk to the wildlife receptors at the Site. If it is determined that no potential risk is expected, the PCOC will be dropped from further analysis and the rationale for the decision will be documented in the CRA. The radionuclide and metal PCOCs passing the 5% screen will then be statistically compared to background concentrations, as appropriate, using the methods discussed in Section 4.4.8.

For those PCOCs that remain, LOAEL-based PRGs calculated using the procedures identified in Section 7.2 and Appendix A will be compared with the Sitewide 95UCL concentrations. As an additional screening step, the Sitewide maximum detected concentrations of each remaining PCOC will be compared to three times the LOAEL-based PRGs. Any PCOC with a 95UCL concentration below the PRG or a maximum concentration below three times the PRG will be dropped from further analysis in the CRA for non-PMJM habitat. Otherwise, the PCOC will be carried forward as a Sitewide ECOC in the non-PMJM risk analysis in the CRA (Figure 7.4).

The output from the Sitewide ECOC screen will be a list of ECOCs for analysis of PMJM habitat and list of ECOCs for non-protected species at the Site. The ECOCs identified in these lists will be carried on to the risk analysis processes described in the following section.

#### **7.4 Risk Analysis Process**

**Actions:** Assess risks to receptors in areas defined as non-PMJM habitat and for the PMJM in its habitat areas

The following sections describe the process for conducting the risk analysis in the CRA for the Site. Two separate analyses will be used in the CRA depending on the status of the habitat designation. The risk analysis process for those areas defined as non-PMJM habitat is presented in Section 7.4.1 while the risk analysis process for the PMJM habitat area is presented in Section 7.4.2.

##### **7.4.1 Risk Analysis Process for Non-PMJM Habitat**

Risk analysis will be conducted in the CRA, following the procedures shown in Figure 7.4, for those ECOC identified in the screening process described in Section 7.3 for non-PMJM habitat areas.

The analyses described in this section apply to all non-protected species. The analysis will be conducted separately for each receptor, based on data on ECOC concentrations in abiotic media from habitats appropriate for each receptor. Data will be aggregated from Sitewide samples and appropriate 95UCL calculated. In addition, summary statistics will be calculated including percent detections, mean, standard deviation, variance, and 95UCL. For

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those ECOCs detected in greater than 5 percent of sample locations, further risk analysis for non-PMJM receptors will be conducted in the CRA. The ECOCs that are detected in less than 5 percent of samples will be evaluated based on process knowledge, spatial and temporal factors, chemical properties (i.e. does the ECOC bioaccumulate in food webs), and toxicological properties using a best professional judgment approach for their potential to cause risk to wildlife receptors. If it is determined that no potential for risk exists, the ECOC will be recommended for no further ecological risk analysis in the CRA and the rationale for the recommendation will be provided.

For those ECOCs that are not eliminated based on frequency of detection, or retained based on a professional judgment decision, the 95UCL will be compared to the LOAEL-based PRG and maximum to three times the PRG for each relevant abiotic medium. This comparison will be conducted for each of the ROCs. As noted in the DQO analysis, data will be aggregated from habitats that are appropriate for each receptor. If either the 95UCL or maximum concentration exceed the comparison value, the ECOC will be further evaluated using additional lines of evidence, and subjected to a data gaps analysis. Those ECOCs for which neither the 95UCL or the maximum exceeds the comparison value will be dropped from further risk analysis. The rationale for the decision to drop an ECOC will be presented in the CRA.

The ECOCs that are carried forward will be mapped using GIS to show the locations where concentrations of the ECOC exceed the LOAEL-based PRG. Alternative lines of evidence such as site ecological monitoring studies, or other applicable sources will be evaluated to determine if other data suggest risk.

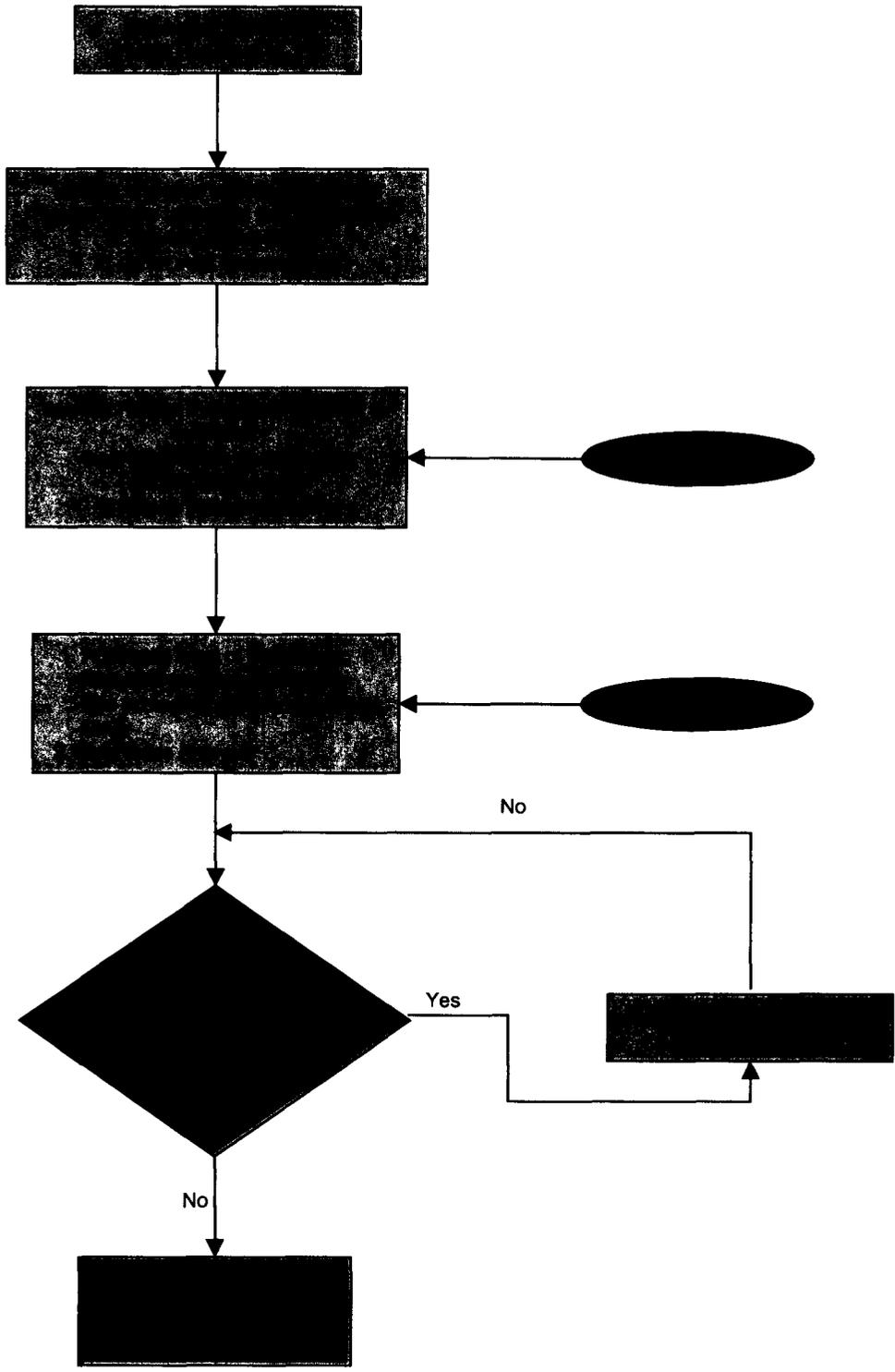
An analysis of potential data gaps will be conducted for ECOCs that represent significant risk. If additional data are deemed to be necessary to reduce the uncertainty in the risk analysis to an acceptable level, steps will be taken to identify the types of data that may be necessary and plans to collect the additional data will be made.

