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Addressees:

200-UR-1 UNPLANNED RELEASE WASTE GROUP OPERABLE UNIT SAMPLING AND ANALYSIS PLAN (SAP), DOE/RL-2006-50, REVISION 0, REISSUE

The purpose of this letter is to transmit the 200-UR-1 Unplanned Release Waste Group Operable Unit SAP, DOE/RL-2006-50, Revision 0, Reissue for your review and approval. It incorporates the responses to the State of Washington Department of Ecology's comments transmitted by e-mail on December 13, 2006, by John Price.

This SAP presents the rationale and strategy for radiological surveys and sampling and analysis activities in support of cleanup decisions for the 200-UR-1 Operable Unit waste sites. The purpose of the surveys and sampling and analysis for sites identified for removal, treatment, and disposal is to verify completeness of the removal activities and that excavated clean soil is appropriate for use as backfill. Sampling and analysis requirements to support waste designation decisions for excavated contaminated material are discussed.

This SAP includes the scoping sampling strategy and analytical requirements developed for the remedial investigation of the BC Controlled Area. This SAP also includes initial radiological survey specifications and data collection needed to support the performance of final status surveys, in accordance with NUREG-1575, EPA/402/R-97/016, DOE/EH-064, "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)," for site closeout of portions of the BC Controlled Area.

Addressees  
07-AMCP-0112

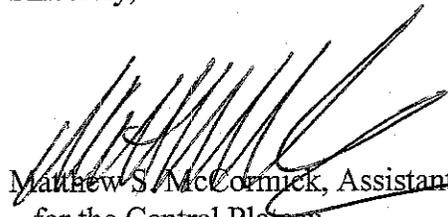
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MAR 06 2007

Review and approval of the attached SAP is requested as soon as possible to enable sampling activities to proceed in the field at the earliest possible time.

If you have questions, please contact me, or your staff may contact, Briant Charboneau, of my staff, on (509) 373-6137.

Sincerely,



Matthew S. McCormick, Assistant Manager  
for the Central Plateau

AMCP:FMR

Attachment

cc w/attach:

C. E. Cameron, EPA

J. B. Price, Ecology

~~Administrative Record~~ *OU 206-UR-1*

Environmental Portal

cc w/o attach:

R. E. Piippo, FHI

J. G. Vance, FFS

DOE/RL-2006-50  
Revision 0  
Reissue

# 200-UR-1 Unplanned Release Waste Group Operable Unit Sampling and Analysis Plan

Prepared for the U.S. Department of Energy  
Assistant Secretary for Environmental Management



**United States**  
**Department of Energy**  
P.O. Box 550  
Richland, Washington 99352

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# 200-UR-1 Unplanned Release Waste Group Operable Unit Sampling and Analysis Plan

Date Published  
February 2007

Prepared for the U.S. Department of Energy  
Assistant Secretary for Environmental Management



**United States  
Department of Energy**

P.O. Box 550  
Richland, Washington 99352

*J. D. Aardal*      *2/14/2007*  
Release Approval      Date

**Approved for Public Release;  
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## TERMS

AEA	alpha energy analysis
CAS	Chemical Abstracts Service
CDI	canyon disposition initiative
CLARC	cleanup levels and risk calculations (Ecology 94-145)
COC	contaminant of concern
CSM	conceptual site model
CUL	cleanup level
d/min	disintegrations per minute
DL	detection limit
DOE	U.S. Department of Energy
DQO	data quality objective
DR	decision rule
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ETF	Effluent Treatment Facility
FE	fundamental error
FS	feasibility study
GEA	gamma energy analysis
GeLi	germanium-lithium
GM	Geiger-Müller
GPC	gas proportional counter
GPS	Global Positioning System
HEIS	<i>Hanford Environmental Information System</i> database
HPGe	high-purity germanium
IC	ion chromatography
ICP	inductively coupled plasma
IH	industrial health
LSC	liquid scintillation counting
MARSSIM	<i>Multi-Agency Radiation Survey and Site Investigation Manual</i> (NUREG-1575, EPA/402/R-97/016, DOE/EH-0624)
MESC/IC/MNA	maintain existing soil cover, institutional controls, and monitored natural attenuation
N/A	not applicable
NaI	sodium iodide
NWTPH-Dx	Northwest total petroleum hydrocarbon-diesel extended
OU	operable unit
PCB	polychlorinated biphenyl
PID	photoionization detector
PFP	Plutonium Finishing Plant
PUREX	Plutonium-Uranium Extraction (Plant)
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control

REDOX	Reduction-Oxidation (Plant)
RESRAD	RESidual RADioactivity (dose model)
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RL	U.S. Department of Energy, Richland Operations Office
RSD	relative standard deviation
RTD	removal, treatment, and disposal
SAP	sampling and analysis plan
SD	standard deviation
STOMP	Subsurface Transport Over Multiple Phases (PNNL-12034)
TBD	to be determined
TCLP	toxicity characteristic leaching procedure
TIC	tentatively identified compound
Tri-Party Agreement	<i>Hanford Federal Facility Agreement and Consent Order</i>
UPR	unplanned release
VOA	volatile organic analyte
VOC	volatile organic compound
WAC	<i>Washington Administrative Code</i>
WTP	Waste Treatment Plant
XRF	X-ray fluorescence

## METRIC CONVERSION CHART

Into Metric Units			Out of Metric Units		
<i>If You Know</i>	<i>Multiply By</i>	<i>To Get</i>	<i>If You Know</i>	<i>Multiply By</i>	<i>To Get</i>
<b>Length</b>			<b>Length</b>		
inches	25.4	millimeters	millimeters	0.039	inches
inches	2.54	centimeters	centimeters	0.394	inches
feet	0.305	meters	meters	3.281	feet
yards	0.914	meters	meters	1.094	yards
miles	1.609	kilometers	kilometers	0.621	miles
<b>Area</b>			<b>Area</b>		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.093	sq. meters	sq. meters	10.76	sq. feet
sq. yards	0.836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.6	sq. kilometers	sq. kilometers	0.4	sq. miles
acres	0.405	hectares	hectares	2.47	acres
<b>Mass (weight)</b>			<b>Mass (weight)</b>		
ounces	28.35	grams	grams	0.035	ounces
pounds	0.454	kilograms	kilograms	2.205	pounds
ton	0.907	metric ton	metric ton	1.102	ton
<b>Volume</b>			<b>Volume</b>		
teaspoons	5	milliliters	milliliters	0.033	fluid ounces
tablespoons	15	milliliters	liters	2.1	pints
fluid ounces	30	milliliters	liters	1.057	quarts
cups	0.24	liters	liters	0.264	gallons
pints	0.47	liters	cubic meters	35.315	cubic feet
quarts	0.95	liters	cubic meters	1.308	cubic yards
gallons	3.8	liters			
cubic feet	0.028	cubic meters			
cubic yards	0.765	cubic meters			
<b>Temperature</b>			<b>Temperature</b>		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius	Celsius	multiply by 9/5, then add 32	Fahrenheit
<b>Radioactivity</b>			<b>Radioactivity</b>		
picocuries	37	millibecquerel	millibecquerel	0.027	picocuries

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## 1.0 INTRODUCTION

This sampling and analysis plan (SAP) presents the rationale and strategy for radiological surveys and sampling and analysis activities in support of removal actions or cleanup decisions for the 200-UR-1 Operable Unit (OU) waste sites. During the data quality objective (DQO) process to support the work plan (DOE/RL-2004-39, *200-UR-1 Unplanned Release Waste Group Operable Unit Remedial Investigation/Feasibility Study Work Plan*), 147 unplanned release sites were evaluated and grouped for four proposed further actions. The sites were grouped according to key site attributes to allow for consistent and expedited decisions concerning the proposed action. The grouping categories and the number of applicable sites identified included the following:

- Candidate sites for rejection or no action (43 sites)
- Candidate sites for rejection or no action with confirmatory sampling (10 sites)
- Candidate sites for inclusion with another OU for completion of remedial action (37 sites)
- Candidate sites for removal, treatment, and disposal (RTD) (56 sites)
- Candidate sites for completion of the remedial investigation/feasibility study (RI/FS) process (one site – BC Controlled Area, UPR-200-E-83).

This SAP is concerned with the fourth and fifth categories, namely, those sites that will be candidate sites for RTD and the special case of the BC Controlled Area. The purpose of the surveys and sampling and analysis for sites identified for RTD is to verify completeness of the removal activities and to verify that excavated clean soil is appropriate for use as backfill. Sampling and analysis requirements to support waste designation decisions for excavated contaminated material are discussed in Section 3.15.

This SAP includes the scoping sampling strategy and analytical requirements developed for the remedial investigation (RI) of the BC Controlled Area. This SAP also includes initial radiological survey specifications and data collection needed to support the performance of final status surveys, in accordance with NUREG-1575, EPA/402/R-97/016, DOE/EH-0624, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*, for site closeout of portions of the BC Controlled Area.

### 1.1 BACKGROUND

The 200-UR-1 OU unplanned release (UPR) sites consist of locations with contamination from spills or leaks to the ground surface, or from dissemination of radioactive particulates, plant materials, and/or animal feces. Many UPR waste sites resulted from loss of control of radioactive materials during waste transfer or containment in areas with process facilities, roads, railroad lines, or tank farms, while a small number of sites are associated with burial grounds, trenches, and cribs. The releases are attributed to administrative failures, equipment failures, operator error, and vegetation or animal intrusion.

The early definition of a UPR was exclusively a release of radioactive material. These releases were given site numbers beginning with the prefix UPR. More recently, releases of nonradiological hazardous materials also have become part of the criteria defining UPRs. New releases, whether radiological or hazardous, usually are cleaned up shortly after they occur. Any new release not cleaned up is numbered, submitted as a "Discovery Item," and evaluated for acceptance as a waste site. Numbers assigned to recent UPRs no longer include the UPR prefix.

Table 1 shows the 200-UR-1 OU waste sites identified for inclusion under the scope of this SAP.

## **1.2 200-UR-1 OPERABLE UNIT GROUP/WASTE SITE LOCATIONS**

The 200-UR-1 OU waste sites are located in south-central Washington State within and adjacent to the Hanford Site 200 Areas. Figures 1 through 14 show detailed locations of UPR waste sites in the vicinity of individual facilities in the 200 Areas.

## **1.3 PROCESS HISTORY OVERVIEW**

The 200-UR-1 OU waste sites may have been contaminated with wastes generated by processes and facilities in the 200 Area, including the following:

- Bismuth/phosphate and lanthanum/fluoride (B and T Plants)
- Uranium recovery and scavenging operations (U Plant)
- Reduction-Oxidation (REDOX) (S Plant)
- Plutonium-Uranium Extraction (PUREX) Plant
- Strontium/cesium separations, recovery, and storage operations (Hot Semiworks Plant)
- Plutonium/americium scrap recovery processes (Recovery of Uranium and Plutonium by Extraction Plant, Plutonium Recovery Facility, and americium recovery) along with several experiments including tritium production, uranium, plutonium, and thorium studies (Plutonium Finishing Plant/Z Plant)
- Tank farm tank condensate
- 200 Area decontamination wastes, which included wastes from the T Plant Complex after it was converted to a decontamination and equipment refurbishment facility in 1957. The 2706-T Building was used to steam clean heavy equipment and vehicles.

## **1.4 CONTAMINANTS OF CONCERN**

Step 1 of the DQO process is to develop a list of contaminants of concern (COC) for 200-UR-1 OU waste sites. Development of a list of COCs is an essential step toward refining

the conceptual site model (CSM). For the 200-UR-1 OU waste sites, a list of potential radiological, organic, and inorganic COCs that were, or could have been, discharged to the 200-UR-1 OU waste sites was compiled based on facility operations in the 200 Areas. This list was prepared after reviewing DQO documents for the OUs in the 200 Areas including 200-CW-1, 200-CS-1, 200-CW-5, 200-LW-1, 200-LW-2, 200-MW-1, 200-PW-1, 200-PW-2, 200-PW-4, 200-TW-1, and 200-TW-2.

The majority of waste generated by 200 Areas plant operations and contamination associated with the 200-UR-1 OU waste sites can be described as originating from a variety of liquid effluents containing radionuclides. Other waste constituents may have included metals, inorganic chemicals, and semivolatile and volatile organic chemicals. The analytical approach for this project targets the significant risk drivers that are representative of the waste constituents present. General suite-type analytical techniques yield results on many metals and organic compounds, thus providing a cost-effective approach for determination of the constituents that could be present.

As a result of the DQO process, a reduced list from an initial list of all contaminants that potentially could have been discharged to 200-UR-1 OU waste sites was retained. Additional COCs were added to the list through the investigation-derived waste DQO process. Development of the COC lists is described in WMP-19920, *Data Quality Objectives Summary Report for 200-UR-1 Operable Unit Unplanned Releases Waste Group*.

The 200-UR-1 OU COCs are identified in Table 2. If contaminants not identified as COCs are detected during laboratory analysis, the data will be evaluated against regulatory standards, or risk-based levels if exposure data are available, and existing process knowledge in support of *Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)* response action and waste designation decision making.

## **PRELIMINARY ACTION LEVELS**

### **Direct-Exposure Preliminary Cleanup Levels**

The radionuclide and nonradionuclide contaminants from UPRs in the 200-UR-1 OU are expected to be located within 4.6 m (15 ft) of the ground surface. Because there are no records of decision for the Central Plateau OUs, remedial action goals are not established. Therefore, preliminary cleanup levels (CUL) are assigned consistent with the planned land uses for the Central Plateau. Inside the Core Zone, the nonradiological constituent CULs for human health and environmental protection are consistent with those identified in WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties." Although the land use identified outside the Core Zone is conservation/mining, contaminated media will be cleaned up to levels below WAC 173-340-740, "Unrestricted Land Use Soil Cleanup Standards," to prevent the need for additional cleanup in the future.

The radionuclide soil cleanup standard of 15 mrem/yr above background is consistent with the U.S. Environmental Protection Agency's (EPA) radionuclide soil cleanup guidance, as described in EPA 1997, *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination*, OSWER Directive 9200.4-18. The CSMs for the UPRs indicate that exposure to

contamination is limited to the shallow surface soil pathway; nevertheless, preliminary CULs for groundwater protection also are provided in Tables 3 and 4.

#### Radiological Constituent Preliminary Cleanup Levels

For radiological constituents, OSWER Directive 9200.4-18 (EPA 1997) limits radiation doses from contaminated sites to 15 mrem/yr above natural background for 1,000 years following completion of cleanup. To determine if a site meets the 15 mrem/yr above background level, soil radionuclide concentrations (picocuries per gram) are converted to a dose rate (millirem per year) using a dose assessment model. The model used for this conversion is the RESidual RADioactivity (RESRAD) dose model (ANL 2002, *RESRAD for Windows*). Preliminary CULs for direct exposure and groundwater protection are provided in Table 4.

#### Nonradiological Constituent Preliminary Cleanup Levels

CULs for soil are consistent with those identified in WAC 173-340-740; WAC 173-340-745; and WAC 173-340-747, "Deriving Soil Concentrations for Ground Water Protection." CULs for individual contaminants occurring within the 200-UR-1 OU will be determined using the methodology consistent with unrestricted land use for sites located outside the Core Zone, and industrial land use for sites located inside the Core Zone. CULs for human health, ecological receptors, and groundwater protection are provided in Table 5.

### **1.5 DATA QUALITY OBJECTIVES**

EPA/600/R-96/055, *Guidance for the Data Quality Objectives Process*, EPA QA/G-4, was used to support the development of this SAP. The DQO process is a strategic planning approach that provides a systematic process for defining the criteria that a data collection design should satisfy. Using the DQO process ensures that the type, quantity, and quality of environmental data used in decision making will be appropriate for the intended application.

This section summarizes the key outputs resulting from implementation of the seven-step DQO process. Additional details are provided in WMP-19920.

#### **1.5.1 Statement of the Problem**

The DQO process for the 200-UR-1 OU includes development of sorting criteria to identify the candidate sites for implementation of an expedited cleanup approach. Sites were identified where the "observational approach" could be used for conducting a proposed CERCLA removal action. This approach collects real-time data (i.e., field screening) used to guide proposed removal action decisions. Verification of cleanup actions is achieved through collection of a final set of samples for laboratory analysis. Data regarding radiological and nonradiological constituents are needed for the UPR waste sites identified for the RTD alternative.

The DQO process also supports the objective of determining what characterization activities are needed for disposal of waste removed from RTD sites. For waste disposition decisions, additional radiological and nonradiological characterization data are required.

Sorting criteria also were developed that identified candidate sites for completion of an RI/FS. The DQO process for the 200-UR-1 OU was used to determine the environmental measurements that would be necessary for characterization of sites identified for completion of an RI. RI data collection is used to refine the preliminary CSM, support an evaluation of risk, and develop response action alternatives. For sites identified for an RI/FS, data regarding the nature and extent of contamination are needed.

As identified during the DQO process, possible response action alternatives for UPR waste sites include the following:

- No action
- Maintain existing soil cover, institutional controls, and monitored natural attenuation (MESCI/MNA)
- RTD.

### **1.5.2 Decision Rules**

Decision rules are developed from the combined results of the standard EPA DQO process Steps 2, 3, and 4. These results include the principal study questions, decision statements, response action alternatives, data needs, COC action levels, analytical requirements, and the scale of the decisions. The decision rules generally are structured as "IF...THEN" statements that indicate what action will be taken when a prescribed condition is met. The decision rules incorporate the parameters of interest (e.g., COCs), the scale of the decision (e.g., location), the action level (e.g., contaminant concentration), and the actions that would result. The 200-UR-1 OU decision rules are summarized in Table 5. CULs for radionuclides and for nonradiological constituents specified in the decision rules are provided in Tables 3 and 4, respectively, which are based on the EPA 15 mrem/yr requirement and the EPA hazardous chemical CULs and site modeling with RESRAD, an EPA-approved code.

### **1.5.3 Error Tolerance and Decision Consequences**

The radioactivity levels are so low that there is a very low risk to human health and the environment. Therefore, knowing exactly how much radioactivity is present is not a significant enough concern to justify more rigorous sampling and analytical techniques. Because capping is not being contemplated, the sites will be available for additional sampling if necessary. Two sampling campaigns will exist. The first series of sampling will be performed to locate and define the extent of the spread of contamination and to be able to estimate costs for the RTD alternative or the possibility of no action. The second series of sampling for RTD sites will be performed to confirm that the sites are cleaned up to the required CULs shown in Tables 3 and 4.

#### 1.5.4 Sample Design Summary

This SAP supports three primary waste site decision-making functions: characterization of the candidate RI/FS site, closeout verification of the RTD sites, and confirmatory sampling to support no action at candidate sites. For the RI/FS waste site (BC Controlled Area), data collection requirements are identified that define the site characteristics in support of response action alternative decision making. The investigative and sampling techniques in this SAP align with the key elements of the 200-UR-1 OU waste site CSMs (Figures 15, 16, 17, 18, and 19). Different sampling approaches will be used for the RTD and RI/FS candidate sites. Radiological surveys and confirmatory sampling will be used for those sites identified as needing additional data to support reclassification as rejected or no action.

Characterization activities for the candidate RTD sites focus on identifying the contaminated material/media that require removal via the observational approach. Field-screening techniques for radiological and nonradiological contaminants will be used to determine lateral and vertical extent, as well as the contaminant concentrations. Verification sampling will be used to verify attainment of response action objectives in support of site closeout. The media of interest are residual soil within the site excavation and the soil stabilization cover for use as backfill material.

Special data collection requirements and sampling design specifications are identified for the BC Controlled Area (UPR-200-E-83). This SAP presents the Phase I sampling design, which is part of a multiphased approach for investigation and decision making at this waste site.

## 2.0 QUALITY ASSURANCE PROJECT PLAN

The quality assurance project plan (QAPjP) establishes the quality requirements for environmental data collection, including sampling, field measurements, and laboratory analysis. The QAPjP complies with the requirements of the following:

- DOE O 414.1A, *Quality Assurance*
- 10 CFR 830.120, "Quality Assurance Requirements"
- EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans, QA/R-5.*

The following sections describe the quality requirements and controls applicable to this investigation. Correlation between EPA/240/B-01/003 (QA/R-5) requirements and information in this SAP is provided below.

EPA QA/R-5 Criteria	EPA QA/R-5 Title	Reference Section
Project Management	Project/Task Organization	2.1.1
	Problem Definition and Background	1.1, 1.5.1
	Project Task Description	1.0, 2.0
	Quality Objectives and Criteria	1.5, 2.3
	Special Training/Certification	2.1.2
	Documents and Records	2.7
Data Generation and Acquisition	Sample Process Design	1.5.4, 3.0
	Sampling Methods	2.9, 3.14
	Sample Handling and Custody	2.9.4, 2.9.5, 2.9.6
	Analytical Methods	2.2, 2.7, Tables 6 and 7
	Quality Control	2.2, 2.3
	Instrument/Equipment Testing, Inspection and Maintenance	2.3.1
	Instrument/Equipment Calibration and Frequency	2.3.1
	Inspection and Acceptance of Supplies and Consumables	2.3.1
	Non-Direct Measurement	1.1
	Data Management	2.7
Assessment and Oversight	Assessment and Response Actions	2.6.1
	Reports to Management	2.6
Data Validation and Usability	Data Review, Verification and Validation	2.8
	Verification and Validation Methods	2.8
	Reconciliation with User Requirements	2.10

EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans, QA/R-5.*

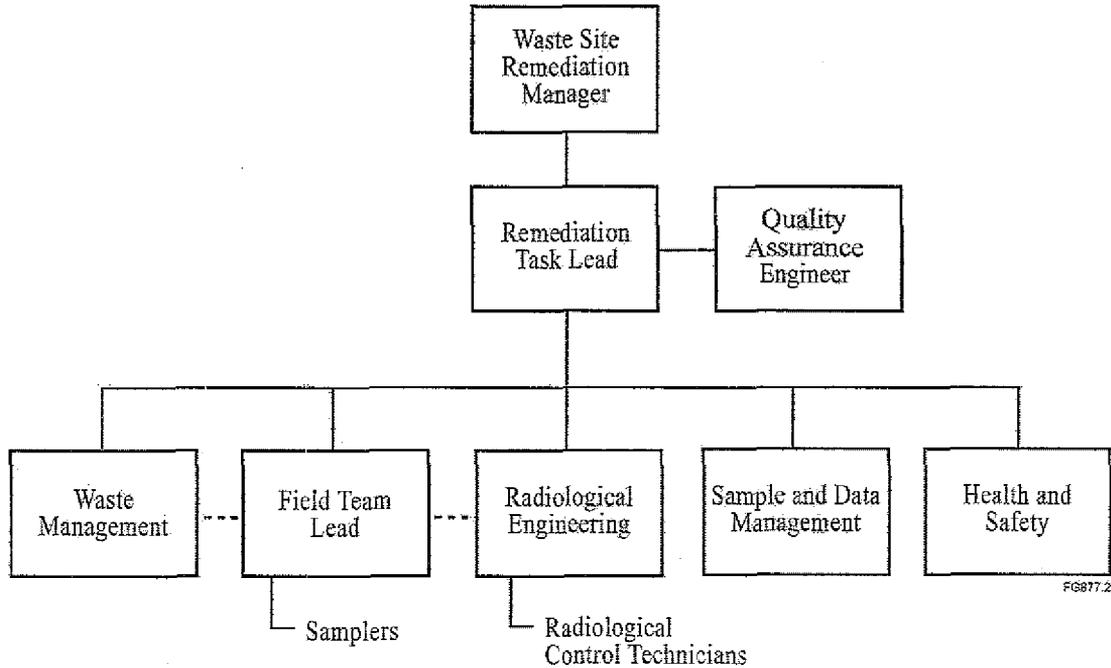
EPA = U.S. Environmental Protection Agency.

### 2.1 PROJECT MANAGEMENT

This section addresses the basic areas of project management and ensures that the project has a defined goal, that the participants understand the goal and approach to be used, and that the planned outputs have been appropriately documented.

### 2.1.1 Project/Task Organization

The Project Hanford Management Contractor is responsible for the planning, coordinating, sampling, preparing, packaging, and shipping of soil samples to the laboratory. The project organization is described in the following subsections and is shown graphically below.



#### 2.1.1.1 Waste Site Remediation Manager

The Waste Site Remediation manager provides oversight for all activities and coordinates with the U.S. Department of Energy (DOE), Richland Operations Office (RL) and regulators in support of sampling activities. In addition, support is provided to the task lead to ensure that the work is performed safely and cost-effectively.

#### 2.1.1.2 Remediation Task Lead

The Remediation task lead is responsible for direct management of sampling documents and requirements, field activities, and subcontracted tasks. The task lead works closely with Quality Assurance (QA), Health and Safety, and the field team lead to integrate these and the other lead disciplines in planning and implementing the work scope. The task lead also coordinates with, and reports to, RL, regulators, and the Project Hanford Management Contractor on all sampling activities.

#### 2.1.1.3 Quality Assurance Engineer

The QA engineer is matrixed to the Remediation task lead and is responsible for QA issues on the project. Responsibilities include oversight of implementation of the project QA

requirements; review of project documents, including SAPs and the QAPjP; and participation in QA assessments on sample collection and analysis activities, as appropriate.

#### **2.1.1.4 Waste Management**

The Waste Management lead communicates policies and procedures and ensures project compliance for storage, transportation, disposal, and waste tracking in a safe and cost-effective manner. Other responsibilities include identifying waste management sampling/characterization requirements to ensure regulatory compliance interpretation of the characterization data to generate waste designations, profiles, and other documents that confirm compliance with waste acceptance criteria.

#### **2.1.1.5 Field Team Lead**

The field team lead has overall responsibility for the planning, coordination, and execution of field characterization activities. Specific responsibilities include converting sampling design requirements into the field task instructions that provide specific direction for field activities. Responsibilities also include directing training, mock-ups, and practice sessions with field personnel to ensure that the sampling design is understood and can be performed as specified. The field team lead communicates with the Remediation task lead to identify field constraints that could affect the sampling design. In addition, the field team lead directs the procurement and installation of materials and equipment needed to support the fieldwork.

The field team lead oversees field-sampling activities, including sample collection, packaging, provision of certified clean sampling bottles/containers, documentation of sampling activities in controlled logbooks, chain-of-custody documentation, and packaging and transportation of samples to the laboratory or shipping center.

The field team leads, samplers, and others responsible for implementation of this SAP and the QAPjP will be provided with current copies of this document and any revisions.

#### **2.1.1.6 Radiological Engineering**

The Radiological Engineering manager is responsible for radiological engineering and health physics support within the project. Specific responsibilities include conducting as-low-as-reasonably-achievable reviews, exposure and release modeling, and radiological controls optimization for all work planning. In addition, radiological hazards are identified and appropriate controls are implemented to maintain worker exposures as low as reasonably achievable. Radiological Engineering interfaces with the project safety and health representative, and plans and directs radiological control technician support for all activities.

#### **2.1.1.7 Sample and Data Management**

The Sample and Data Management organization selects the laboratories that perform the analyses. This organization also ensures that the selected laboratories conform to Hanford Site internal laboratory QA requirements, or their equivalent, as approved by RL, EPA, and the Washington State Department of Ecology (Ecology). Sample and Data Management receives analytical data from the laboratories, makes data entries into the *Hanford Environmental*

*Information System* (HEIS) database, and arranges for data validation. Validation on completed data packages will be performed by qualified Project Hanford Management Contractor personnel or by a qualified independent contractor.

#### **2.1.1.8 Health and Safety**

Health and Safety responsibilities include coordination of industrial safety and health support within the project as carried out through safety and health plans, job hazard analyses, and other pertinent safety documents required by Federal regulation or by internal Fluor Hanford work requirements. Health and Safety also assists project personnel in complying with applicable health and safety standards and requirements. Personnel protective clothing requirements are coordinated with Radiological Engineering.

#### **2.1.2 Special Training Requirements/Certification**

Training or certification requirements have been instituted by the Project Hanford Management Contractor team to meet requirements imposed by the Project Hanford Management Contract (DE-AC06-96RL13200, *Contract Between the U.S. Department of Energy, Richland Operations Office, and Fluor Hanford, Inc.*), regulations, DOE Orders, contractor requirements documents, American National Standards Institute/American Society of Mechanical Engineers standards, *Washington Administrative Code*, etc. For example, training or certification requirements needed by sampling personnel will be in accordance with Hanford Site analytical quality requirements.

The Environmental Safety and Health Training Program provides workers with the knowledge and skills necessary to safely execute assigned duties. Field personnel typically will have completed the following training before starting work:

- Occupational Safety and Health Administration 40-hour hazardous waste worker training and supervised 24-hour hazardous waste site experience
- 8-hour hazardous waste worker refresher training (as required)
- Hanford general employee radiation training
- Radiological worker training.

A graded approach is used to ensure that workers receive a level of training that is commensurate with their responsibilities and that complies with applicable DOE Orders and government regulations. Specialized employee training includes prejob briefings, on-the-job training, emergency preparedness, plan-of-the-day activities, and facility and worksite orientations.

## **2.2 FIELD QUALITY CONTROL**

Field quality control (QC) samples will be collected to evaluate the potential for cross contamination and laboratory performance. Field QC for sampling in the 200-UR-1 OU will require the collection of field replicates, field splits, equipment rinsate blanks, and trip blank

samples. The QC samples and the required frequency for collection are described in this section. QC samples will be collected as part of the verification and confirmatory sampling activities.

### **2.2.1 Field Replicates**

Field replicates will be collected from a minimum frequency of 5 percent of total collected samples or 1 field replicate for every 20 samples (whichever is greater). Field replicates are used to evaluate the precision of field-sampling methods.

For multi-increment samples, field replicates will be collected as two additional multi-increment samples in one decision unit area; i.e., three multi-increment samples will be collected from the site targeted for field QC. The field replicate samples will be retrieved from the same depth interval as the primary multi-increment sample but at additional randomly selected locations.

### **2.2.2 Field Splits**

One soil split sample will be collected during soil sampling. The sample media will be homogenized, split into two separate aliquots in the field, and sent to two independent laboratories. The split will be used to verify the performance of the primary laboratory.

The split sample will be obtained from sample media suitable for analysis at an offsite laboratory and shall be analyzed for all of the analytes listed in Tables 6 and 7.

### **2.2.3 Equipment Rinsate Blanks**

Equipment blanks shall be collected from a minimum of 5 percent of the total collected soil samples or 1 equipment blank for every 20 samples (whichever is greater), and will be used to verify the adequacy of sampling equipment decontamination procedures. The field geologist may request that additional equipment blanks be taken. Equipment blanks shall consist of pure deionized water washed through decontaminated sampling equipment and placed in containers, as identified on the project Sampling Authorization Form. NOTE: The bottle and preservation requirements for water may differ from the requirements for soil.

Equipment rinsate blanks shall be analyzed for the following:

- When characterization analysis is for radionuclides only
  - Gamma emitters
  - Gross alpha
  - Gross beta

- When characterization analysis is for radionuclide and nonradionuclide constituents
  - Gamma emitters
  - Gross alpha
  - Gross beta
  - Metals (excluding hexavalent chromium and mercury)
  - Anions
  - Semivolatile organic analyte
  - Volatile organic analytes.

#### **2.2.4 Trip Blanks**

The volatile organic trip blanks will constitute approximately 5 percent of all samples designated for analysis of volatile organic compounds, or approximately one in every sixth batch (cooler) that contains samples requiring volatile organic compound analyses. The trip blank shall consist of pure deionized water added to clean sample containers in the Sample Shipping Facility. These containers will be transported to the field with the bottle set(s) and will be returned unopened to the laboratory. Trip blanks are prepared as a check for possible contamination originating from container preparation methods, shipment, handling, storage, or site conditions. The trip blank shall be analyzed only for volatile organic compounds.

#### **2.2.5 Prevention of Cross Contamination**

Special care should be taken to prevent cross contamination of soil samples. In particular, care will be exercised to avoid the following common ways in which cross contamination or background contamination may compromise a sample:

- Improperly storing or transporting sampling equipment and sample containers
- Contaminating the equipment or sample bottles by setting the equipment or sample bottle on or near potential contamination sources (e.g., uncovered ground)
- Handling bottles or equipment with dirty hands
- Improperly decontaminating equipment before sampling or between sampling events.

### **2.3 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA**

Quality objectives and criteria for soil measurement data are presented in Table 6 for radionuclides and in Table 7 for chemical analytes. Analysis of soil physical properties will be performed according to American Society for Testing and Materials procedures, if applicable.

### **2.3.1 Measurement and Testing Equipment**

Measurement and testing equipment used in the field or laboratory that directly affects the quality of analytical data will be subject to preventive maintenance measures to ensure minimization of measurement system downtime. Laboratories and onsite measurement organizations must maintain and calibrate their equipment. Maintenance requirements (such as parts lists and documentation of routine maintenance) will be included in the individual laboratory and the onsite organization QA plan or operating procedures as appropriate. Calibration of laboratory instruments will be performed in accordance with SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A*, or with auditable DOE Hanford Site-wide and contractual requirements. Calibration of radiological field instruments is discussed in Section 2.9.7.

Consumables, supplies, and reagents will be reviewed in accordance with SW-846 requirements and will be appropriate for their use. NOTE: Contamination is monitored using the QC sample process discussed in Section 2.2.

### **2.3.2 Laboratory Sample Custody**

Sample custody during laboratory analysis will be addressed in the applicable laboratory standard operating procedures. Laboratory custody procedures will ensure the maintenance of sample integrity and identification throughout the analytical process.

### **2.3.3 Quality Assurance Objective**

The QA objective of this plan is to develop implementation guidance that will provide data of known and appropriate quality. Data quality is assessed by representativeness, comparability, accuracy, and precision. The applicable QC guidelines, detection limits, and levels of effort for assessing data quality are dictated by the intended use of the data and the nature of the analytical method. Each of these is addressed below.

#### **2.3.3.1 Representativeness**

Representativeness is a measure of how closely the results reflect the actual concentration and distribution of the radiological and nonradiological constituents in the matrix sampled. Sampling plan design, sampling techniques, and sample-handling protocols (e.g., storage, preservation, and transportation) have been developed. The documentation will establish that protocols have been followed and that sample identification and integrity are ensured.

#### **2.3.3.2 Comparability**

Comparability expresses the confidence with which one data set can be compared to another. Data comparability will be maintained using standard procedures and consistent methods and units. Tables 6 and 7 list applicable analytical methods for analytes and target detection limits. Actual detection limits will depend on the sample matrix and sample quantity available. Data will be reported as defined for specific samples.

### 2.3.3.3 Accuracy

Accuracy is an assessment of the closeness of the measured value to the true value. Accuracy of chemical test results is assessed by spiking samples with known standards and establishing the average recovery. A matrix spike is the addition to a sample of a known amount of a standard compound similar to the compounds being measured. Radionuclide measurements that require chemical separations use this technique to measure method performance. For radionuclide measurements that are analyzed by gamma spectroscopy, laboratories typically compare results of blind audit samples against known standards to establish accuracy. Validity of calibrations are evaluated by comparing results from the measurement of a standard to known values and/or by generation of in-house statistical limits based on three standard deviations ( $\pm 3$  SD). Tables 6 and 7 list the accuracy provided for fixed laboratory analyses for the project.

### 2.3.3.4 Precision

Precision is a measure of the data spread when more than one measurement has been taken on the same sample. Precision can be expressed as the relative percent difference for duplicate measurements or relative standard deviation (RSD) for triplicates. Analytical precision for fixed laboratory analyses is listed in Tables 6 and 7.

### 2.3.3.5 Detection Limits

Detection limits are functions of the analytical methods used to provide the data and the quantity of the sample available for analyses. Detection limits are listed in Tables 6 and 7.

## 2.3.4 Laboratory Quality Control

Instead of laboratory duplicates, triplicate samples will be analyzed for multi-incremental sampling. Two additional laboratory QC samples will be analyzed from the primary sample from the investigation area selected for field QC. Field replicates are discussed in Section 2.2.1. This process will result in triplicate laboratory analyses for one sample.

The laboratory method blanks, laboratory control sample/blank spike, and matrix spike are defined in Chapter 1.0 of SW-846 and will be run at the frequency specified in that reference. As previously discussed, instead of laboratory duplicates, triplicates will be analyzed. Specific multi-incremental samples will need to be pre-selected for the laboratory QC analysis so that sufficient sample quantity is obtained. For the laboratory control analyses, at a minimum, a primary sample and a supplemental (backup) sample will be required. Sample volume requirements will vary with analytical method. Coordination among field sample collection personnel, Sample and Data Management, and the laboratory will occur before sampling to verify sample volume requirements for these analyses.

## **2.4 SAMPLE PRESERVATION, CONTAINERS, AND HOLDING TIMES**

Soil sample preservation, containers, and holding time guidelines for radiological and nonradiological analytes of interest and physical property tests are presented in Table 8. Final sample collection requirements will be identified on the Sampling Authorization Form.

## **2.5 ONSITE MEASUREMENTS QUALITY CONTROL**

The collection of QC samples for onsite measurements is not applicable to field-screening techniques described in this SAP. Field-screening instrumentation will be calibrated and controlled, as discussed in Section 2.3.1, as applicable.

## **2.6 ASSESSMENT/OVERSIGHT**

Routine evaluation of data quality described for this project will be documented and filed along with the data in the project file.

### **2.6.1 Assessments and Response Actions**

The Project Hanford Management Contractor QA organization may conduct random surveillance and assessments to verify compliance with the requirements outlined in this SAP, project work packages, a project quality management plan, procedures, and regulatory requirements.

Deficiencies identified by these assessments shall be reported in accordance with existing programmatic requirements. The Project Hanford Management Contractor QA organization coordinates corrective actions/deficiencies in accordance with the Project Hanford Management Contractor QA Program. When appropriate, corrective actions will be taken by the project engineer and/or task lead.

### **2.6.2 Reports to Management**

All deficiencies identified by self-assessments will be reported to management. Identified deficiencies also will be reported to the Project Hanford Management Contractor 200 Areas Waste Site Remedial Actions manager, as appropriate.

## **2.7 DATA MANAGEMENT**

Data resulting from the implementation of the QAPjP shall be managed and stored in accordance with applicable programmatic requirements governing data management procedures. At the direction of the task lead, all analytical data packages shall be subject to final technical review by qualified personnel before results are submitted to regulatory agencies or before inclusion in reports. Electronic data access, when appropriate, shall be via a database (e.g., HEIS or a

project-specific database). Where electronic data are not available, hard copies shall be provided in accordance with Section 9.6 of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989).

Planning for sample collection and analysis shall be in accordance with the programmatic requirements governing fixed laboratory sample collection activities as discussed in the sample team's procedures. If specific procedures do not exist for a particular work evolution or if it is determined that additional guidance to complete certain tasks is needed, a work package will be developed to adequately control the activities, as appropriate. Examples of the sample team's requirements include activities associated with the following:

- Chain-of-custody and sample analysis requests
- Project and sample identification for sampling services
- Certificates of analysis controls
- Logbooks and checklists
- Sample packaging and shipping.

Approved work control packages and procedures will be used to document radiological measurements when implementing this SAP. Examples of the types of documentation for field radiological data include the following:

- Instructions regarding the minimum requirements for documenting radiological controls information in accordance with 10 CFR 835, "Occupational Radiation Protection"
- Instructions for managing the identification, creation, review, approval, storage, transfer, and retrieval of Hanford Site radiological records
- The minimum standards and practices necessary for preparing, performing, and retaining radiological-related records
- The indoctrination of personnel on the development and implementation of survey/sample plans
- The requirements associated with preparing and transporting regulated material.

Data will be cross-referenced between laboratory analytical data and radiation measurements to facilitate interpretation of the investigation results.

### **Resolution of Analytical System Errors**

Errors reported by the laboratories are reported to the Sample Management Project coordinator, who initiates a Sample Disposition Record in accordance with Project Hanford Management Contractor procedures. This process is used to document analytical errors and to establish the resolution with the project task lead. In addition, the Project Hanford Management Contractor QA engineer receives quarterly reports that provide summaries and summary statistics of the analytical errors.