Each ECOC evaluated in the risk analysis for non-PMJM habitat will be subjected to a best professional judgment evaluation taking in to account process knowledge, spatial and temporal patterns of contamination and other factors for incorporation into the risk characterization portion of the CRA. A detailed evaluation of the uncertainties involved in the risk analysis will also be included in the CRA.

#### **7.4.2 Risk Analysis Process for PMJM Habitat**

ECOCs identified in PMJM habitat will be subjected to a more conservative risk analysis process than those identified in the non-PMJM habitats due to the regulatory status of the PMJM. Section 7.3 discussed the process to be used to determine the list of ECOCs to be discussed in the risk analysis for the PMJM habitat. The process to be used for the risk analysis process for PMJM habitat is shown in Figure 7.5.

Figure 7.5  
CRA Risk Analysis Process for PMJM Habitat



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For each ECOC identified for risk analysis in the PMJM habitats, maps will be prepared using a GIS system in order to identify the sampling locations in PMJM habitat which ECOC concentrations exceed either the NOAEL-based PRGs or 3 times the NOAEL-based PRGs

These maps will be prepared for review by the appropriate regulatory agencies for input on further risk analysis activities. The major goal of the first agency input step is to identify patches of habitat, which can be used to aggregate data into groupings that could reasonably be expected to represent home ranges of individual PMJM. Aggregated data will be used to calculate upper bound exposure concentrations (95UCL) and to aid in the presentation of the data on maps using the GIS and Thiessen polygon mapping techniques to visualize the areas of potential risk to the PMJM.

Based on regulatory agency input and best professional judgment, decisions regarding the acceptability risk levels for the PMJM will be made. A binary decision point of acceptable or unacceptable levels of risk will be the outcome of the risk analysis process for the PMJM habitat. Additional data may also be collected if data gaps are evident. A detailed evaluation of potential data gaps will be provided prior to the determination of the potential for risk. The results of this decision point and the uncertainties associated with the potential risk to the PMJM will be discussed in detail in the CRA.

#### **7.4.3 Exposure Units**

The habitats and areas over which data will be aggregated will be appropriate for each receptor type. For all receptors except PMJM, the residual risk analysis will be based on Site-wide risks. For each receptor, data from applicable abiotic media will be aggregated from habitats appropriate for the receptor. The 95UCL of these aggregated data will be compared to LOAEL-based PRGs for the initial risk characterization.

For PMJM, no prescribed exposure unit will be identified. As indicated above, sampling locations with ECOC concentrations that exceed PRGs will be identified and mapped for locations in PMJM habitat (Figure 7.6). This information will be presented to the Agencies for consultation to help determine whether removal actions are appropriate. Removal actions may not be appropriate in areas with minor risks, but good habitat. Destruction of habitat in such areas may have a detrimental effect on the species.

Habitats to be included in exposure analyses will be identified for each species based on discussions with biologists from the Agencies. For wildlife, vegetation community is often one of the best indicators of habitat. Extensive information is available on the types and locations of vegetation communities at RFETS (Figure 7.7). Once appropriate habitats are identified for each receptor, abiotic sampling locations in these habitats will be identified and data from the locations aggregated for comparison to PRGs.

## **7.5 Integration of the Accelerated Action and Sitewide Risk Analysis Results**

**Actions:** Provide the risk managers with a detailed analysis of the sitewide risk assessment results and residual risk following the accelerated actions

As described earlier, accelerated action analyses will be conducted for much of the IA and some areas in the BZ. As a result of the accelerated action process, all of the IA will meet criteria for acceptable risk, either because sampling from specific areas in the IA indicated no action (i.e., removal was not necessary to protect ecological receptors, or because removal actions resulted in acceptable risk levels. Those areas that have been identified as areas requiring removal to attenuate risk will be re-sampled following remediation and determinations of their future potential for ecological risk will be made based in part on the planned habitat in each area.

Following agency concurrence on the completion of accelerated actions, data will be included in the CRA risk analysis process described above, and the CRA report will be prepared which integrates the results of both analyses into a presentation of the Sitewide ecological risk. The CRA will, therefore, provide the risk managers with a detailed discussion of the risk analysis process in both the IA and BZ and will provide a description of the Sitewide residual risk following the completion of all accelerated actions.