## 2.8 VALIDATION AND VERIFICATION REQUIREMENT

Completed data packages will be validated by qualified Fluor Hanford Sample and Data Management personnel or by a qualified independent contractor. Validation will consist of verifying required deliverables, requested versus reported analyses, and transcription errors. Validation also will include evaluating and qualifying the results based on holding times, method blanks, laboratory control samples, laboratory duplicates, and chemical and tracer recoveries, as appropriate. No other validation or calculation checks will be performed.

Level C data validation as defined in the contractor's validation procedures, which are based on EPA functional guidelines (Bleyler 1988a, *Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses*; Bleyler 1988b, *Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses*), will be performed for up to 5 percent of the data by matrix and analyte group. Analyte group refers to radionuclides, volatile chemicals, semivolatiles, polychlorinated biphenyls, metals, and anions. The goal is to cover the various analyte groups and matrices during the validation.

When outliers or illogical results are identified in the data quality assessment, additional data validation will be performed. The additional validation will be up to 5 percent of the statistical outliers and/or illogical data. The additional validation will begin with Level C and may increase to Levels D and E as needed to ensure that the data are usable. Level C validation is a review of QC data, while Levels D and E include reviews of calibration data and calculations of representative samples from the dataset. All data validation will be documented in data validation reports. Results below background would not be expected and could trigger a validation inquiry. With the exception of "R" qualified or rejected data, all data will be used.

At least one data validation package will be generated. Validation requirements identified in this section are consistent with Level C validation, as defined in data validation procedures. Relative to analytical data in biotic and abiotic media, physical data and/or field-screening results are of lesser importance in making inferences of risk. Because of the secondary importance of such data, no validation for physical property data and/or field-screening results will be performed. However, field QA/QC will be reviewed to ensure that the data are useable. Field instrumentation, calibration, and QA checks will be performed in accordance with the following.

- Calibration of radiological field instruments on the Hanford Site is performed under contract by Pacific Northwest National Laboratory, as specified in its program documentation.
- Daily calibration checks will be performed and documented for each instrument used to characterize areas that are under investigation. These checks will be made on standard materials that are sufficiently like the matrix under consideration that direct comparison of data can be made. Analysis times will be sufficient to establish detection efficiency and resolution.

The approval of field-data collection plans by the Radiological Engineering manager represents the data validation and usability review for hand-held field radiological measurements.

## **2.9 SAMPLE COLLECTION REQUIREMENTS**

### **2.9.1 Sample Location**

Locations of multi-incremental samples shall be randomly selected and identified during sampling. Sample locations for discrete samples will be staked and labeled before the sampling activity is started. Locations will be identified as part of the work planning process for the collection of samples. Changes in sample locations that do not impact the DQOs will require project manager approval; however, changes to sample locations that result in impacts to the DQOs will require Ecology concurrence. Sample design specifications are presented in Chapter 3.0.

### **2.9.2 Sample Identification**

The Fluor Hanford *Sample Data Tracking* database will be used to track samples from the point of collection through the laboratory analysis process. The HEIS database is the repository for laboratory analytical results. HEIS sample numbers will be issued to the sampling organization for this project in accordance with onsite organization procedures. Each radiological/nonradiological and physical properties sample will be identified and labeled with a unique HEIS sample number. The sample location, depth, and corresponding HEIS numbers will be documented in the sampler's field logbook.

Each sample container will be labeled with the following information using a waterproof marker on firmly affixed, water-resistant labels:

- Sampling Authorization Form
- HEIS number
- Sample collection date/time
- Name of person collecting the sample
- Analysis required
- Preservation method (if applicable).

### **2.9.3 Field-Sampling Log**

All information pertinent to field sampling and analysis will be recorded in field checklists and bound logbooks in accordance with existing sample collection protocols. The sampling team will be responsible for recording all relevant sampling information. Entries made in the logbook will be dated and signed by the individual making the entry. Program requirements for managing the generation, identification, transfer, protection, storage, retention, retrieval, and disposition of records with the Project Hanford Management Contractor also will be followed.

#### **2.9.4 Sample Custody**

Sample custody will be maintained in accordance with existing Hanford Site protocols. The custody of samples will be maintained from the time the samples are collected until the ultimate disposal of the samples, as appropriate. A chain-of-custody record will be initiated in the field at the time of sampling and will accompany each set of samples shipped (by cooler) to any laboratory. Wire or laminated waterproof tape will be used to seal the coolers. Analyses requested for samples will be indicated on accompanying chain-of-custody forms.

Chain-of-custody procedures will be followed throughout sample collection, transfer, analysis, and disposal to ensure that sample integrity is maintained. Each time the responsibility changes for the custody of the sample, the new and previous custodians will sign the record and note the date and time. The sampler will make a copy of the signed record before sample shipment and will transmit the copy to Project Hanford Management Contractor Sample and Data Management within 48 hours of shipping.

A custody seal (i.e., evidence tape) will be affixed to the lid of each sample jar. The container seal will be inscribed with the sampler's initials and the date.

#### **2.9.5 Sample Containers and Preservatives**

Level I EPA pre-cleaned sample containers will be used for soil samples collected for radiological and nonradiological analysis. Container sizes may vary depending on laboratory-specific volumes and requirements for meeting analytical detection limits. If, however, the dose rate on the outside of a sample jar or the curie content of a sample exceeds levels acceptable by an offsite laboratory, the sampling lead and task lead can send smaller volumes to the laboratory after consultation with Project Hanford Management Contractor Sample and Data Management to determine acceptable volumes. Preliminary container types and volumes are identified in Table 8. The final types and volumes will be indicated on the Sampling Authorization Form.

#### **2.9.6 Sample Shipping**

The radiological control technician will measure the contamination levels on the outside of each sample jar and the dose rates on each sample jar. The radiological control technician also will measure the radiological activity on the outside of the sample container (through the container), and will document the highest contact radiological reading in millirems per hour. This information, along with other data, will be used to select proper packaging, marking, labeling, and shipping paperwork in accordance with U.S. Department of Transportation regulations (49 CFR, "Transportation"), and to verify that the sample can be received by the analytical laboratory in accordance with the laboratory's acceptance criteria. The sampler will send copies of the shipping documentation to Project Hanford Management Contractor Sample and Data Management within 48 hours of shipping.

As a general rule, samples with activities of  $<1$  mR/h will be shipped to an offsite laboratory. Samples with activities between 1 and 10 mR/h may be shipped to an offsite laboratory; however, samples with dose rates in this range will be evaluated on a case-by-case basis by

Project Hanford Management Contractor Sample and Data Management. Samples with activities of >10 mR/h will be sent to an onsite laboratory arranged for by Sample and Data Management.

### 2.9.7 Radiological Field Data

Alpha and beta/gamma field data will be used to support the characterization described in this SAP, as appropriate. The following information will be disseminated to personnel performing work in support of this SAP, as appropriate:

- Instructions to the radiological control technicians on methods required to measure sample activity and media for gamma, alpha, and/or beta emissions, as appropriate. This will include direction to allow the radiological control technicians to calculate a number of quantities supporting sample analysis.
- Information regarding the Geiger-Müller<sup>1</sup> portable instrument, to include a physical description of the Geiger-Müller instrument, radiation and energy response characteristics, calibration/maintenance and performance testing descriptions, and the application/operation of the instrument. The Geiger-Müller instrument is a commonly used beta/gamma instrument on the Hanford Site when removable surface contamination measurements and direct measurements of the total surface contamination are performed.
- Information regarding the portable alpha meter, to include a physical description of the portable alpha meter, radiation and energy response characteristics, calibration/maintenance and performance testing descriptions, and the application/operation of the instrument. The portable alpha meter instrument is a commonly used alpha instrument on the Hanford Site when removable surface contamination measurements and direct measurements of the total surface contamination are performed.
- Information regarding the sodium iodide detector, to include a physical description of the sodium iodide detector, radiation and energy response characteristics, calibration/maintenance and performance testing descriptions, and the application/operation of the instrument. The sodium iodide detector instrument is a commonly used gamma detector on the Hanford Site when direct measurements are performed.
- Information on the characteristics associated with the hand-held probes to be used in the performance of direct radiological measurements, to include a physical description of the probe, radiation and energy response characteristics, calibration/maintenance and performance testing descriptions, and the application/operation of the instrument. Probes appropriate for the type and energy range of radioactivity present in the soils commonly are used on the Hanford Site when removable surface contamination measurements and direct measurements of the total surface contamination are performed.

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<sup>1</sup> Geiger-Müller is not a trademark.

## 2.10 DATA QUALITY ASSESSMENT

The data quality assessment process compares completed field-sampling activities to those proposed in corresponding sampling documents and provides an evaluation of the resulting data. This data evaluation determines if quantitative data are of the correct type and are of adequate quality and quantity to meet the project DQOs. EPA/240/B-06/002, *Data Quality Assessment: A Reviewers Guide*, EPA G-9R and EPA/240/B-06/003, *Data Quality Assessment: Statistical Tools for Practitioners*, EPA G-9S, identify five steps for evaluating data generated from this project, as summarized below.

**Step 1 – Review DQOs and Sampling Design.** Step 1 requires a comprehensive review of the sampling and analytical requirements outlined in the project-specific DQO workbook and SAP.

**Step 2 – Conduct a Preliminary Data Review.** In Step 2, a comparison is made between the actual QA/QC achieved (e.g., detection limits, precision, and accuracy) and the requirements determined during the DQO. Any significant deviations will be documented. Basic statistics will be calculated from the analytical data at this point, including an evaluation of the distribution of the data.

**Step 3 – Select the Statistical Test.** In Step 3, an appropriate statistical hypothesis test is selected and justified using the data evaluated in Step 2.

**Step 4 – Verify the Assumptions.** Step 4 assesses the validity of the data analyses by determining if the data support the underlying assumptions necessary for the analyses or if the data set must be modified (e.g., transposed or augmented with additional data) before further analysis. If one or more assumptions are questioned, return to Step 3.

**Step 5 – Draw Conclusions from the Data.** The statistical test is applied in Step 5. The results either should reject the null hypothesis or fail to reject the null hypothesis; if the latter is true, the data should be analyzed further. If the null hypothesis is rejected, the overall performance of the sampling design should be evaluated by performing a statistical power calculation to assess the adequacy of the sampling design.

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### **3.0 FIELD-SAMPLING PLAN**

#### **3.1 GENERAL SAMPLING OBJECTIVES FOR REMOVAL, TREATMENT, AND DISPOSAL SITES**

WMP-19920 identified RTD candidate sites that could proceed to site cleanup through use of the observational approach.

Field-screening analyses performed during excavation provide the following:

- Ongoing guidance with regard to the extent of excavation
- Waste characterization for segregation and disposition decisions.

To document final site conditions (confirmatory and cleanup verification), radiological surveys and analytical sampling will be performed to meet the following objectives.

- Verify that residual contamination levels in the site achieve the radiological and nonradiological CULs.
- Obtain mean concentration data to support closeout decisions for RTD sites.
- Support the development of waste profiles for disposal and waste treatment decisions.

The confirmatory and cleanup verification sampling design applies to waste sites containing only radiological contamination, sites mixed with radiological and nonradiological contaminants, and sites that contain only nonradiological contaminants. Significant distinctions are not in the sampling design, but rather in the determination of the required analyses. Tables 4 through 14 provide sampling design details. Table 15 identifies the constituent types in each waste site (i.e., radiological only, mixed, or hazardous only).

#### **General Conceptual Site Models for Removal, Treatment, and Disposal Sites**

Based on the CSMs developed for the UPR waste sites, if contamination is present, it is expected to occur within one of four potential depth intervals shown in Table 9. An overview of general site conditions and contaminant distribution profiles associated for the UPR waste sites is presented in the following subsections. The CSMs are based on historical information and empirical data. The models will be revised if needed as data are collected during removal actions.

### Lateral Waste Site Boundaries

The 200-UR-1 OU waste sites identified for RTD may be covered by a layer of clean soil or gravel (stabilization cover). In some cases, the locations and dimensions of the release are clearly documented and/or delineated with fencing and posting. In other instances, the site locations are poorly defined or unknown. Because structures generally are not associated with UPRs, the defining physical features in the CSM are limited to surface soils. Note that lateral dimensions of many of the release areas are not well defined because the contaminated soil is covered by stabilizing fill. While the stabilizing cover effectively fixes surface contamination, it also masks waste site boundaries. If other specific site boundary information is not available, the soil stabilization cover will be used as the defining feature when establishing waste site boundaries.

### Vertical Contaminant Distribution

Waste sites consisting of windblown, disseminated contamination are assumed to occur at the ground surface to a maximum depth of approximately 0.3 m (1 ft). For liquid release sites, the contamination front may have reached the bottom of the surface soil zone (soil depth extending to 4.6 m [15 ft]).

Liquid release sites are assumed to have relatively homogenous contaminant distributions at the release point. Spurious, or "hot spot," contamination is not expected except where dripping has occurred during transport of liquids, such as with railroad tank cars. Sites with windblown contamination may be discontinuous, exhibiting hot spots. Because many of these sites may have been covered with stabilizing soil, it cannot be assumed that contamination decreases with depth from the current ground surface (i.e., top of stabilizing cover surface). However, contamination is expected to decrease with depth below the original release surface. The vertical contaminant distribution at each waste site depends on the characteristics of the release (liquid or solid) and on contaminant mobility.

If the contaminated media originally released were solid (e.g., particulates, tumbleweed parts, or animal feces), then that media and the surface soils are considered contaminated. The underlying soils also are expected to be contaminated to some nominal depth. If the release medium was liquid, then the soil is expected to be contaminated to a greater depth than at a site where solid media were released.

## **3.2 SAMPLING OBJECTIVE – STABILIZATION COVER MATERIAL/SOIL**

Site cover materials used to stabilize surface contamination are present at approximately one-half of all 200-UR-1 OU waste sites identified for RTD. Cover materials generally are 0.3 to 0.6 m (1 to 2 ft) thick and generally consist of soil and/or gravel. Some locations, particularly roads where spills have occurred, may have an asphalt cover. Both solid and liquid releases have been surface stabilized. The lateral extent of the stabilization cover generally is equal to or slightly larger than the area that was impacted by the release. The stabilization cover is a sampling objective for 200-UR-1 OU RTD sites (CSMs 1, 2, 3, and 4).

### **Sampling Design – Stabilization Cover Material/Soil**

In most cases, the lateral extent of the stabilization cover material can be defined by visual inspection. The cover material will need to be removed to access the underlying contaminated soil. As the cover soils are excavated, radiological screening will be used to determine if radionuclide contamination is present on the exposed site surface and in the excavated material. Cover material will be removed in lifts to reduce the potential to mix stabilizing material with underlying contaminated media; however, some mixing is expected at the cover/contaminated soil interface. Removed material will be screened and segregated into potential clean or contaminated stockpiles. Analytical results that indicate contamination levels above action levels will be used in support of waste profiling and waste designation.

### **3.3 SAMPLING OBJECTIVE – CLEANUP VERIFICATION FOR WINDBLOWN MATERIALS AND SMALL LEAK/SPILL SITE SOILS**

A contaminant depth of no more than 0.3 m (1 ft) is anticipated for sites that are included in the windblown and small leak/spill site CSMs. Contaminated media at these waste sites include redistributed particulates or flake material resulting from emissions or residue associated with tanks that have been mobilized and distributed by wind. Some site contamination is the result of windblown radiologically contaminated tumbleweed parts. Animal ingestion of contaminants also has resulted in the presence of radioactive fecal material at some locations (Figure 15).

Small-volume spills, drips, and leaks have occurred along some rail lines, in storage yards, and on road surfaces. These liquid releases may have penetrated further into underlying materials than windblown contaminants, but are not expected to exceed 0.3 m (1 ft) in depth (Figure 16).

The physical setting for the windblown materials, animal feces, and vegetation parts includes land areas that are not directly associated with a particular building or structure. Radionuclides are the only COC for these sites. Because the composition of the liquid releases is not known, radiological and nonradiological contaminants are considered contaminants for small leak/spill sites.

### **Sampling Design – Cleanup Verification for Windblown and Small Leak/Spill Site Soils**

Cleanup actions may require removal of stabilization covers before excavating the contaminated media. The sampling design specifications for the stabilization cover are discussed above.

Because the expected depth of contamination at these waste sites is very shallow, RTD operations will consist of soil scraping or backhoe excavation to very shallow depths. The excavation operations will be performed to depths below the contaminated media, thereby exposing soils that contain background contaminant concentrations. Therefore, a two-step cleanup verification process will be employed, consisting of a gridded radiological survey and verification sampling.

The radiological survey grid will be established during site excavation and will provide a referenced coordinate system for field screening and verification sampling. The gridded radiological surveys will be a primary component of the observational approach used to monitor the progress of contaminant removal. Verification sampling will be performed by radioisotopic gamma spectroscopy analysis of combined sample aliquots (i.e., multi-increment soil samples) at sites with redistributed solid contaminated media.

Radioisotopic analyses will provide sufficient data with which to determine acceptability of the cleanup of sites consisting of radioactive windblown materials, animal droppings, and vegetation parts. Because the composition of the leak or spill is not known at the small leak/spill liquid release sites, laboratory analysis for radiological and nonradiological constituents will be performed.

The number of verification samples will be based on the site size and associated number of decision units. Collection locations for the multi-increment portions comprising each verification sample will be randomly selected.

### **3.4 SAMPLING OBJECTIVE – CLEANUP VERIFICATION FOR MODERATE SCALE LEAK/SPILL SITE SOILS**

Contaminated soils are not expected to exceed 2 m (6.6 ft) in depth for the sites associated with the 200-UR-1 OU moderate scale spill/leak CSM (Figure 17). The physical setting for this group of sites principally consists of railroads; however, some outlying areas, roads, and storage yards also are included. Lateral contaminant distribution is smaller at these site locations than at sites affected by wind-distributed materials. Larger leak/spill sites, discussed in the next section, have the same sampling design as moderate leak/spill sites, but vertical contaminant distribution may extend up to 4.6 m (15 ft).

Transportation of process liquids occurred using the railroad system and tanker cars. Radionuclides are assumed to be the primary contaminants, but metals and organic constituents also may have been a component of the released liquid. Exact release locations are not specified in association with many of the rail line UPR waste sites because intermittent leaks and spills have occurred throughout segments of the rail system. Liquid releases also are documented at loading and unloading locations. Spills of contaminated solids and subsequent decontamination operations involving the use of water may have provided a mechanism for infiltration at some sites.

#### **Sampling Design – Cleanup Verification for Moderate Spill/Leak Site Soils**

Cleanup actions may require removal of stabilization covers before excavating the contaminated media. The sampling design specifications for stabilization covers are discussed above.

RTD operations will consist of soil scraping or backhoe excavation to a depth of several feet. The excavation operations will be performed to depths below the contaminated media, thereby exposing soils that contain background constituent concentrations.

A radiological survey grid will be established during site excavation and will provide a referenced coordinate system for field screening, confirmation, and/or verification sampling. The gridded radiological surveys will be a primary component of the observational approach used to monitor the progress of contaminant removal. The confirmatory radiological sampling will be performed by radioisotopic analysis of soil composites in Marinelli beakers. Verification sampling will be analyzed for radiological and nonradiological contaminants using a standard fixed laboratory. The number of verification samples will be based on site size and the associated number of decision units. Verification sample locations will be randomly selected. Analytical results will be used for site closeout.

### **3.5 SAMPLING OBJECTIVE – SITE CHARACTERIZATION OF LARGER SCALE SPILL/LEAK SITE SOILS**

Several unique site locations have been identified where potentially larger liquid releases have occurred and the depth of soil contamination may extend to 4.6 m (15 ft) (Figure 18). Composition of the liquid releases includes petroleum products (diesel or other hydrocarbons), solvents (hexone), tracers (calcium nitrate), and radioactive solutions (uranyl nitrate hexahydrate). In some cases, only the general area where the release occurred is documented. The lateral and vertical extent of the potentially impacted area is uncertain.

#### **Sampling Design – Site Characterization of Larger Spill/Leak Site Soils**

RTD operations and sampling design for the larger spill/leak sites will follow the general process described above for the small and moderate spill/leak sites. However, because of the nature of the release, removal activities potentially could extend to 4.6 m (15 ft). Chemical field-screening techniques will be used as appropriate for releases that may have involved nonradioactive constituents (i.e., hydrocarbon spills). Regulators will be contacted to determine further actions if contaminant levels exceeding CULs below 4.6 m (15 ft) are encountered.

### **3.6 USE OF THE OBSERVATIONAL APPROACH FOR REMOVAL, TREATMENT, AND DISPOSAL SITES**

Under the observational approach, the cleanup process is streamlined such that characterization and cleanup of a site will include the following:

- Verifying site boundaries
- Establishing a radiological survey and sampling grid
- Removing soil stabilization cover materials (if present) to expose the soil surface existing at the time of the release and conducting field screening for radiological and nonradiological contaminants (as appropriate) within cover materials

- Conducting gridded radiological surveys and selected field screening for nonradiological contaminants (as appropriate) on the exposed excavated surface to determine the extent of contamination (if any) underlying the soil stabilization cover; locating area(s) with the highest level of contamination
- Sampling and analysis of soils, at the location with the highest level of contamination, for waste characterization
- Excavating the contaminated media (soil, wood, concrete, asphalt, etc.)
- Performing a verification radiological survey and subsequent verification radiological soil sampling and laboratory analysis to document the successful removal of radiologically contaminated media to levels below CULs
- Verifying laboratory analysis for radiological and nonradiological contaminants at sites where a liquid release reportedly occurred.

Site conditions may be encountered where specific monitoring and sample collection are required to meet additional project needs. Examples of these situations include the following.

- A sampling activity will be initiated if action levels for health and safety are approached that require increased environmental and worker protection. Action levels are defined in the appropriate documents (i.e., radiation work permit, health and safety plan) and will be referenced in the instruction guide.
- A sampling activity may be initiated if visual anomalies are encountered during the excavation. Visual anomalies include discoloration of soils, appearance of a sheen on soil particles, obvious change in soil textural characteristics, structural materials uncovered unexpectedly, or other unexpected changes in site conditions.
- A sampling activity will be initiated if the waste profile, as indicated by onsite measurement, approaches the Environmental Restoration Disposal Facility waste acceptance criteria. The instruction guide will establish trip numbers in relation to the criteria that would initiate a sampling activity.
- A sampling activity may be initiated if increases in contaminant levels determined by onsite measurement indicate the presence of unexpected levels of contamination.

Other field conditions may be encountered in which additional sampling may be required. All sampling activities will be evaluated by project and/or technical personnel to ensure that representative and quality samples and analyses are taken and performed to specifically address the field condition in a cost-effective manner.

### **3.6.1 Radiological Field-Screening Methods**

Field-screening radiological instrumentation and applications are shown in Table 10.

### 3.6.1.1 Radiological Screening for Excavation Guidance

Excavations for sites with radionuclide contaminants will be guided by onsite measurements. Sodium iodide detectors with the ability to discriminate the specific energy of the limiting action levels will be used to provide isotope-specific count rate information. Other detectors may be used on a case-by-case or site-specific basis.

Sodium iodide detectors will be used to verify that contamination levels are within allowable limits. If the onsite radiological measurements indicate acceptable levels of contamination for release, quick turnaround samples will be collected for high-purity germanium analysis. If the sodium iodide and high-purity germanium analyses agree, the verification release process will be initiated.

If surface radiation surveys indicate that an area exceeds release levels, samples will not be collected, because additional excavation is required. If, however, the general area contamination levels are deemed acceptable but discrete hot spots are noted, samples will be collected from the hot spots for high-purity germanium analysis.

Surface radiation surveys will be used to identify existing surface contamination and to support decisions regarding health and safety requirements. Qualified radiological control technicians shall conduct surface radiation surveys in accordance with applicable approved radiological procedures (see Section 2.9.7). A post-sampling survey also will be performed to document changes to surface contamination levels as a result of sampling activities.

Radiological survey information will be used to make decisions concerning no action and/or completeness of soil removal actions. Gridded surveys will provide spatial variability estimates of the radiological contamination. The surveys will be a combination of static counting, sequential static counting, and scanning counts, depending on the identity and level of contamination to be detected. Because of the unique size and contamination distributions, each site will require a slightly different design. In addition to identifying any areas of elevated residual radiological activity that can aid in the selection of focused samples, the data can be used to evaluate spatial variability for representative statistical sampling designs. The following formula may be used to calculate survey scan rates and associated minimum detectable activities:

$$MDA = \frac{2.71 + 3.29 \sqrt{T_S B \left( 1 + \frac{T_S}{T_B} \right)}}{2.22 \times (E) (T_S) \times c}$$

where

MDA = minimum detectable activity, at the 95 percent confidence level (disintegrations per minute [d/min]/100 cm<sup>2</sup>)

B = background count rate (counts per minute)

T<sub>S</sub> = sample counting time (min)

T<sub>B</sub> = background count time

E = efficiency of instrument

- c = grams of dirt or material in the modeled area interrogated by detector (an 80 by 15 cm disk of soil weighs approximately  $1.2 \times 10^5$  g)  
 2.22 = conversion factor from d/min to units of pCi/g.

### 3.6.1.2 Determination of Site-Specific Background

The background used to determine the contamination level in each area will be determined on a site-by-site basis. Soil surfaces will be surveyed principally for Cs-137 using the sodium iodide detector. Alpha- and beta-emitting isotopes will be screened using scintillation detectors. In both cases, the laboratory data of concentration will be scaled to the field results to determine radioisotope spatial distribution and concentration. Whenever possible, the response of the instrument should be calibrated to respond to the specific radionuclides that would be present after decay and long-term environmental exposure.

### 3.6.2 Chemical Screening Measurements for Excavation Guidance

Potentially applicable chemical field-screening methods are listed in Table 11. Where field screening can be used to detect and quantify contaminant concentrations at the site, an RSD or standard deviation ( $s$ ) and mean ( $\bar{x}$ ) can be computed. Non-detect results should be taken at half the detection limit for such computations (Ecology 1992, *Statistical Guidance for Ecology Site Managers*). If more than 50 percent of the results are below detection, the field measurements are not suitable for computing an RSD or ( $s$ ) and ( $\bar{x}$ ).

Table 11 lists the chemical field-screening methods that may be used at RTD sites during soil removal operations.

Chemical field-screening methods may be employed to determine anomalous conditions, assess site contaminant variability, and confirm the need for removal activities. The potential nonradiological contaminants will be evaluated against potential screening technologies to determine if field screening offers an advantage. Censored data (non-detect results) likely are not usable when the practical quantitation limit of the field-screening method is equal to or above the action level.

Chemical field screening would be completed using the most practical techniques appropriate under expected sampling constraints. Contaminant fate and transport, constituent location, and environmental impacts (such as degradation) must be considered in determining target compounds for field screening.

Field-screening instruments will be used, maintained, and calibrated in accordance with the manufacturer's specifications and other approved procedures. The field team lead will record field-screening results in the field log.

### **3.7 CONFIRMATORY SAMPLING FOR THE MESC/IC/MNA REMEDY OR NO-ACTION DECISIONS**

Current levels of contamination are not known at many of the candidate RTD sites. For RTD sites with a soil stabilization cover, the contaminant nature and extent may not be determined until the cover material is removed to expose the surface on which the release may have originally occurred. Because of past cleanup or decontamination operations, contaminant levels may be below CULs or at background concentrations underlying the stabilization cover. At other candidate RTD sites, because of poor documentation concerning the level of prior cleanup activities or the extent of potential contamination, all or part of the site may have no contaminants present, or the contaminants occur at levels below CULs. Confirmatory samples may be needed at some of these sites to receive regulatory concurrence for a no-action decision.

Certain sites identified as candidates for rejection or no action will require a radiological survey and confirmatory soil sample collection to provide supporting data for regulatory concurrence. Those waste sites for which the preferred alternative is MESC/IC/MNA will have the soil occurring below the cover material sampled to confirm site conditions. Analytical results will be used to confirm the presence or absence of contaminants and to assess if attenuation or decay would occur within the time frame defined in the decision documents.

Initial radiological surveys performed at all sites will indicate whether radiological levels occur above background and/or CULs. If radiological survey results indicate a removal action is not required, confirmatory samples also will be collected as needed. The confirmatory samples will be taken at the same frequency as proposed for verification sample collection following soil removal actions. At some site locations, anomalous conditions may require development of a site-specific sampling plan, with the number of samples required for site closeout determined on a statistical basis. Site-specific sampling plans will be developed in coordination with Ecology. RL will submit site-specific sampling and analysis instructions to Ecology for these no-action waste sites. Sites confirmed as not requiring a removal action will be proposed for no action.

### **3.8 VERIFICATION FOR USE OF THE REMOVED SOIL STABILIZATION COVER MATERIAL AS BACKFILL**

The soil stabilization cover removed as part of RTD site excavations will be sampled and analyzed to verify that the spoil piles do not contain any contaminants above CULs; this decision process is shown in Figure 20. This verification will be accomplished by onsite radiological measurements during excavation, followed by discrete sampling and laboratory analyses for contaminants, if needed, in accordance with standard methods. Samples will be analyzed for radiological contaminants only at non-liquid-release sites. At liquid release UPR waste sites, analysis for radionuclides and nonradiological constituents will be conducted. A standard fixed laboratory will perform the analyses with 5 percent validated data packages.

Sampling of the stabilized cover soil resulting from the site excavation process will be based on a statistical approach. Material verified as noncontaminated will be used for site backfill.

### **3.9 VERIFICATION OF SITE CLEANUP**

At the end of excavation, the objective will be to verify that remaining site soils do not contain contaminants above the CULs. This verification will be accomplished by standard analytical methods. All samples will be analyzed for contaminants by a standard fixed laboratory with 5 percent validated data packages. The sampling strategy will be based on the use of a statistical approach. The overall sample design process using the observational approach for RTD sites is presented in Figure 20. Samples will be analyzed for radiological contaminants only at non-liquid-release sites. At liquid spill or leak sites, analysis for radionuclide and nonradionuclide constituents will be conducted. As discussed with confirmatory sample collection above, anomalous conditions encountered during the removal action may require development of a site-specific sampling plan, with the number of samples required for site closeout determined on a statistical basis. If required, a site-specific sampling plan will be developed in coordination with Ecology.

### **3.10 IMPORTED BACKFILL**

Imported backfill is soil taken from noncontaminated borrow sites. Acceptance or rejection of soils for backfill material will be based on existing knowledge of the prospective borrow areas. The imported backfill will be radiologically surveyed as a check for suitability for use as clean fill. Occasionally, clean rubble material may be appropriate for use as backfill, provided prior approval is received. Acceptance of clean rubble will be based on a pre-approved acceptance or approval plan.

### **3.11 SUMMARY OF SAMPLE COLLECTION REQUIREMENTS FOR REMOVAL, TREATMENT, AND DISPOSAL SITES**

Tables 12, 13, and 14 identify the site media and quantification criteria used for determining the number of verification samples needed for analysis of the removed stabilization cover soils and the exposed excavation surface. Table 15 shows the potential number of samples to be collected from identified RTD sites based on the estimated site area and required sample numbers specified in Table 14. For sites where radiological surveys and/or other screening techniques have indicated that confirmatory sample collection is appropriate, sample quantities will be the same as if a removal action had been performed (i.e., verification sampling). Sample quantities will be adjusted, as needed, if a site-specific sampling plan has been prepared.

#### **Multi-Increment Soil Sampling and Analysis**

Verification sampling will be based on use of a multi-increment sampling procedure that was designed to control the fundamental error (FE) for an average, based on collecting an adequate sample mass (Pitard 1993, *Pierre Gy's Sampling Theory and Sampling Practice: Heterogeneity,*

*Sampling Correctness, and Statistical Process Control*; Ramsey 2004, *Sampling for Environmental Activities*). The following steps are involved in determining an adequate sample mass to collect in the field and the proper particle size for the analytical laboratory to measure for radiological and nonradiological analysis.

1. Randomly sample each decision unit using the multi-increment methodology.
2. Select or measure a reasonable maximum sample particle size in the field. Because soils typically are defined as comprising particles  $\leq 2$  mm, an assumption is made that the maximum particle size is 2 mm or 0.2 cm. This will be achieved by sieving the soil samples to exclude the  $> 2$  mm size particles.
3. Select the desired FE, which has been specified as 10 percent.
4. Calculate the mass of sample (M) needed based on the FE and particle size (d, in cm) as

$$M = 22.5 \times \frac{d^3}{FE^2}.$$

If  $d=0.2$  cm and  $FE=0.1$  (10%), then  $M=18$  g.

5. Using a scoop large enough to capture the maximum particle size, collect enough sample increments ( $k=50$ ) to equal at least the mass calculated in step 4 and place them in a container, combining increments into one "sample" (m). Care will be taken to obtain consistent and representative samples for the desired sample depth, and the multi-increment sample will be formed such that the material is representative of the particle size fractions that are less than 2 mm. Sufficient sample mass will be collected for all laboratory analyses.
6. Repeat step 5 within one site decision unit when obtaining the field QC sample that will be used as a field replicate by sampling an additional set of 50 randomly selected locations.
7. Deliver the samples and QC samples to the laboratory.
8. In the analytical laboratory, the laboratory will calculate the particle size of sample needed based on the desired FE and the mass that the laboratory normally uses for a given analysis as

$$\sqrt[3]{\frac{M(FE)^2}{22.5}} = d.$$

9. The laboratory must extract/digest, prepare, and analyze the entire mass for each test method or grind the sample. If grinding is to be performed, the analytical laboratory must grind the entire mass of the field sample (and QC sample) to the agreed-upon maximum analytical particle size in step 8. For example, if the required sample mass for the analytical measurement is 10 g and the FE is 10 percent, then  $d=0.16$  cm.

10. If grinding is performed, the analytical laboratory must perform one-dimensional subsampling of the entire mass (spread entire ground sample on a flat surface in a thin layer, then systematically or randomly collect sufficient small mass subsampling increments to equal the mass that the laboratory requires for an analysis; do likewise for each QC sample).
11. If grinding is required, combine increments from step 10 into the "sample," then digest/extract/analyze the sample and QC samples.
12. Calculate the concentration from the sample.
13. The concentration represents average concentration or activity in the decision unit.

### **3.12 POTENTIAL SAMPLE DESIGN LIMITATIONS**

The sample design developed for this SAP has several potential limitations that may affect sampling results. Some of the factors with the potential to affect the outcome of this sampling activity include the following.

- The sampling design is based on the use of multiple interdependent technologies to locate and characterize UPR waste sites. The overall success of this sampling activity depends on the effective use of the individual technologies.
- Large particle size ranges at soil, roadbed, and railroad line sites may make it more difficult to obtain representative soil samples.
- If there are difficulties in locating an analytical laboratory to successfully complete steps 8 through 11 in Section 3.11, then the analytical laboratory will be directed to run triplicate analyses on each original sample. In addition, the field team will instruct the analytical laboratory to run triplicate analysis on two of the QC samples.
- Because of inadequate historical documentation, construction of new facilities over old release locations, or other past activities, it may no longer be possible to locate some sites.

### **3.13 RADIOLOGICAL CONTROLS DURING SITE CLEANUP ACTIVITIES**

If not properly planned and controlled, excavation operations and soil sampling potentially could result in airborne exposure and contamination spread. Detailed pre-job planning and preparation may require the use of mockup staging.

### 3.14 REMEDIAL INVESTIGATION SAMPLING DESIGN – BC CONTROLLED AREA PHASE I SITE SCOPING

#### 3.14.1 Nonradiological Contaminant Characterization

Using existing historical radiometric survey and analytical data documented in WMP-18647, *Historical Site Assessment of the Surface Radioactive Contamination of the BC Controlled Area*, a preliminary CSM for the BC Controlled Area was developed with three separate zones displaying different radiological contamination characteristics (Figure 19). Strontium-90 and Cs-137 are the primary contaminants. Zone A, adjacent to the BC Cribs and Trenches, shows the highest level of radiological activity, with a nearly continuous lateral dissemination of contamination. Zone B is a transitional zone, with intermixed contaminated and noncontaminated regions. Zone C, the most extensive area, is mainly uncontaminated. This CSM delineates lateral changes in radiological contaminant density and activity.

Based on historical site information, process knowledge, and analytical results for samples collected in March 2005, nonradiological constituents were eliminated from consideration as contaminants of potential concern in the BC Controlled Area. A supporting sampling activity completed in March 2005 was performed to determine whether the nonradiological contaminants were present in the BC Controlled Area at concentrations above human health or ecological CULs. This sampling activity was performed in accordance with D&D-24693, *Sampling and Analysis Instruction for BC Controlled Area Soil Characterization*. The analytical results from this sampling activity are summarized in WMP-25493, *Central Plateau Terrestrial Ecological Risk Assessment Data Quality Objectives Summary Report – Phase II*, Appendix B.

A bounding case approach, using a focused sampling design, was developed for this supplemental sampling activity to verify the presence or absence of nonradiological contaminants. In addition, random sampling was employed to enhance the database.

The bounding case in this sampling approach took advantage of the coexistence of radiological and nonradiological constituents (if present) that would have been released jointly into the environment. The rationale holds that, if nonradiological constituents are present in the most highly and moderately radiologically contaminated portion of the site, the constituents should be considered to exist throughout the site. Conversely, if nonradiological constituents are not present in those areas with highly and moderately radiologically contaminated soils, they can be discounted from soil analyses in the remaining portions of the site.

The bounding case sampling was applied to Zones A and B in the BC Controlled Area. Focused sampling in Zone A collected three soil samples from locations identified with radiological detectors to ensure collection of samples with the highest activity readings. At each of these locations, samples were collected from 0 to 0.3 m (0 to 1 ft) and 0.76 to 1.1 m (2.5 to 3.5 ft) depth intervals. The Zone A focused samples were analyzed for Cs-137, Sr-90, inductively coupled plasma metals, mercury, anions, and polychlorinated biphenyls.

In addition to focused sampling, random soil sampling consisting of surface soil sampling from the 0 to 0.3 m (0 to 1 ft) depth interval was performed in Zones A and B. Sampling locations were determined through a random number generator applied to a grid that overlays Zones A and B. Four randomly selected samples were collected from Zone A and six random samples were collected from Zone B. The randomly collected soil samples underwent inductively coupled plasma metals analysis. Laboratory analytical results showed that detected concentrations were below ecological screening levels and/or the Hanford Site background concentrations. Additional information on sample locations, number of samples, sample depths, and analytical requirements is provided in D&D-24693.

### 3.14.2 Use of MARSSIM

A phased sampling design will be used for the RI because of the nature and extent of radiological contamination in the BC Controlled Area. This sampling design was developed incorporating existing data presented in WMP-18647 and follows guidance provided in Chapters 4.0 and 5.0 of MARSSIM (NUREG-1575, EPA/402/R-97/016, DOE/EH-0624). For the first phase of the BC Controlled Area RI, the sampling objective is focused on determination of current radiological contaminant levels and distribution, and refinement of the preliminary CSM (Figure 19). Radiological data also will be collected to support assignment of MARSSIM area classifications (i.e., Area Classes 1, 2, and 3). The current BC Controlled Area CSM equates Zone A as a Class 1 area, Zone B as a Class 2 area, and Zone C as a Class 3 area.

Radiological surveys will be used to evaluate the lateral variability in surface radiation. Instrument measurements (i.e., count rates) will be converted into radionuclide concentration values. A supporting correlation study will be conducted separately to establish the relationship between instrument readings and radionuclide concentrations in the soil. With Cs-137 being the primary gamma-emitting radionuclide present, survey results will be used to map two isopleths based on the calculated Cs-137 concentrations. Additional discussion concerning the survey objectives and approach is provided in Section 3.14.3. Determination of where the radiological surveys should be conducted was based on evaluation of the data presented in WMP-18647 and previous survey information presented in BHI-01319, *Data Assessment Report for the Sampling and Analysis Activities Conducted to Support Reposting the 200 B/C Soil Contaminated Area*.