## **8.0 COMPREHENSIVE RISK ASSESSMENT REPORT ORGANIZATION**

The CRA report will be written in two volumes for RFETS the Sitewide RI/FS and will support the RI/FS, Proposed Plan (PP), and Corrective Action Decision/Record of Decision (CAD/ROD) for the Site. Summaries of the HHRA and ERA will be included in the RI/FS text. The full assessments with supporting documentation will be attached as appendices. The HHRA will contain the following sections:

Executive Summary,

Section 1.0 Introduction,

Section 2.0 Site Description,

Section 3.0 Data Quality Assessment and Adequacy,

Section 4.0 COC Identification,

Section 5.0 Exposure Assessment,

Section 6.0 Toxicity Assessment,

Section 7.0 Risk Characterization and Uncertainty Analysis,

Section 8 0 Summary,

Section 9 0 References

The ERA will contain the following sections

Section 1 0 Introduction/Problem Statement,

Section 2 0 Conceptual Model and Assessment Endpoints,

Section 3 0 Data Quality Assessment and Adequacy,

Section 4 0 Risk Characterization and Analysis by Receptor Group,

Section 7 0 Uncertainty Analysis,

Section 8 0 Summary,

Section 9 0 References

Appendices for reports will be combined to reduce redundancy and will include the following

Data Summary - This appendix will present data used in both the HHRA and ERA reports

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**APPENDIX A  
ECOLOGICAL SOIL PRG CALCULATION PROCESS**

This appendix is still in preparation

**APPENDIX B  
ACCELERATED ACTION RISK ANALYSIS PROCESS**

RFETS is undergoing an accelerated action process in which risk screens and remediation, when necessary, are applied to AOCs. The confirmation sampling results from the accelerated actions will be used to predict future ecological risks based on the proposed future land configuration. The ecological risk screen for accelerated actions and ecological risk analysis for the CRA process are separated into two distinct methodologies based on the future presence or absence of PMJM habitat in the areas being subjected to the accelerated action process. The two differing risk analysis methodologies for accelerated action screening are discussed in the following sections.

#### **Accelerated Action Screen for Non-PMJM habitat**

Figure B 1 shows the ecological risk screening process for accelerated actions in areas of the Site that are not PMJM habitat and are not planned to become PMJM habitat following the completion of all accelerated actions. The Sitewide ECOCs identified earlier in the CRA risk analysis process (Figure 7 3) will be filtered by location using GIS. Basic Sitewide descriptive statistics will be calculated including detection percentage, mean, maximum, standard deviation, and 95UCL.

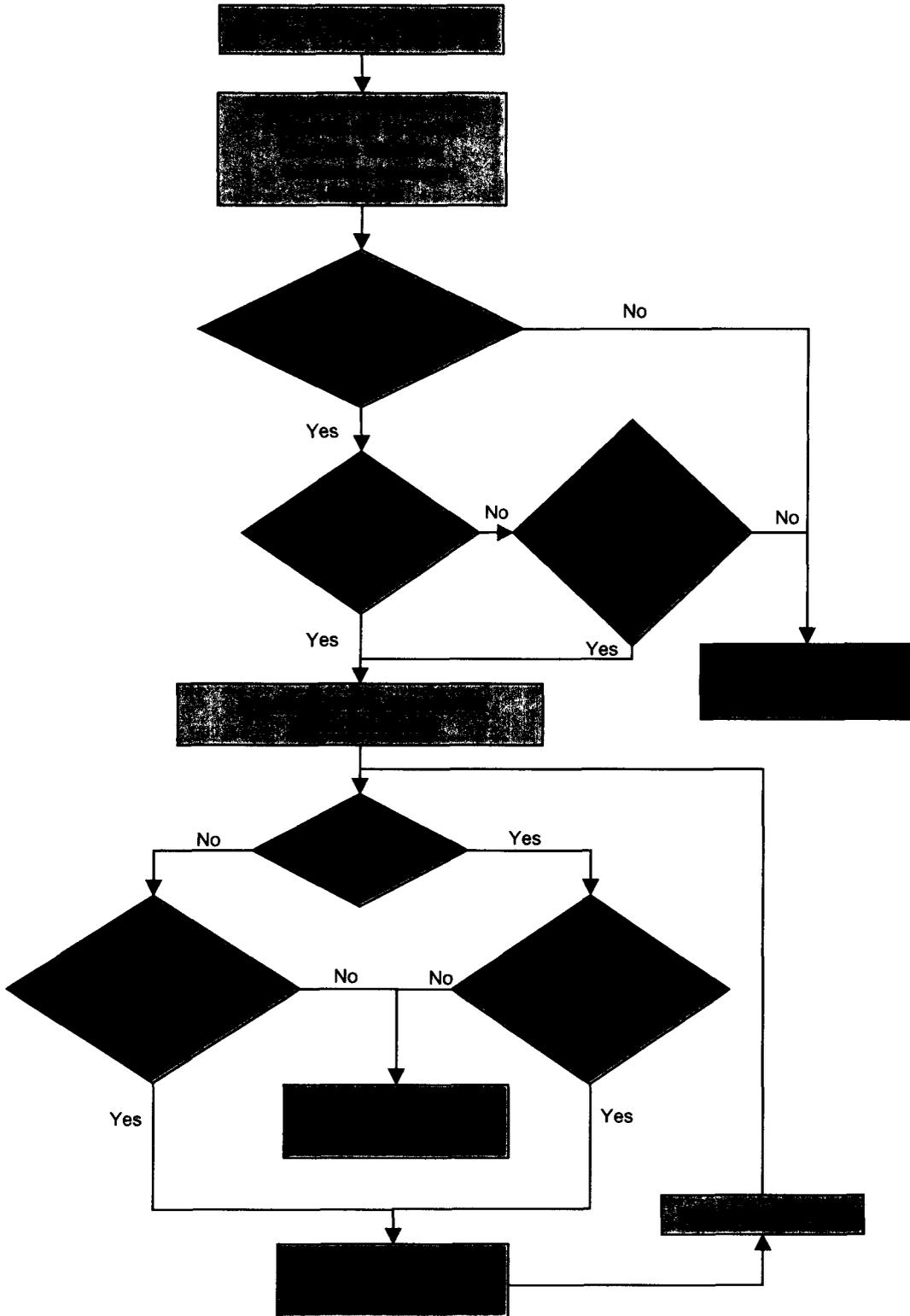
Areas in non-PMJM habitat with concentrations of ECOCs above the LOAEL-PRGs will be designated as ecological non-PMJM AOCs. The data for the AOC will be aggregated and the 95UCLs will be calculated for ECOCs. The 95UCLs will be compared to LOAEL-PRGs. The most conservative small-mammal, soil-based LOAEL-PRG for the habitat in the AOC will be used. ECOCs that have 95UCL concentrations that are less than the LOAEL-PRG will be dropped from further risk analysis and the rationale for their removal discussed. The remaining ECOCs will be evaluated based on frequency of detection. Any ECOC detected in less than 5 percent of the applicable samples will be subjected to a best professional judgment evaluation based on process knowledge, spatial and temporal distributions of the detections as well as the physical and chemical properties of the ECOC. If it is determined that the ECOC is likely to cause no potential for ecological risk, the ECOC will be dropped from further analysis and the rationale for the decision will be documented.