Soil sampling will be performed to provide additional data on the vertical concentration distribution of the primary radionuclides in the soil. Analytical data pertaining to concentrations of the primary radionuclides (Cs-137 and Sr-90) at a depth greater than 0.3 m (1 ft) are limited to three samples collected in March 2005 within the most contaminated region of the BC Controlled Area (Zone A). These samples indicated elevated concentrations of Cs-137 and Sr-90 occurring to a depth of 1 m (3 ft) underlying areas with high surface contamination (Table 16). Further discussion on the proposed soil sampling is presented in Section 3.14.5. Radiological analytical results also will be used to supplement existing information on the Cs-137 and Sr-90 radionuclide ratios (Table 16).

The existing analytical data support use of Cs-137 as a target radionuclide for the scoping radiological surveys and for conducting future MARSSIM surveys. A MARSSIM survey may be proposed for site closeout of CSM Zone C. MARSSIM radiological surveys focus on the

demonstration of compliance for sites with residual radioactivity using a final status survey technique that integrates the remedial design/remedial action step of the CERCLA remedial process. Survey instrumentation will be used with scan capabilities that are appropriate for minimum detectable concentration criteria and acceptable derived concentration guideline levels as defined in MARSSIM guidance (NUREG-1575, EPA/402/R-97/016, DOE/EH-0624).

Radiological survey data and soil sampling analytical results will be used to refine the CSM and for the remedial alternatives assessment that will be conducted as part of the FS. Additional data collection as part of a Zone A treatability study may be required before completing the FS for the BC Controlled Area. If needed, a separate DQO document will be prepared to address data collection requirements for the treatability study.

### 3.14.3 Surface Radiation Surveys

#### Objectives

Gamma radiation instrument measurements (i.e., count rates) will be taken systematically at specified locations using portable radiological equipment (Table 10). Instrument count rates will be converted into picocuries per gram concentrations using a correlation relationship that will be developed in a separate study. The minimum detectable concentration capability of the radiological survey instrumentation also will be established.

The primary objective of the surface radiation surveys is to clearly define two boundary lines in the BC Controlled Area: the Zone A/B boundary and the Zone B/C boundary. These will be presented as concentration isopleths for Cs-137. In addition, the survey results will provide spatial variability data on the Cs-137 surface contamination.

Radiological survey instrument response will be recorded at evenly distributed data collection points and later will be converted into concentration values. The Zone A/B boundary line will be based on detected Cs-137 concentrations equal to approximately two times the ecological biota concentration guide (DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*) value. The Zone B/C boundary will be based on Cs-137 concentrations equal to approximately two times the residential human-health CUL for Cs-137. The respective boundary concentrations are as follows:

- **Zone A/B boundary line – 41 pCi/g** (approximately two times the Cs-137 ecological biota concentration guide)
- **Zone B/C boundary line – 12 pCi/g** (approximately two times the Cs-137 rural residential CUL).

The use of these values for the boundaries will minimize the potential for false-positive indications during the radiological surveys based on the detection limit capabilities of the radiological instruments (see Table 10). The minimum detectable concentration for Cs-137 based on a static instrument count is estimated to be approximately 5 pCi/g (Table 10). A minimum detectable concentration study will be used to establish survey instrument detection capabilities before initiating the radiological surveys.

Because the zone boundary lines are set at twice the Cs-137 action levels, they will delineate those regions where the radiological contamination levels return to the ecological biota concentration guide and rural residential values after 1 half-life of decay; in this case, 30 years of institutional control. Notably, these concentration values are not being used to establish CULs within the BC Controlled Area, but to clearly define radiological activity boundaries in support of remedial decision making.

#### **3.14.3.1 Hand-Held Instrument Static Survey Approach**

A hand-held 2- by 2-in. sodium iodide detector will be used when collecting static radiological measurements (Table 10) for defining the zone boundary Cs-137 isopleths. The hand-held instrument surveys will consist of surface radiological measurements using systematic grids at specified locations. Survey readings will be recorded via an integrated system consisting of a portable radiological survey meter, a Global Positioning System, and a data logger that records instrument response and location coordinates. Approximated locations for 41 and 12 pCi/g concentration isopleths in the BC Controlled Area are shown in Figure 21. The locations of the isopleths were estimated by evaluating the existing surface radiological characterization data.

To accommodate effective and early review of instrument readings, the survey area will be subdivided into survey blocks, with measurements tracked using a combination of associated survey block numbers, survey line numbers, and survey point numbers. Each survey block will measure 250 m (820 ft) on a side. Survey lines and individual survey points will be located 25 m (82 ft) apart within each block. A full survey block will include 110 survey points. Survey blocks sharing common sides will have a lower number of points because of completed survey lines in the adjacent blocks. Based on the anticipated survey area, radiological data will be gathered from approximately 4,300 survey locations. Additional survey blocks will be added to expand the area coverage, if the two boundary lines are not clearly defined within the 46 planned survey blocks (Figure 21).

If prescribed survey points cannot be accessed because of obstructions or hazards, nearby locations will be selected and recorded along the survey lines. Radiological control technicians will perform the surface radiation surveys in accordance with applicable health and safety procedures. Instrument measurements and data-recording operations will be performed according to radiological survey task instructions generated by the Radiological Control organization. A survey report will be prepared that documents the procedures, deviations, instrument raw count rate values, survey location coordinates, and calculated concentrations of Cs-137. The calculated Cs-137 concentrations determined at each survey location will be used to delineate the 41 and 12 pCi/g concentration lines.

#### **3.14.3.2 Vehicle-Mounted Moving Survey Approach**

Vehicle-mounted radiological survey equipment will be used for moving radiological surveys in a selected portion of Zone B (Figure 21). Project-specific survey procedures for the mobile surveys and the equipment-specific minimum detectable concentration study will be established before field implementation.

This roving radiological survey will be used to obtain scoping data on the density and magnitude of hot spots in areas that generally are not contaminated. The survey area was selected after

review of existing historical airborne (WMP-18647) and walking radiological survey (BHI-01319) data.

The survey area measures about 1.6 by 0.8 km (1 by 0.5 mile) in lateral dimensions. The survey will consist of approximately 132 east-west transects that cross the area. Available tractor-mounted radiological survey equipment (Table 10) has an effective scanning width of approximately 1.2 m (4 ft). The survey will be designed to provide 20 percent areal coverage, using randomly spaced survey transects. The survey equipment will be configured with a Global Positioning System and data logger to record radiological measurements.

#### **3.14.4 Driven Soil Probes for Geophysical Surveys**

Driven small-diameter soil probes will be installed using a GeoProbe<sup>2</sup> 5400 hydraulic ram system (or other comparable equipment) at selected locations for geophysical logging with a small-diameter gross gamma logging system. The small-diameter logging system will be used to detect Cs-137 in the shallow subsurface soil to obtain vertical distribution profiles of gamma isotopes in Zones A and B. The soil probe locations will be selected based on the contamination data obtained by the surface radiological surveys.

Soil probes will be installed to a depth of approximately 3 m (10 ft) below ground surface. A detector will be incrementally lowered to the bottom of the soil probe, measuring in situ Cs-137 levels. Radiological profiles subsequently will be plotted for each location. The expected minimum detectable activity of the gamma-logging detector will be approximately 5 pCi/g for Cs-137.

Soil probes will be installed at 30 locations within Zone A and 24 locations within Zone B. The soil probe locations will provide good spatial coverage of the two zones. Ten of the Zone A soil probe locations will be in areas of the highest surface contaminant levels, ten will be installed in medium-level surface contamination areas, and ten in areas of the lowest detected Cs-137 concentrations. A similar distribution of soil probe locations also will be applied to Zone B; the 24 soil probes will be distributed in eight high concentration areas, eight medium concentration areas, and eight low concentration areas.

Results of the geophysical logging also will be used to identify soil-sampling locations for laboratory analysis. Logging capabilities are limited to analysis of gamma-emitting radionuclides. Strontium-90, which emits beta particles, will not be detected by the gamma-logging probe. Therefore, the soil analytical results will be used to provide data on the distribution of Sr-90 within the upper 3 m (10 ft) of the soil column. Soil sampling and analytical requirements are discussed in the following section.

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<sup>2</sup>GeoProbe is a registered trademark of GeoProbe Systems, Salina, Kansas.

### 3.14.5 Soil Sampling

Soil samples will be collected from within the areas defined by 41 and 12 pCi/g isopleths following the surface radiological survey and vertical logging data collection activities. The soil sampling will provide analytical data associated with the vertical distribution of Cs-137 and Sr-90 from ground surface to a depth of 3 m (10 ft). Direct-surface radiological measurements and logging results will be used to determine worst-case locations for soil sampling and laboratory analysis for Cs-137 and Sr-90. The soil sampling requirements are presented in Table 17. Analytical and sample container requirements are presented in Tables 6 and 8.

The 3 m (10 ft) sampling depth was set to extend beneath the maximum depth of Cs-137 and Sr-90 migration based on existing data. The analytical results will be used to supplement geophysical logging results for Cs-137 and to support risk calculations and evaluation of remedial action alternatives. Sampling locations will be selected to provide good spatial distribution of the waste site. Samples obtained for the vertical contamination profile will be collected from four depth intervals, including 0 to 0.15 m (0 to 0.5 ft), 0.15 to 0.3 m (0.5 to 1 ft), 0.8 to 1.1 m (2.5 to 3.5 ft), and 1.8 to 2.1 m (6 to 7 ft) below ground surface. A contingent sample will be collected from the 2.7 to 3 m (9 to 10 ft) depth interval at all locations. Laboratory analysis for the contingent sample only will be performed if detections for Cs-137 or Sr-90 occur within the 1.8 to 2.1 m (6 to 7 ft) sample interval.

## 3.15 WASTE MANAGEMENT SAMPLING

A DQO process was conducted to identify additional sampling that may be required to support waste management of the soil or other materials generated during site cleanup and sampling. The DQO process included a review of the contaminants of potential concern identified for the 200-UR-1 OU and an analysis of any additional constituents that should be evaluated to complete the waste designation and profile. Based on the results of WMP-19920, samples for additional contaminants are required as listed in Table 18. Table 19 details the additional sampling identified and the corresponding analytical requirements. Bottle requirements are presented in Table 8. Figures 22 and 23 illustrate the decision processes related to waste designation characterization.

Modification of the waste sampling and analysis requirements determined during the DQO process may be required at some sites. Site-specific waste characterization sampling and analytical requirements will be developed as needed for waste acceptance at the Environmental Restoration Disposal Facility. Additional analytical data may be needed at some sites if no existing waste profiles correspond to the suspected waste streams.

### 3.15.1 Waste Designation Sampling Design

A judgmental sampling approach is used for waste designation determinations. Table 20 presents the key features of the material/media waste sampling designs for the 200-UR-1 OU waste sites. Wastes that require characterization include material/media that cannot be designated without characterization and may require special handling for human-exposure

protection or waste acceptance. Uncontainerized, unknown material/media and unknown waste containers have been included in this category even though it is not anticipated that this type of waste will be encountered during cleanup of the 200-UR-1 OU waste sites. The sampling protocols for waste material/media and unknown waste forms also are identified in Table 20.

### **3.15.2 Optimal Sample Size that Satisfies the Data Quality Objectives**

Because judgmental sampling has been applied, a statistical design is not applicable. Sampling for waste profile/designation of the material/media will be focused in two areas. Sampling of herbicides and pesticides will be performed near the material/media surface where these constituents are most likely to be present. Sampling of material/media also will be performed in the most highly contaminated areas as determined through field-screening techniques.

Periodic sampling for quick-turnaround laboratory analyses of nonradiological contaminants may be performed to verify waste profiles as directed by the resident engineer.

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#### **4.0 HEALTH AND SAFETY**

All field operations will be performed in accordance with Project Hanford Management Contractor health and safety requirements and the appropriate Deactivation and Decommissioning Project procedures. In addition, a work control package will be prepared in accordance with procedures that will further control site operations. This package will include an activity hazard analysis, a site-specific health and safety plan, and applicable radiological work permits. Work shall be performed in accordance with site-specific health and safety plans and applicable radiological work permits.

The sampling procedures and associated activities will take into consideration exposure reduction and contamination control techniques that will minimize the radiation exposure to the sampling team as required by the procedures mentioned earlier.

Health and safety personnel will use data collected during the removal action as input to determine exposure levels to workers and to conduct health and safety assessments in accordance with the health and safety plan.

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## 5.0 MANAGEMENT OF REMOVAL ACTION WASTE

The waste generated during excavation or characterization activities will be managed in accordance with existing waste management procedures that identify the requirements and responsibilities for containment, labeling, and tracking of investigation-derived waste. Management of investigation-derived waste, minimization practices, and waste types applicable to 200-UR-1 OU waste control will be described in a waste control plan.

Unused samples and associated laboratory waste for the analysis will be dispositioned in accordance with the laboratory contract, which in most cases will require the laboratory to dispose of this material. The approval of the remedial project manager is required before returning unused samples or waste from offsite laboratories.

Investigation-derived waste is defined as potentially contaminated waste materials that result from field investigation and characterization activities and may pose a risk to human health and the environment. This waste may include soil and other materials from the collection of samples, residues from the testing of treatment technologies, contaminated personal protective equipment, decontamination fluids (aqueous or otherwise), and disposable sampling equipment (EPA 1992, *Guide to the Management of Investigation-Derived Wastes*, Publication 9345.3FS).

The highest levels (contamination and dose-rate information) indicated on the survey record will be used for waste verification purposes. This information then will be converted from the reported units (e.g., dose rate, disintegrations per minute) to an activity per unit mass. The basis for the conversion will be documented. All radiological instruments used will be calibrated within the frequency specified in the instrument operating procedures. Daily instrument response checks for portable instruments will be performed in accordance with existing applicable protocols.

The isotopic distribution for waste designation will be derived from the soil sampling analytical results. The waste generated during site operations will be handled according to a waste control plan for the 200-UR-1 OU.

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## 6.0 REFERENCES

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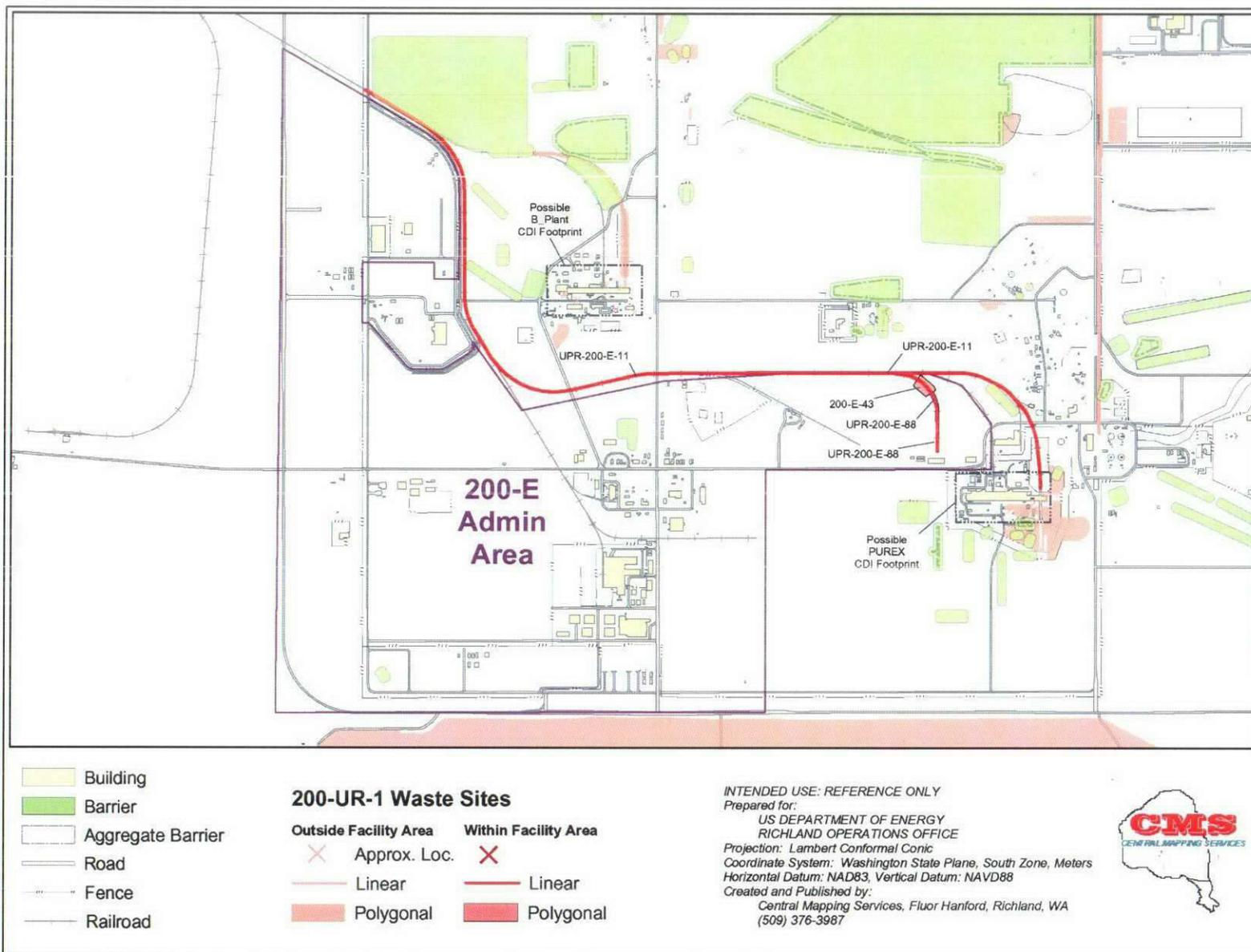
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Figure 1. 200-UR-1 Operable Unit Sites Within the 200 East Administrative Area.



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Figure 2. 200-UR-1 Operable Unit Sites Within the B Plant Area.

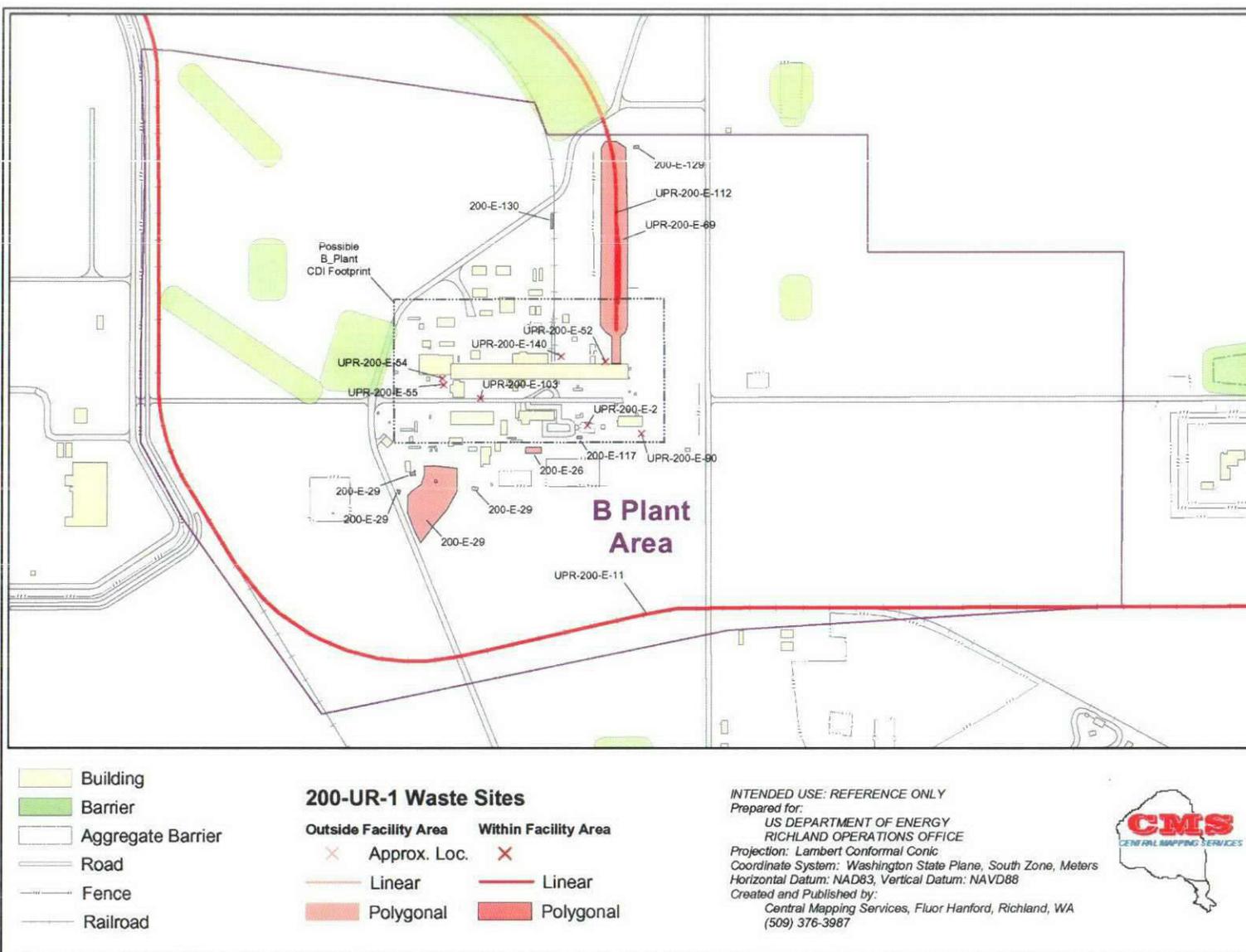


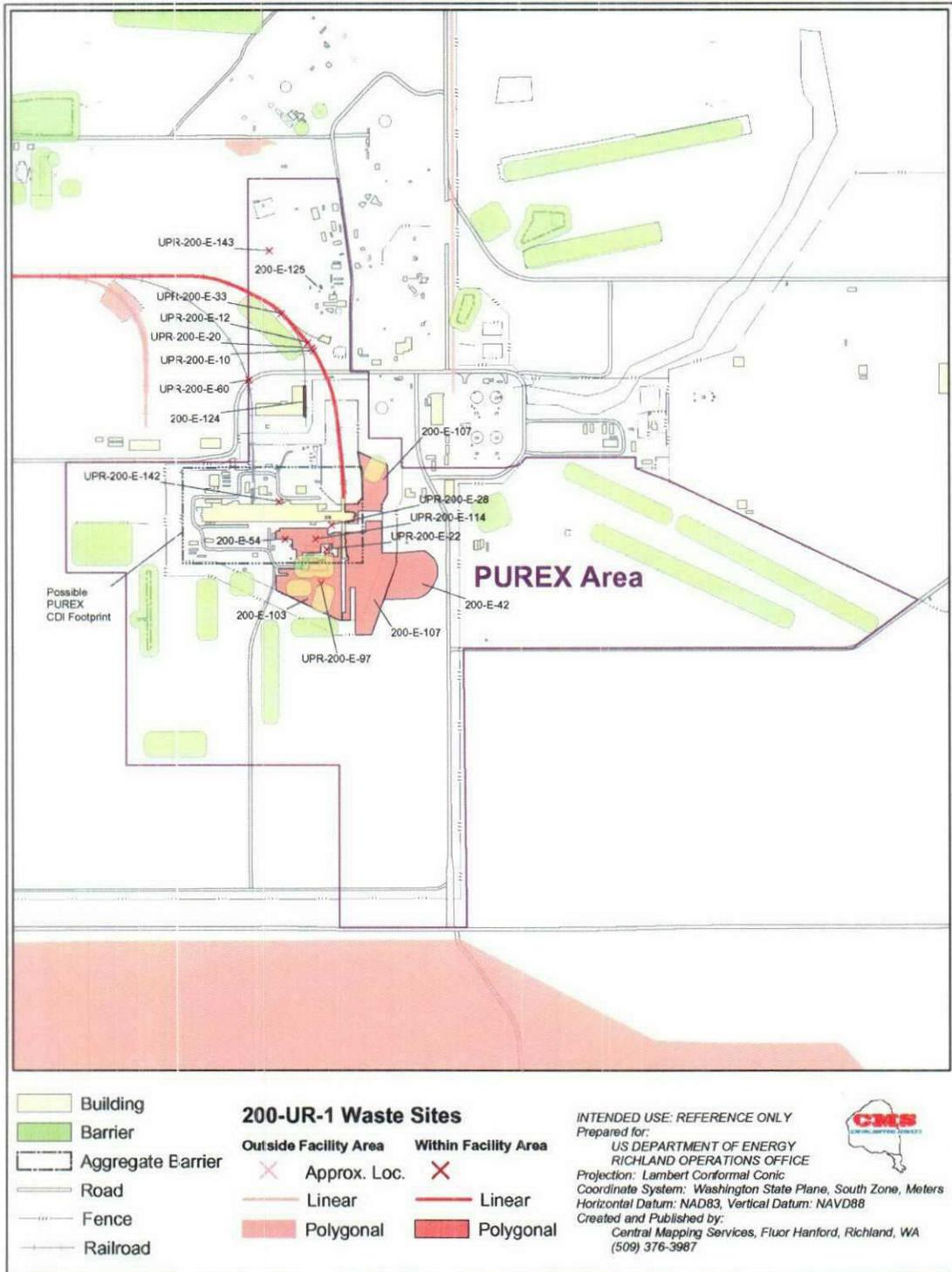
Figure 3. 200-UR-1 Operable Unit Sites Within the B Farm Area.



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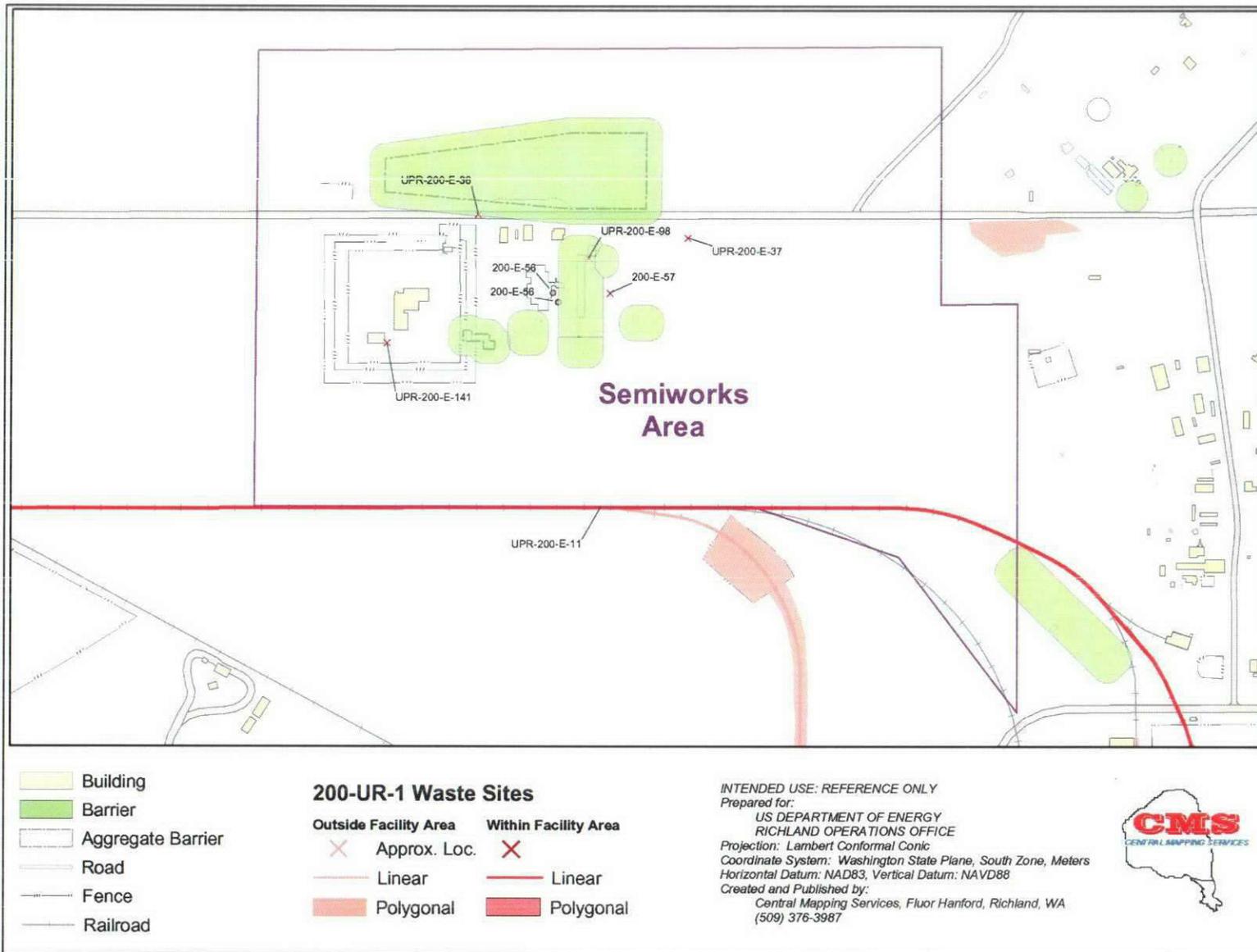
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Figure 4. 200-UR-1 Operable Unit Sites Within the Plutonium-Uranium Extraction Plant Area.



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Figure 5. 200-UR-1 Operable Unit Sites Within the Semiworks Area.



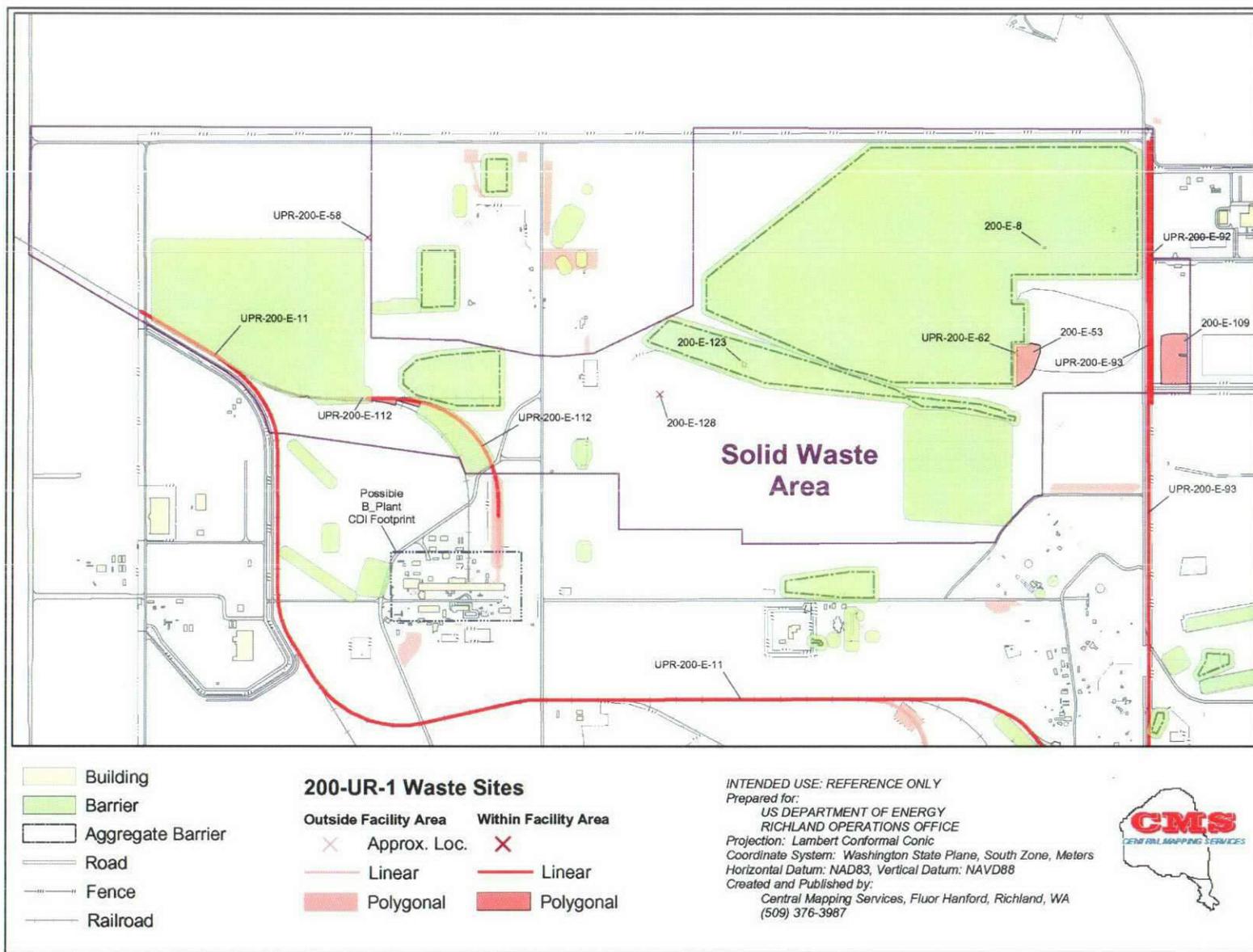
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Figure 6. 200-UR-1 Operable Unit Sites Within the Waste Treatment Plant A Farm, C Farm, and Effluent Treatment Facility Farm Areas.



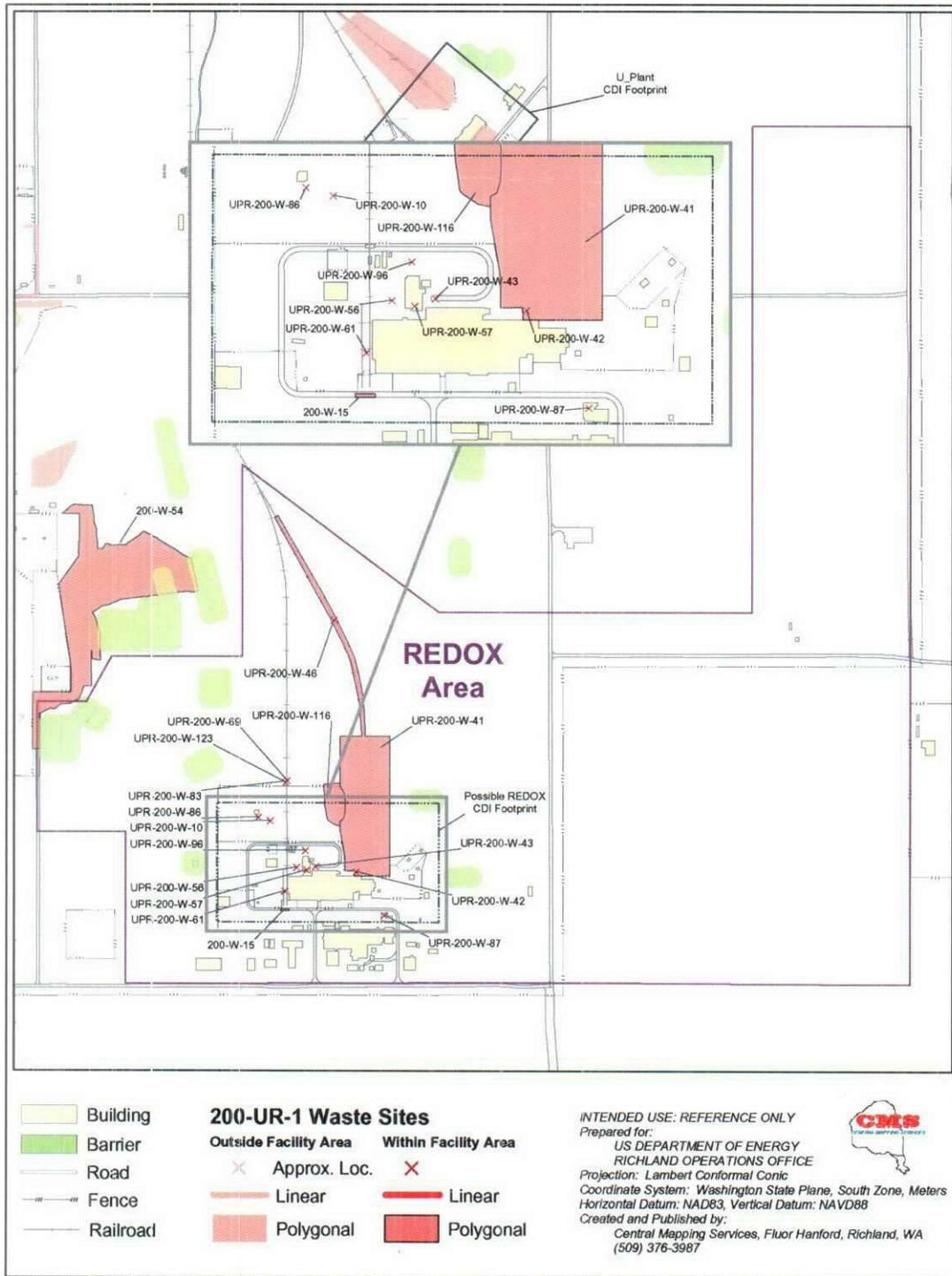
Figure 7. 200-UR-1 Operable Unit Sites Within the Solid Waste Area.



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Figure 8. 200-UR-1 Operable Unit Sites Within the Reduction-Oxidation Plant Area.



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Figure 9. 200-UR-1 Operable Unit Sites Within the S/U Farm Area.

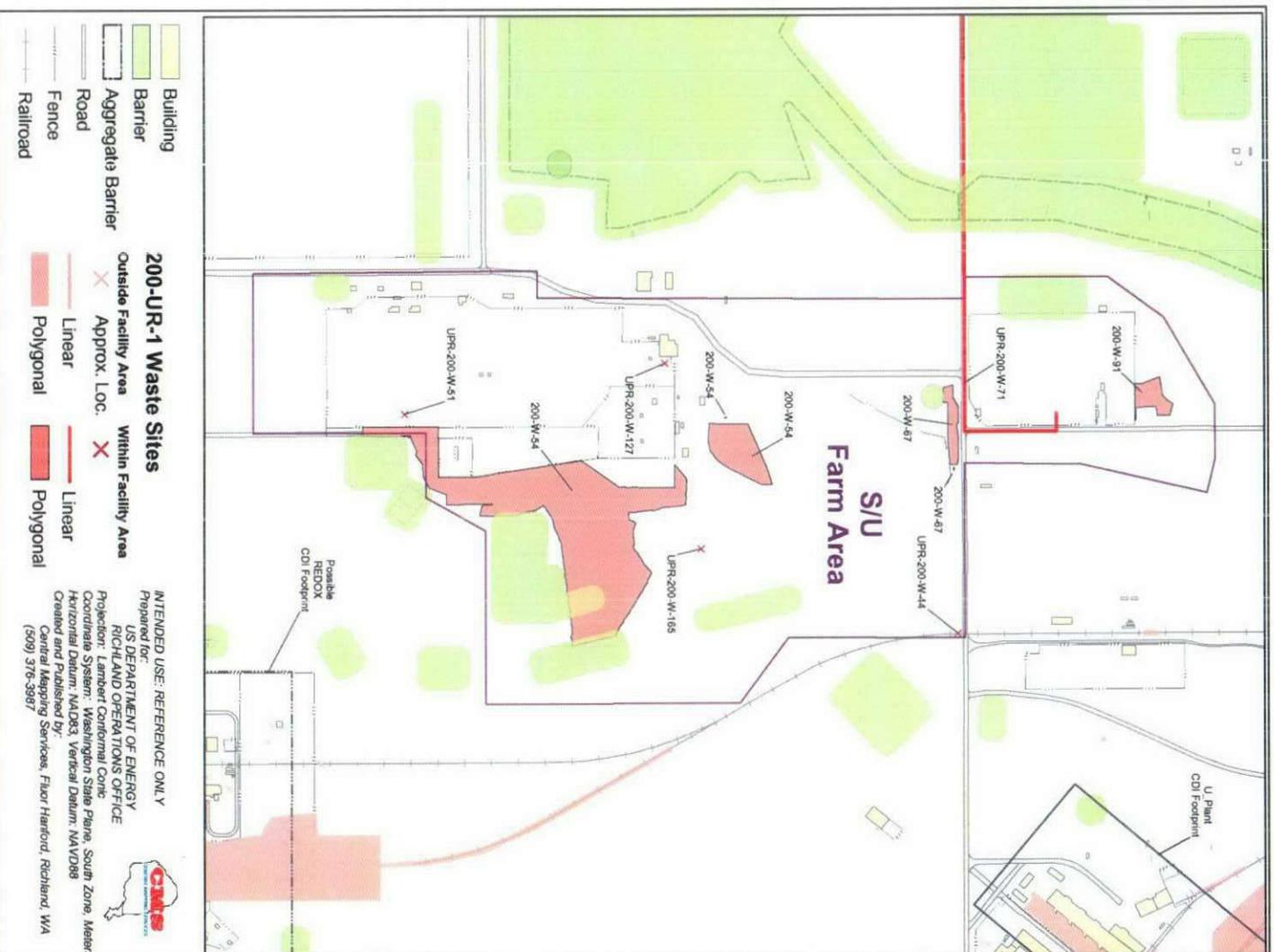


Figure 10. 200-UR-1 Operable Unit Sites Within the U Plant Area.