The remaining non-PMJM ECOCs will be divided in to two groups

- 1 Those with 95UCLs above the LOAEL-PRG and maximums below 3 times the LOAEL-PRG, and
- 2 Those with maximums greater than 3 times the LOAEL-PRG

Each group will then undergo professional judgment evaluations. The ECOCs with 95UCLs below three times the LOAEL-PRGs will be evaluated for factors that indicate risks may be more significant than indicated, such as a tendency for bioaccumulation or special distribution. The ECOCs that have maximum values greater than 3 times the LOAEL-PRG will be evaluated for factors that indicate risk may be less significant than indicated, such as lack of bioaccumulation, mode of action, and restricted distribution. Results of the evaluation will be discussed with the agencies. Remediation in the AOC will be undertaken if there is agreement that the ECOCs present significant ecological risk.

**Figure B.1 Accelerated Action Risk Analysis for Non-PMJM Habitat**



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Following remediation, summary statistics for the ECOCs in the AOC will be recalculated using post-removal confirmation data. The 95UCL of the confirmation data will once again be compared to the LOAEL-PRGs. The level of risk following remediation will be considered acceptable if the 95UCL does not exceed the LOAEL-PRG. If any ECOC has a 95UCL greater than the LOEAL-PRG, then the professional judgment and agency consultation step will be repeated to decide if risks are acceptable. The data from all accelerated action areas will be included in the Sitewide CRA analyses described in Section 7.

#### **Accelerated Action Screen for PMJM Habitat**

Prior to analyses, a base map will be submitted to the agencies depicting areas of the Site expected to be PMJM habitat. The expectations will be based on the planned final configuration of the Site, and criteria for defining PMJM habitat. Currently, RFETS site definitions for identifying PMJM habitat are being used because USFWS proposed critical PMJM habitat have not been finalized.

A more sensitive risk analysis process will be performed for the identified PMJM habitat areas. Maximum concentrations will be compared to NOAEL-PRGs. Figure B 2 shows this process.

The Sitewide ECOCs for PMJM habitat will be evaluated in this accelerated action screen. Sampling locations within the current or proposed PMJM habitat areas will be identified. ECOC concentrations at these sampling locations will be compared to the NOAEL-PRGs (Sections 7.2.5). If the maximum concentration is below the NOAEL-PRG, risks will be considered acceptable. Locations with concentrations above the NOAEL-PRG will be mapped and AOCs determined.

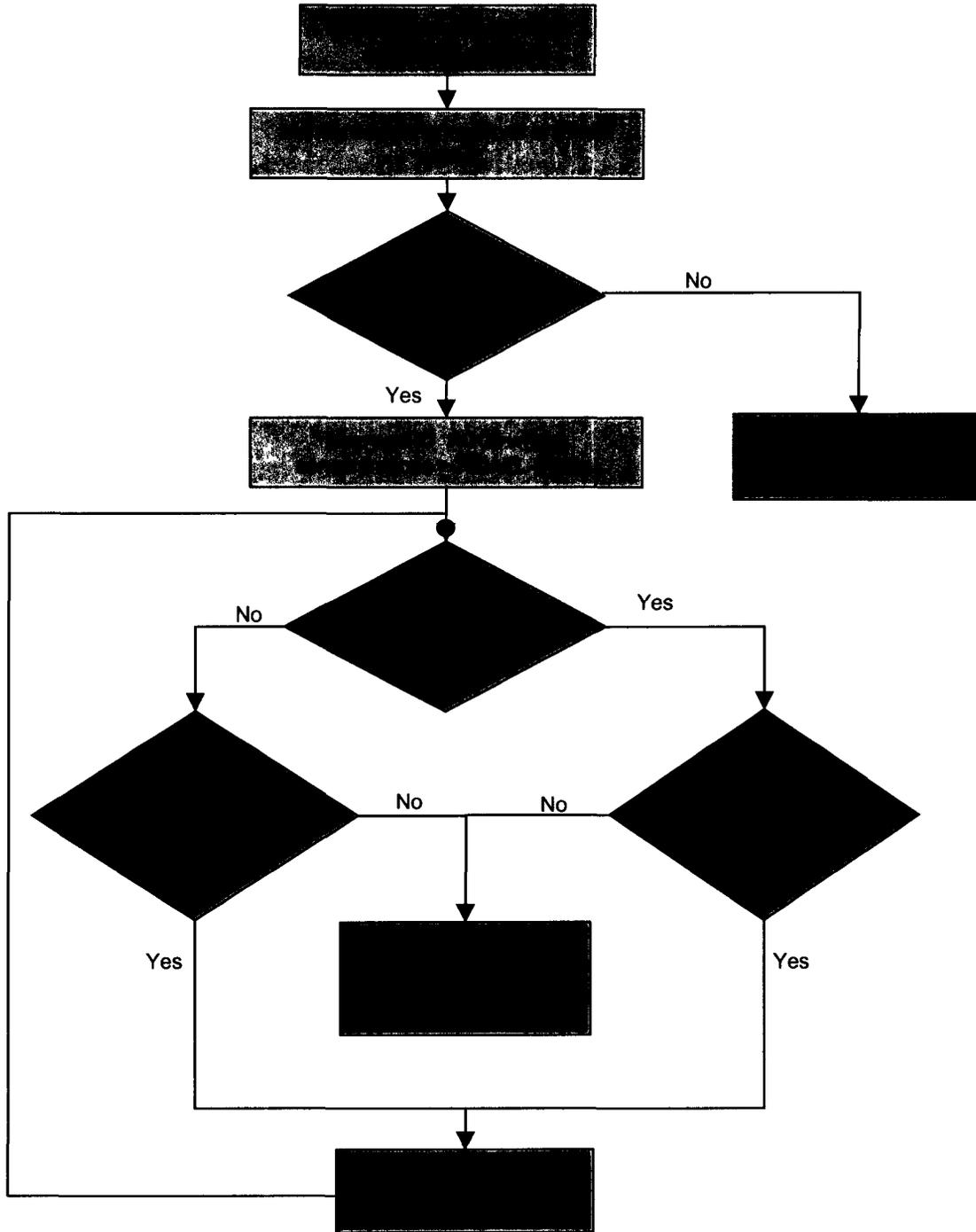
The remaining PMJM ECOCs will be divided into two groups:

- 1 Those with maximums above the NOAEL-PRG and below 3 times the NOAEL-PRG, and
- 2 Those with maximums greater than 3 times the NOAEL-PRG

Each group will then undergo professional judgment evaluations. The ECOCs with maximums below three times the NOAEL-PRGs will be evaluated for factors that indicate risks may be more significant than indicated, such as a tendency for bioaccumulation or special distribution. The ECOCs that have maximums greater than 3 times the NOAEL-PRG will be evaluated for factors that indicate risk may be less significant than indicated, such as lack of bioaccumulation, mode of action, and restricted distribution. Results of the evaluation will be discussed with the agencies. Remediation in the AOC will be undertaken if there is agreement that the ECOCs present significant ecological risk.

Following remediation, maximum values from the confirmation sampling data for the ECOCs in the AOC will be reevaluated. The maximums will once again be compared to the NOAEL-PRGs. The level of risk following remediation will be considered acceptable if the maximum value does not exceed the NOAEL-PRG. If any ECOC has a maximum value greater than the NOEAL-PRG, then the professional judgment and agency consultation step will be repeated to decide if risks are acceptable. The data from all accelerated action areas will be included in the Sitewide CRA analyses described in Section 7.

Figure B.2 Accelerated Action Risk Analysis Process for PMJM Habitat



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Figure 4.2  
Exposure Units  
with IHSSs

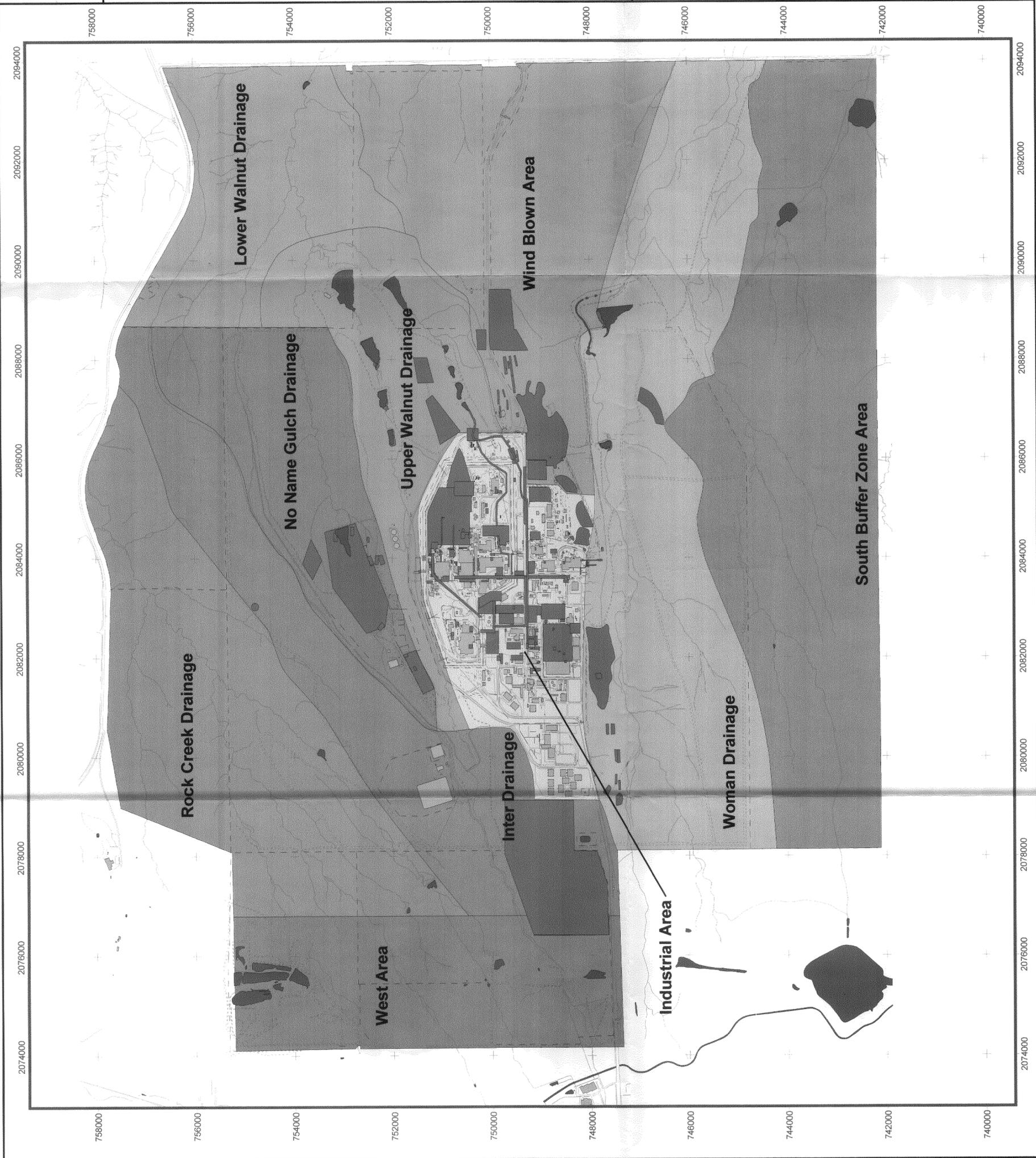
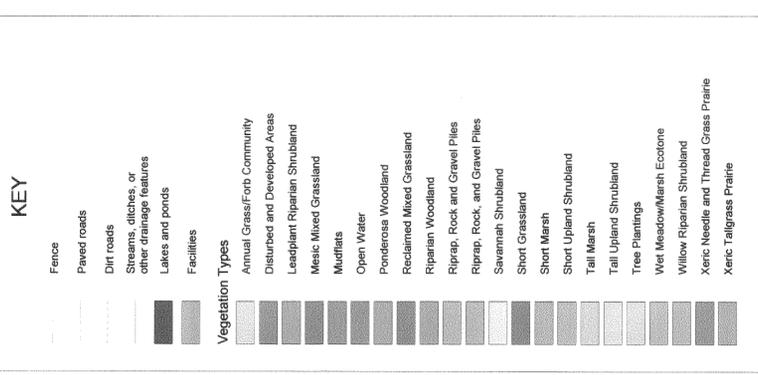
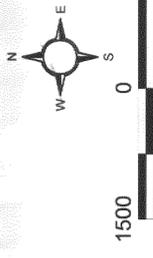