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Figure 11. 200-UR-1 Operable Unit Sites Within the Plutonium Finishing Plant Area.

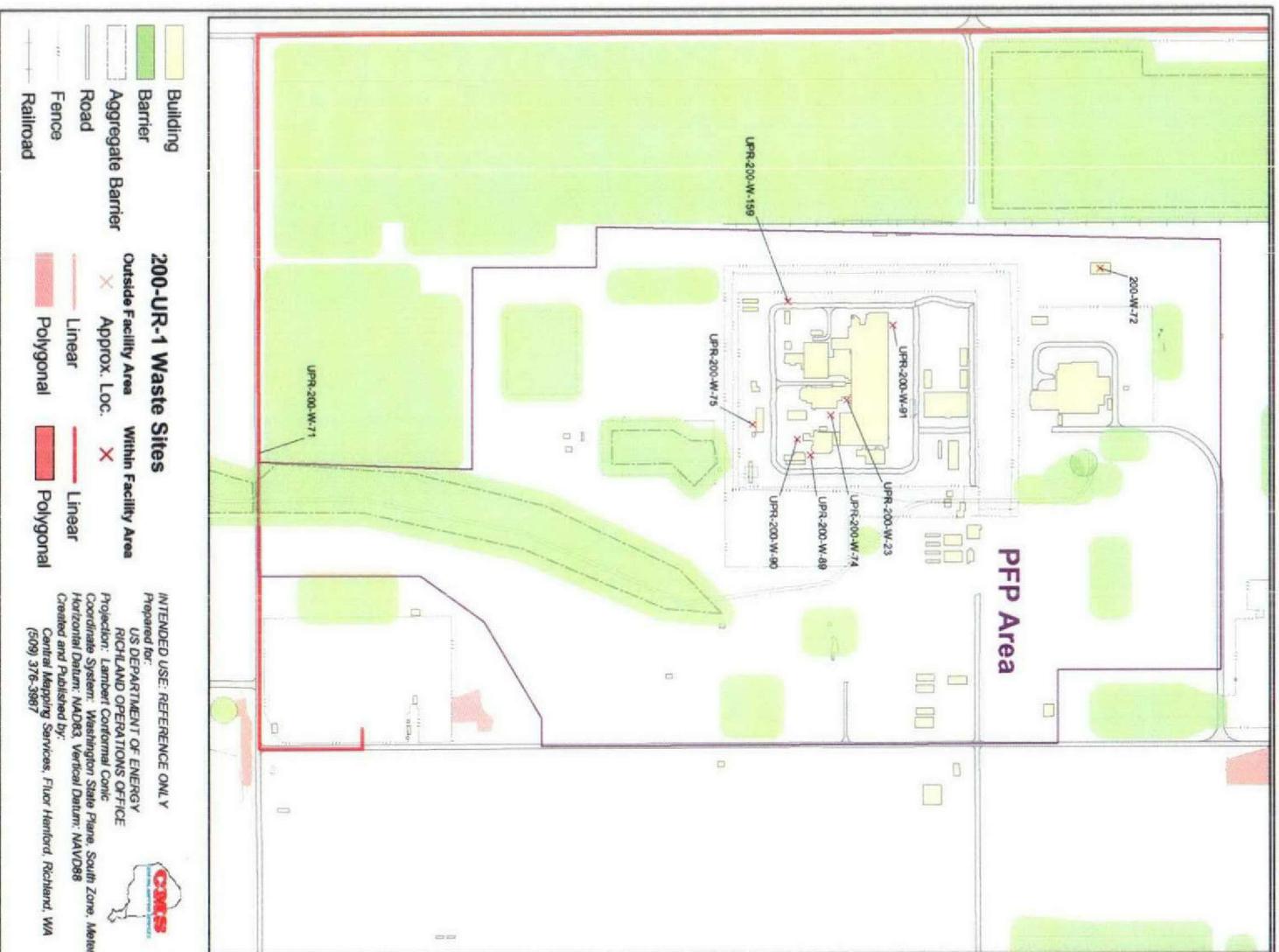
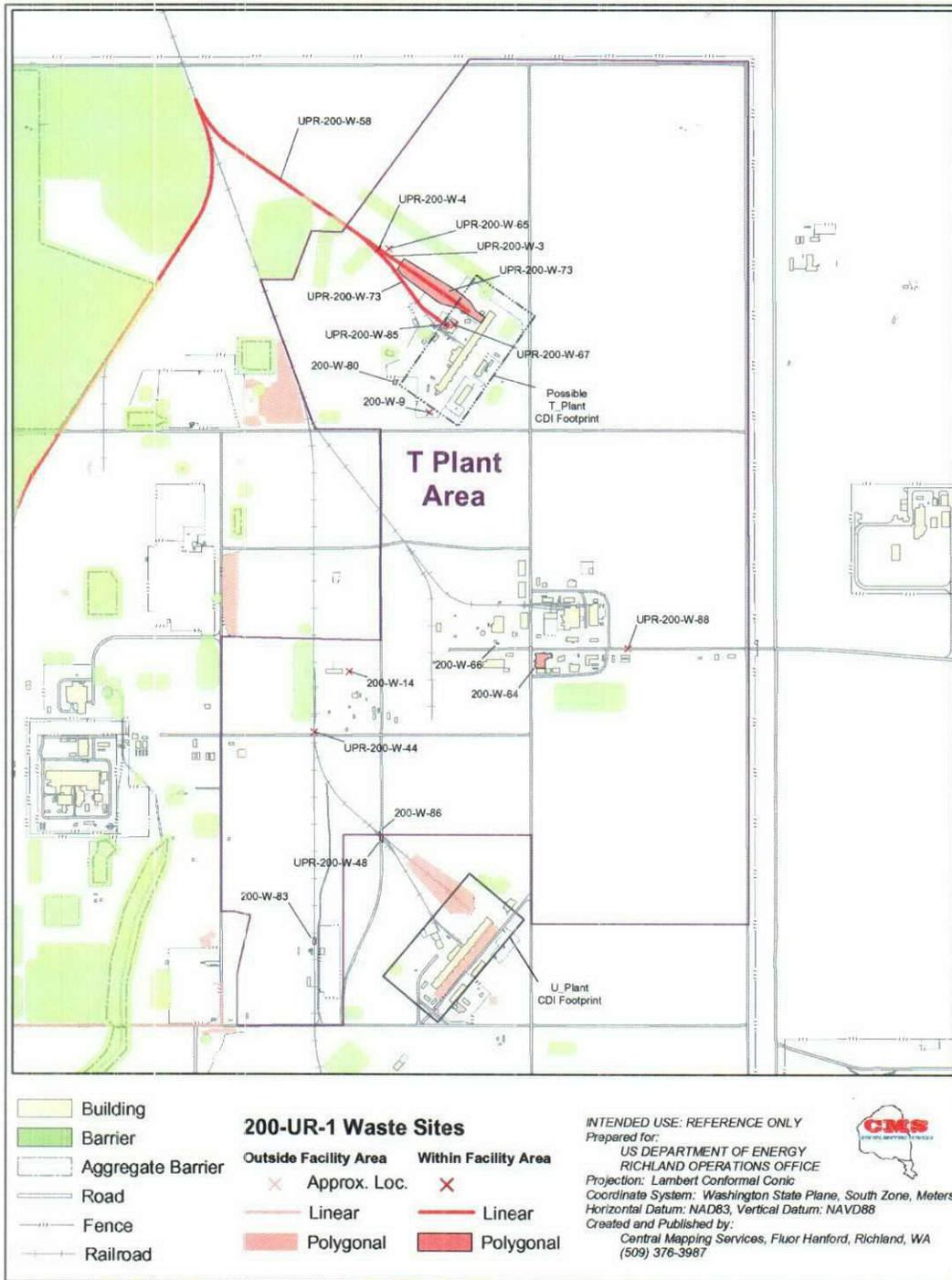


Figure 12. 200-UR-1 Operable Unit Sites Within the T Farm Area.



Figure 13. 200-UR-1 Operable Unit Sites Within the T Plant Area.



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Figure 14. 200-UR-1 Operable Unit Sites Within the WM Area.



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Figure 15. Conceptual Site Model for Animal Droppings, Vegetation Material, and Windblown Particulate Waste Sites, 200 Area Unplanned Releases.

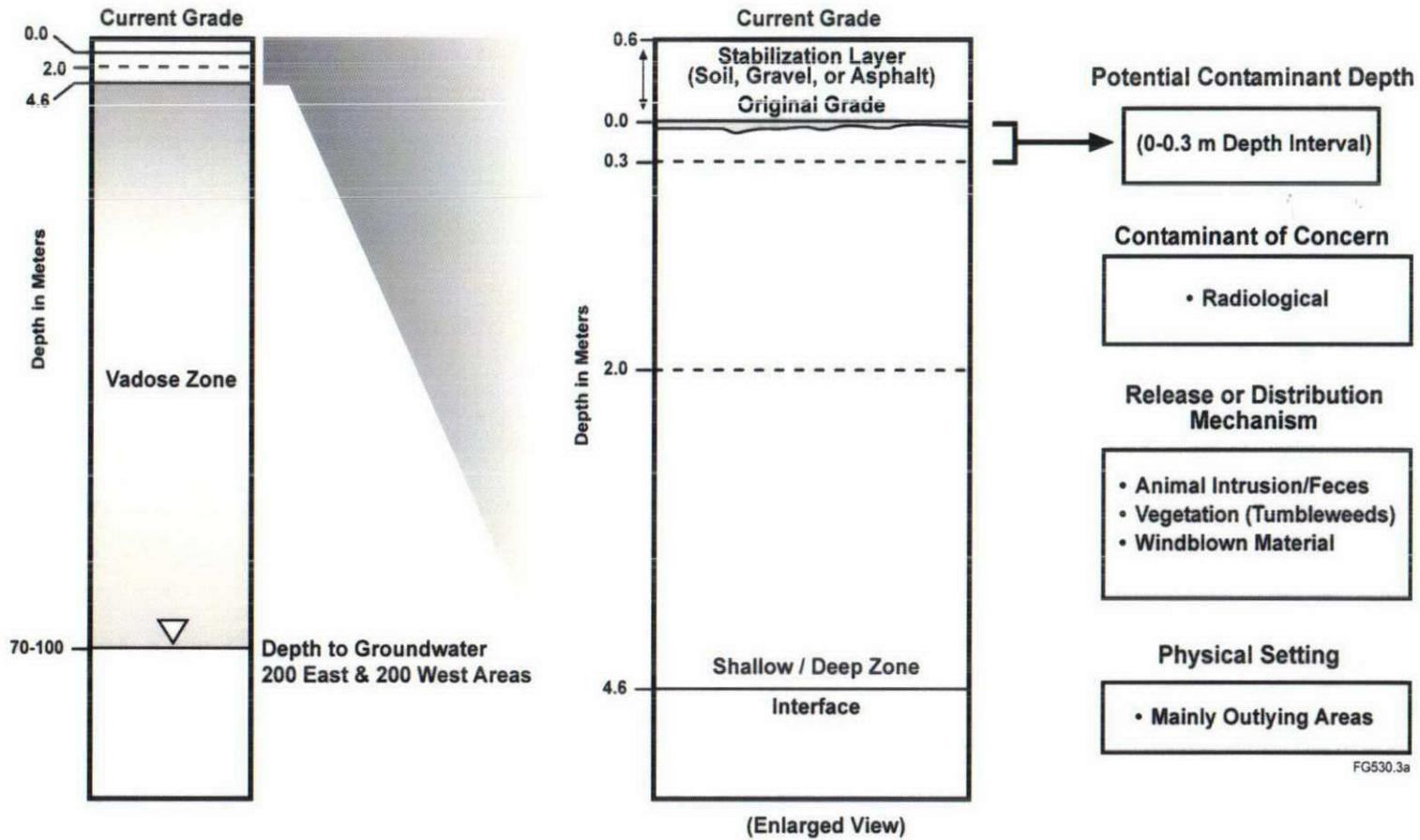


Figure 16. Conceptual Site Model for Small Leak/Spill Sites, 200 Area Unplanned Releases.

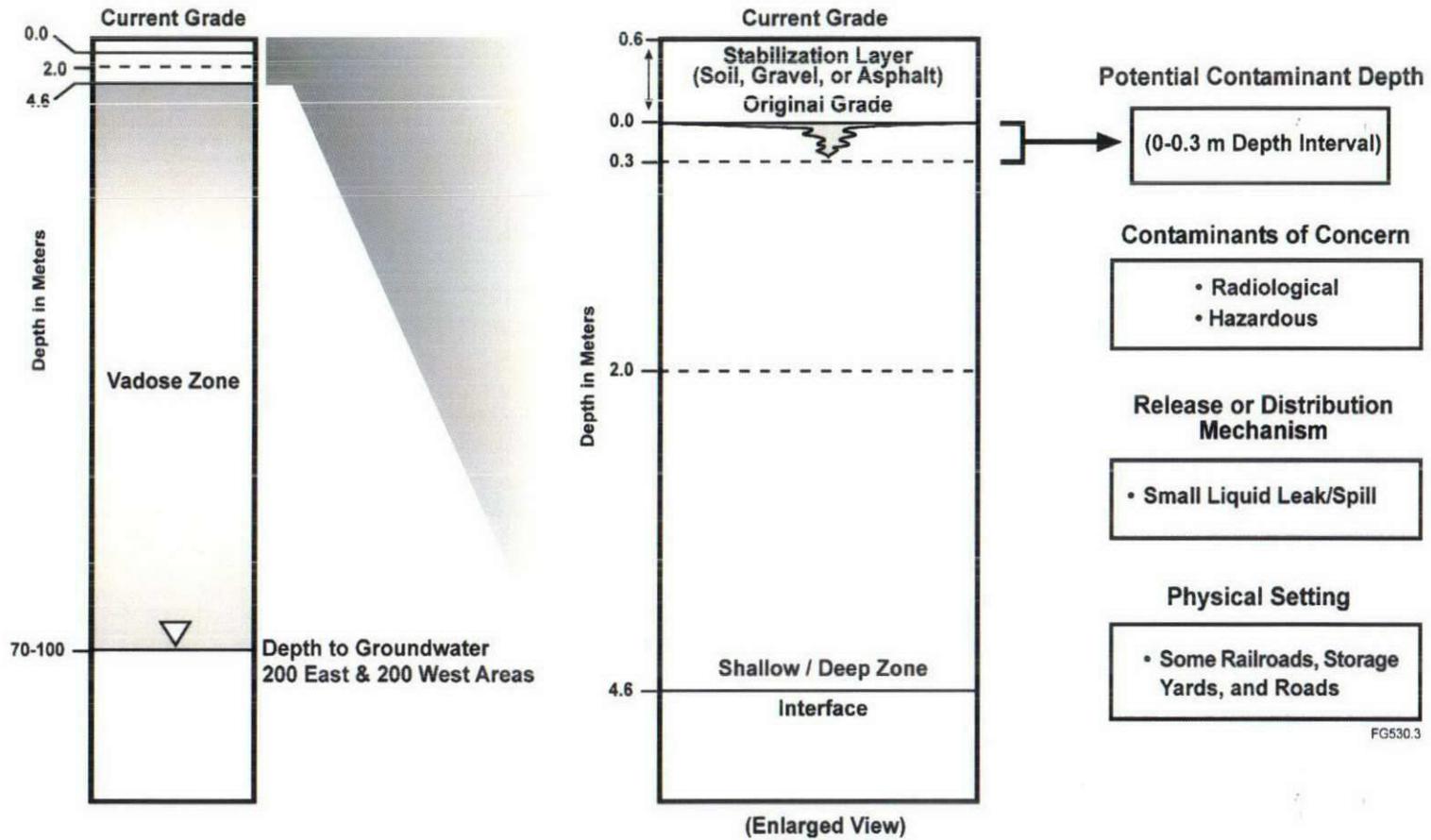


Figure 17. Conceptual Site Model for Moderate Leak/Spill Sites 200 Area Unplanned Releases.

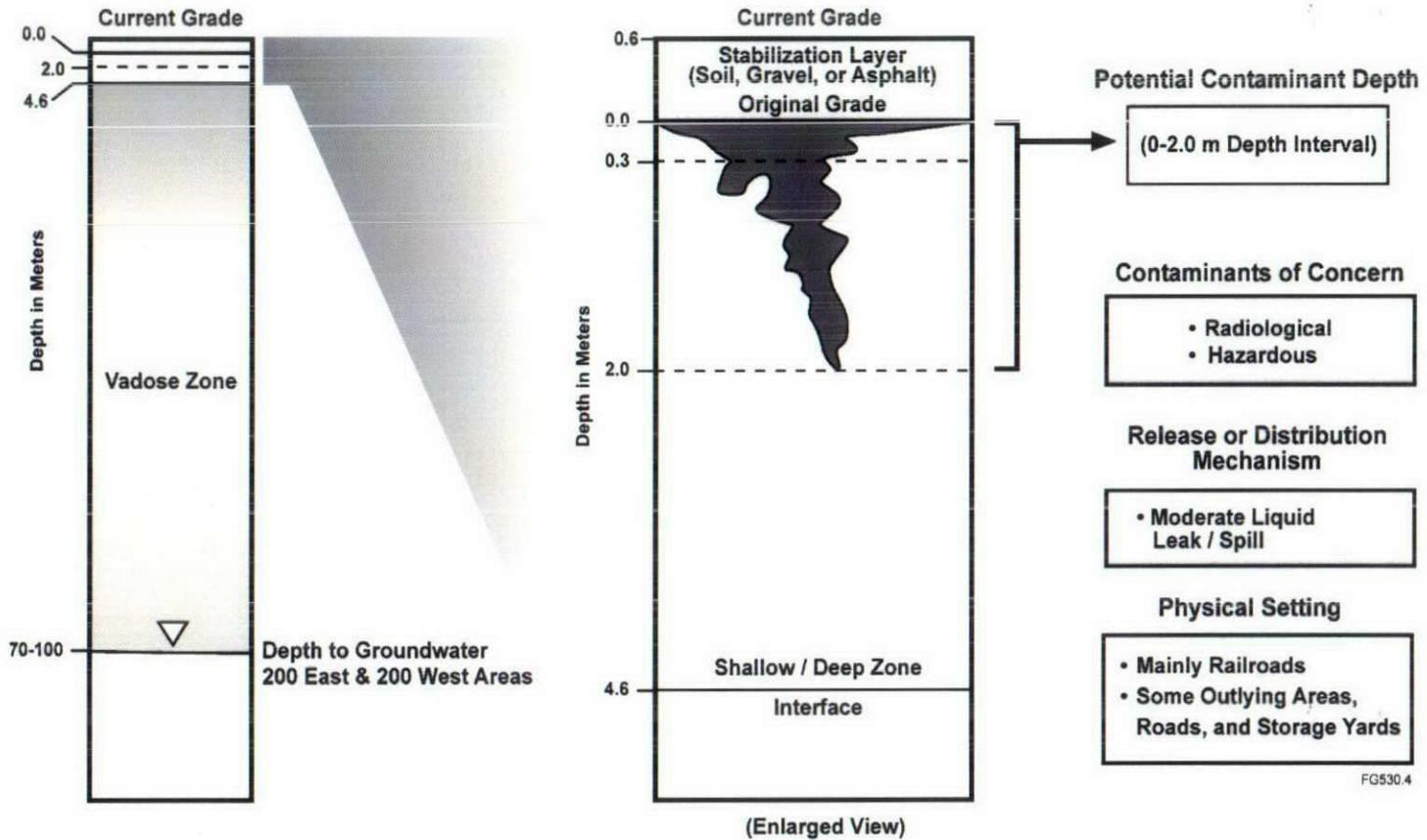


Figure 18. Conceptual Site Model for Larger Leak/Spill Sites 200 Area Unplanned Releases.