Figure 7.7  
RFETS Vegetation Map



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State Plane Coordinate Projection  
Colorado Central Zone  
Datum: NAD 27

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



Prepared by: RADMS  
Prepared for: KAISER-HILL COMPANY  
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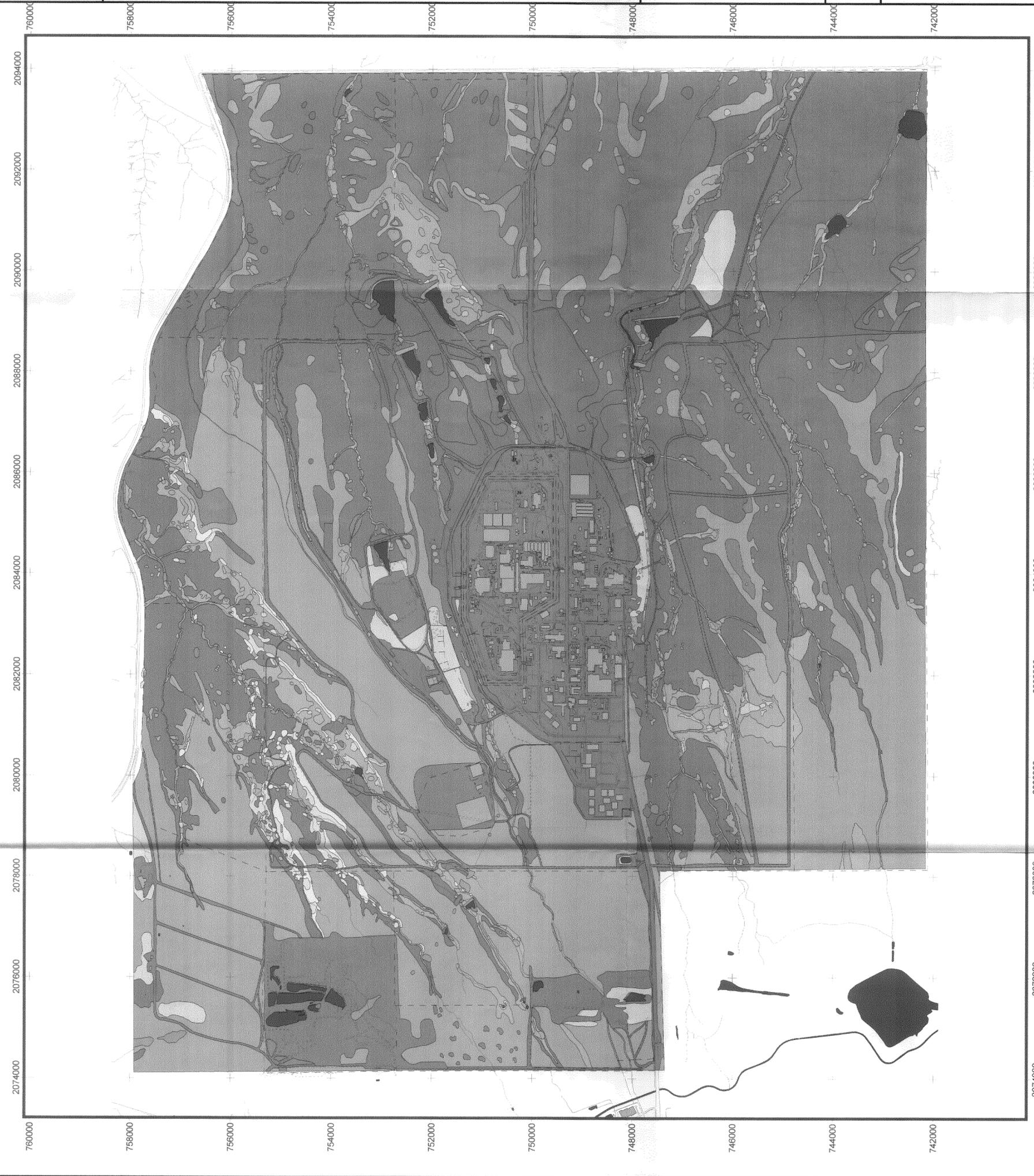
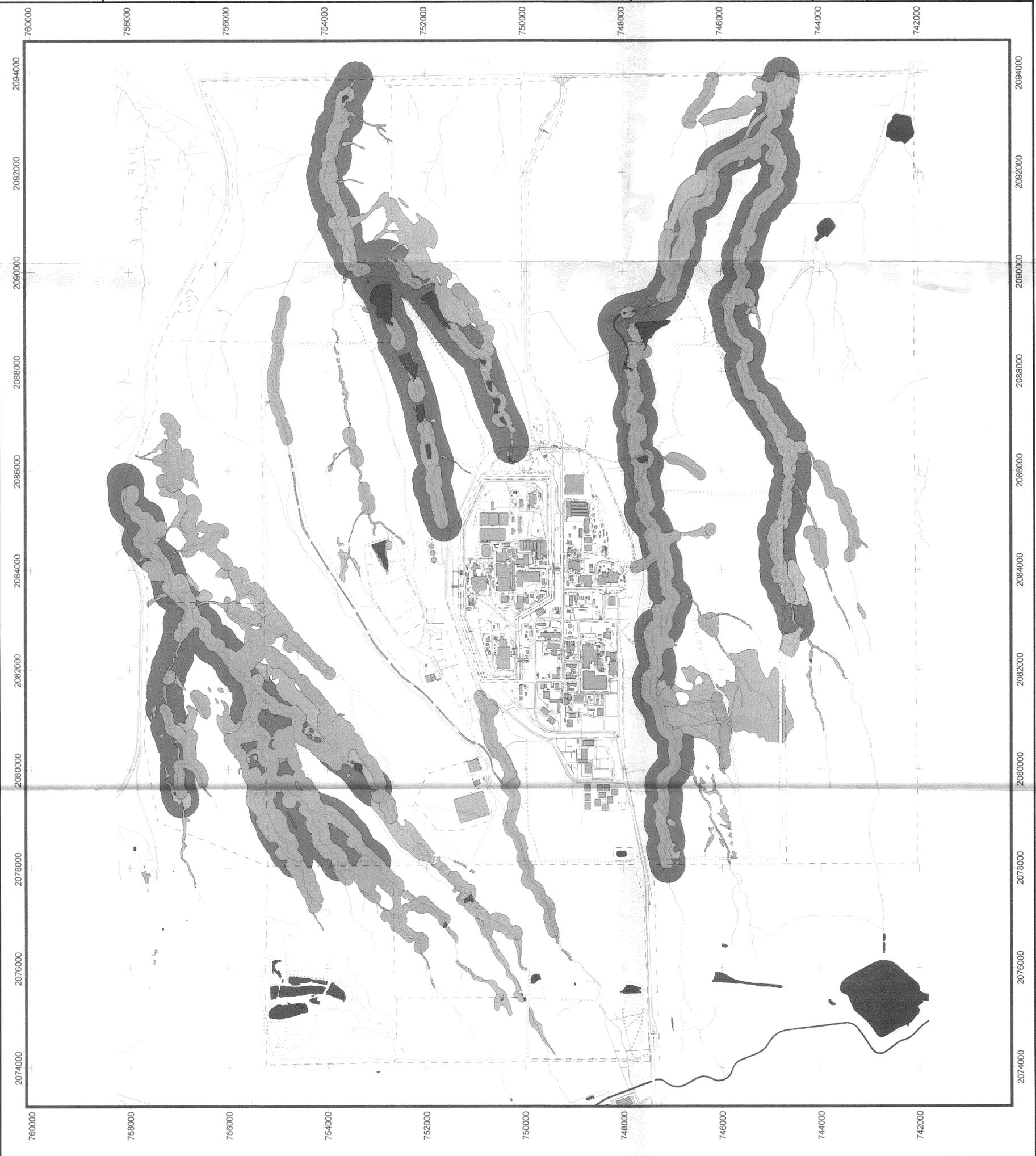


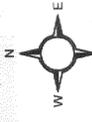
Figure 7.6  
Preble's Mouse  
Habitat



**KEY**

- Fence
- Paved roads
- Dirt roads
- Streams, ditches, or other drainage features
- Lakes and ponds
- Facilities
- Preble's Mouse Habitat Types**
- Proposed Critical Habitat
- Contiguous wetland
- Protection Area

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1500 0 1500 Feet

Scale 1: 17000  
State Plane Coordinate Projection  
Colorado Central Zone  
Datum: NAD 27

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

Prepared by:  
**RADMS**

Prepared for:  
**KAISER-HILL COMPANY**

File: W:\Projects\Fy2003\ecoleco.apr Date: 5.30.03

Figure 4.1  
Human Health  
Exposure Units

KEY

- Streams, ditches, or other drainage features
- Paved roads
- Dirt roads
- Lakes and ponds
- Fence
- Facilities

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1500 0 1500 Feet

Scale 1: 17000

State Plane Coordinate Projection  
Colorado Central Zone  
Datum: NAD 27

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

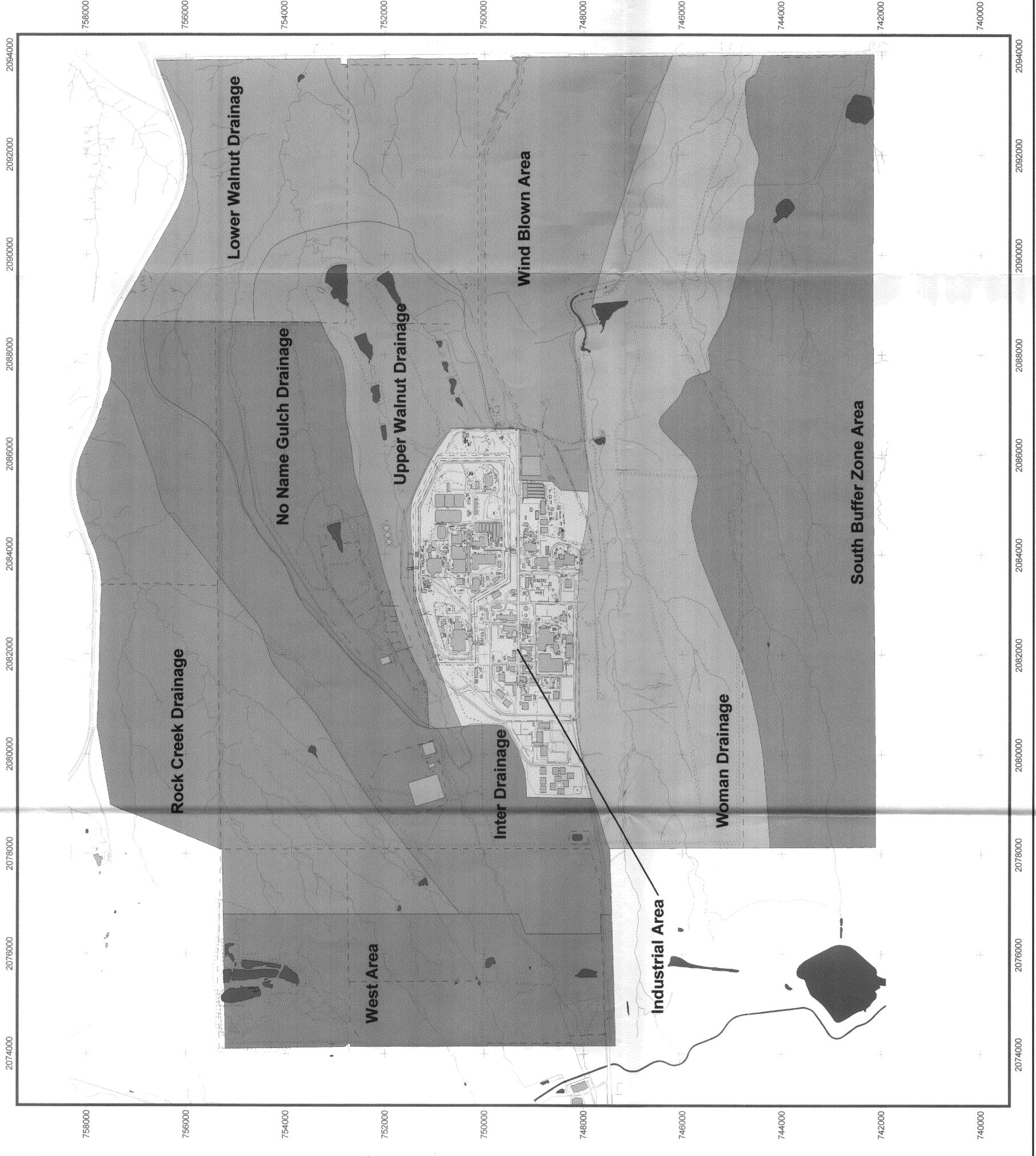
Prepared by:



Prepared for:



File: W:\Projects\FY2003\ecoleco.apr Date: 5.30.03



**Figure 4**  
**NE Subsurface Soil Sample**  
**Results Greater than Background**  
**Mean Plus Two Standard Deviations**  
**or Detection/Reporting Limit**

**KEY**

- Below Action Level
- ▤ Dirt Road
- ▥ Paved Road
- ▧ PAC
- ▨ IHSS

**Notes:**  
 Only results with WRW Action Levels (ALs) are shown.

Soil Action Levels have been proposed as modifications to RFCA Attachment 5.

m\_2sd = 0.00 indicates no background values are available

Sbd = Sample begin depth

Sed = Sample end depth

DI = Detection/Reporting limit



Scale = 1 : 1280



State Plane Coordinate Projection  
 Colorado Central Zone  
 Datum: NAD 27

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

Prepared by: Date: 4.3.03



Prepared for:

2088500

2088500

2088500

2087500

2087500

2087500

750500

750000

749500

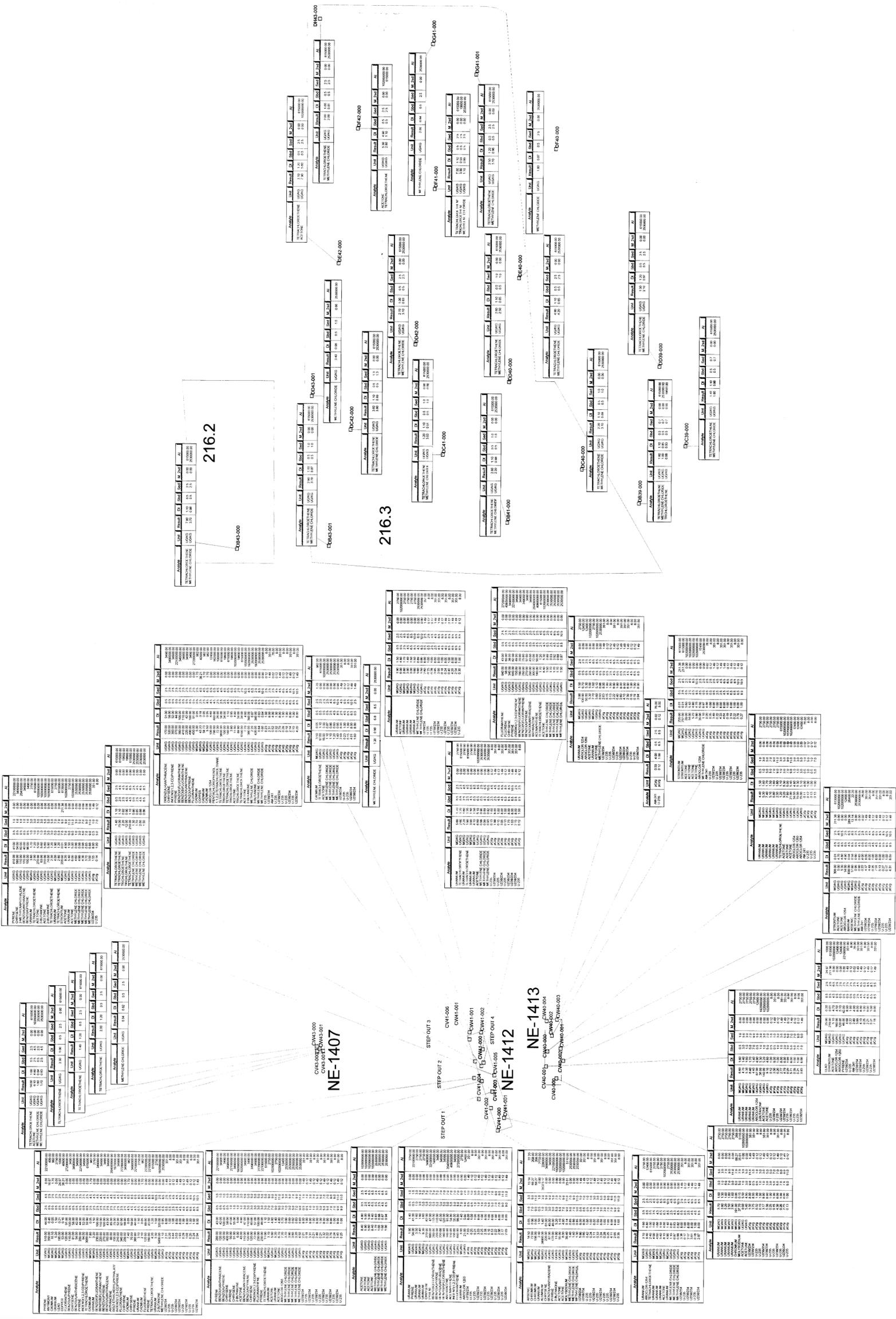
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