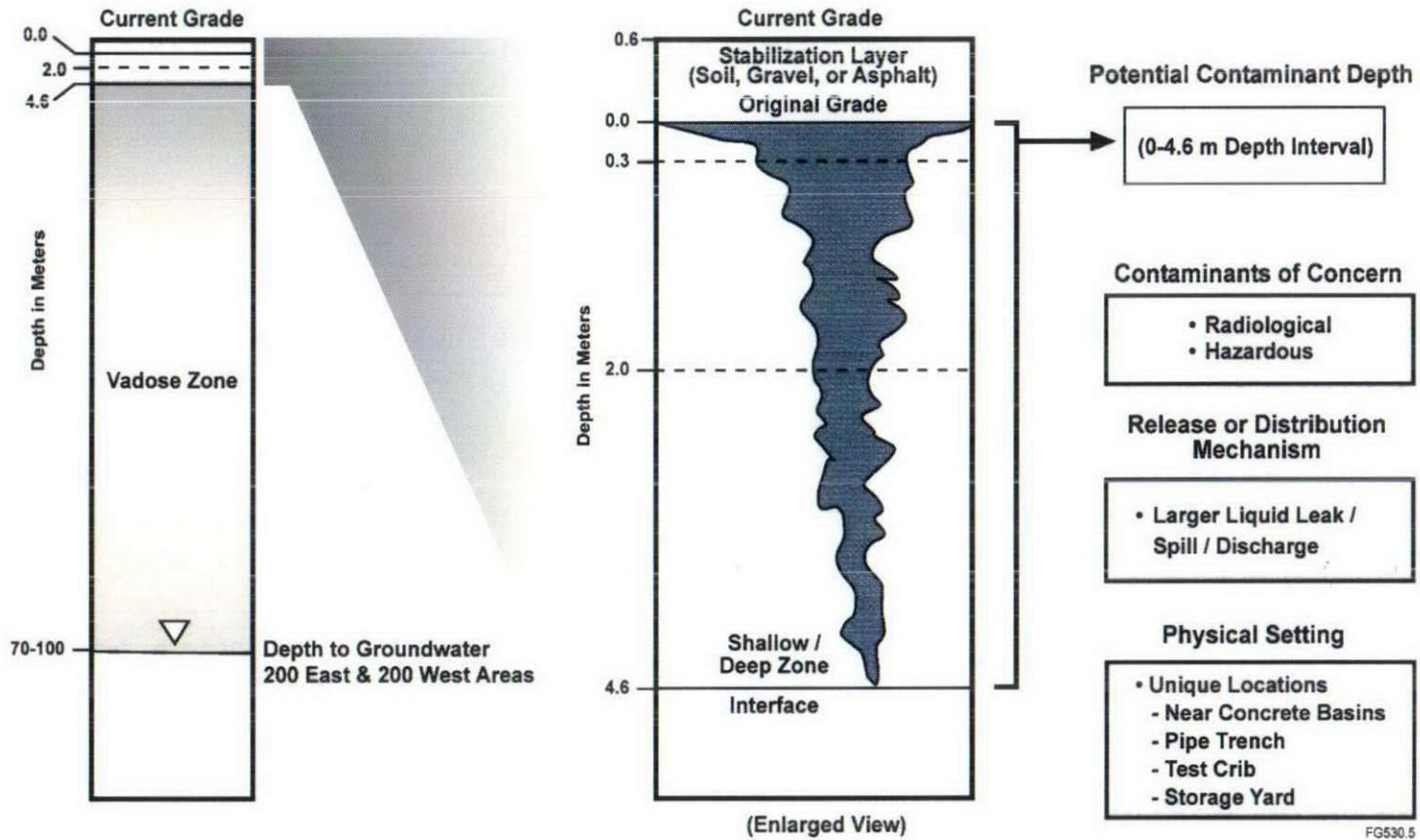
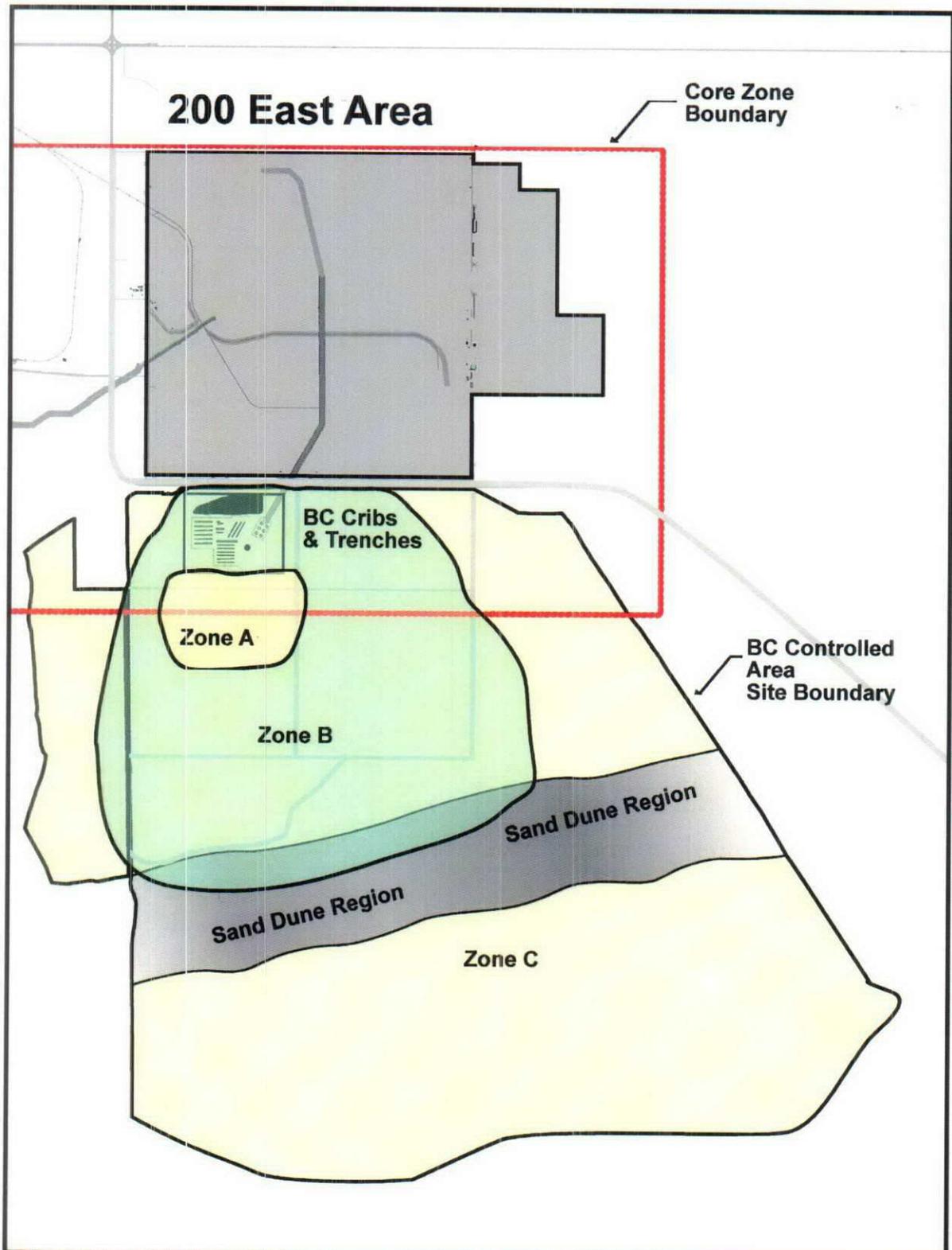
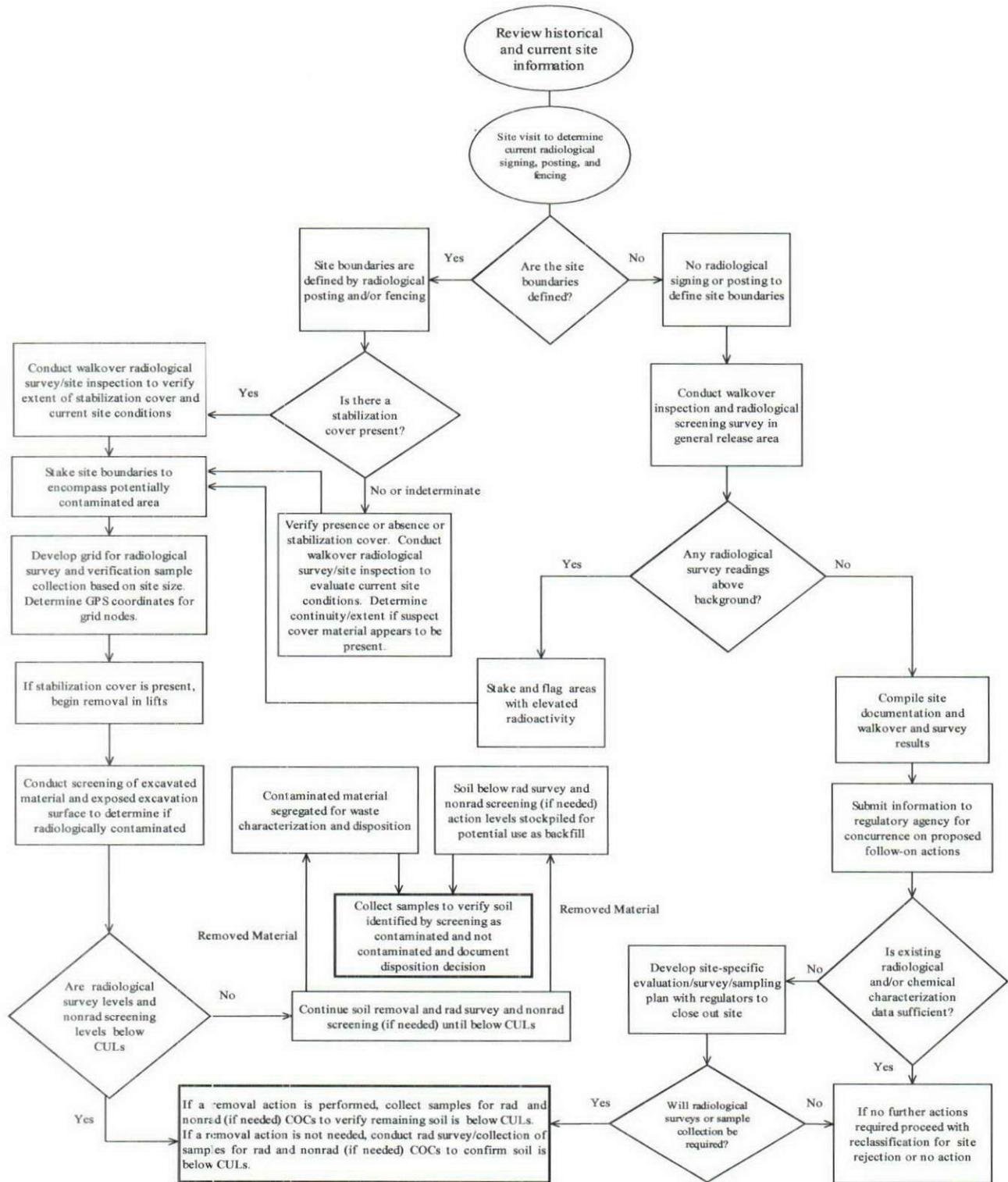


Figure 19. Identification of Conceptual Site Model Zones Within the BC Controlled Area.



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Figure 20. Sample Design Process Flow for Removal, Treatment, and Disposal Sites.



COC = contaminant of concern.  
 CUL = cleanup level.  
 GPS = Global Positioning System.

Figure 21. Proposed Radiological Survey Grid Locations Within the BC Controlled Area.

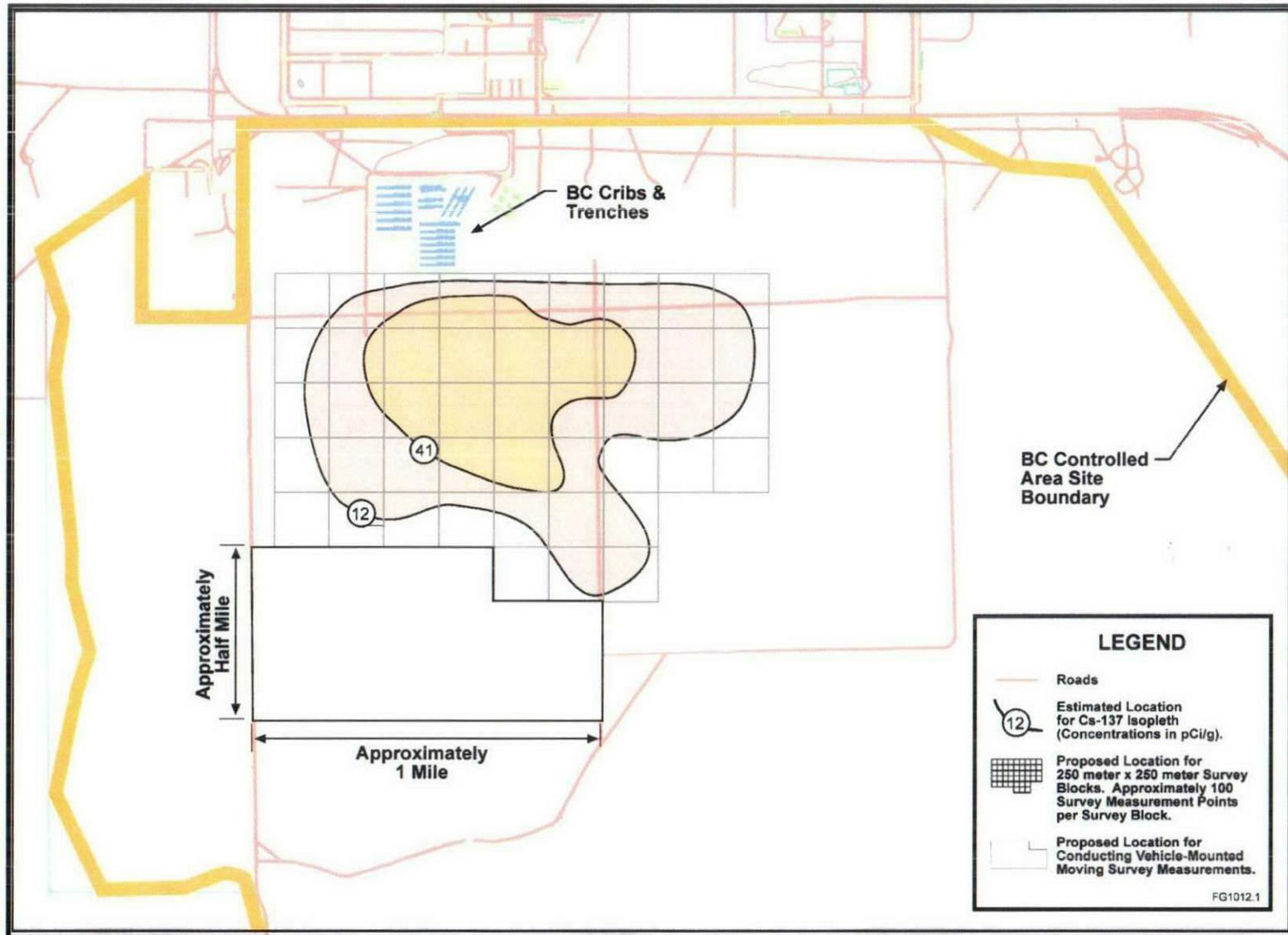
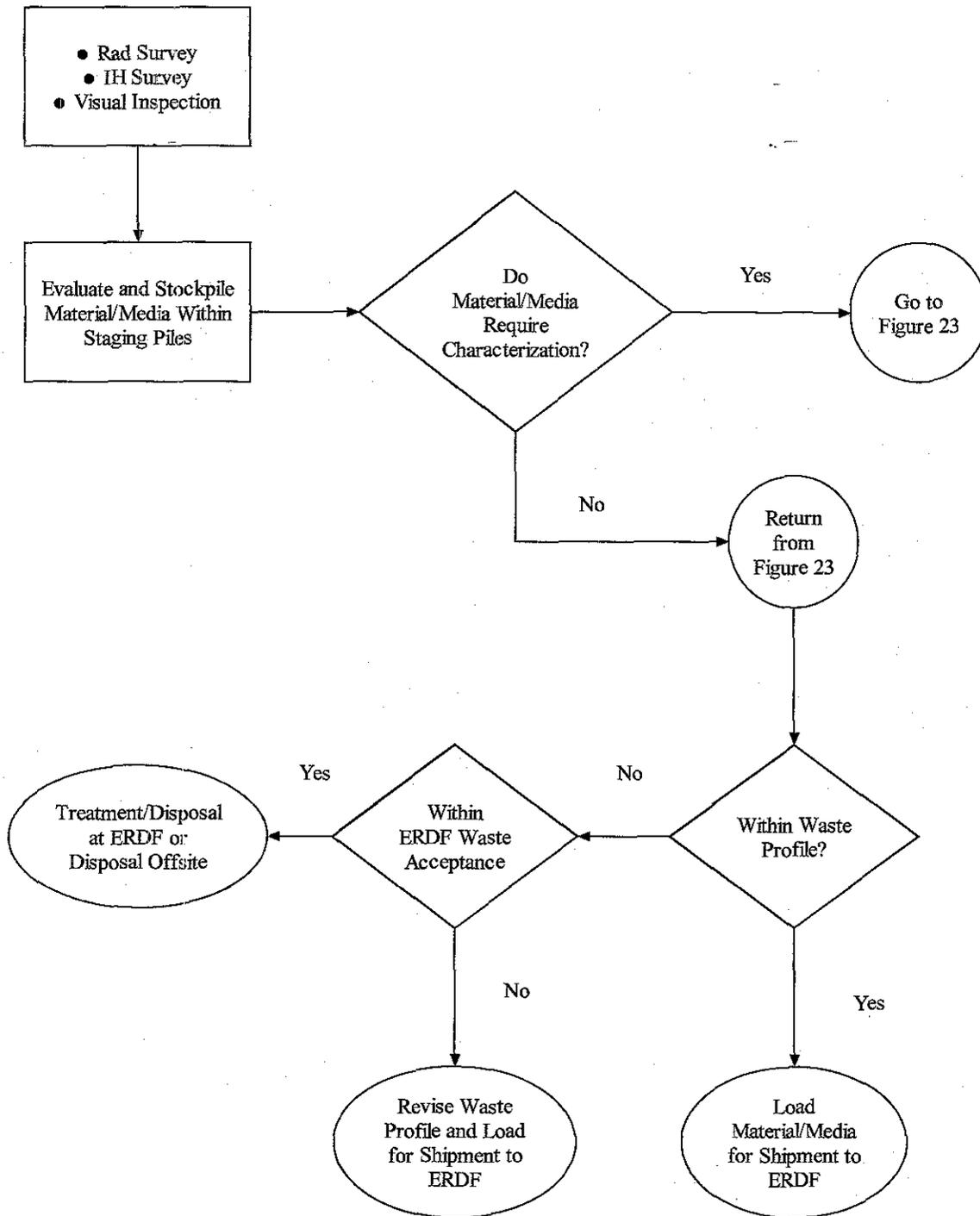
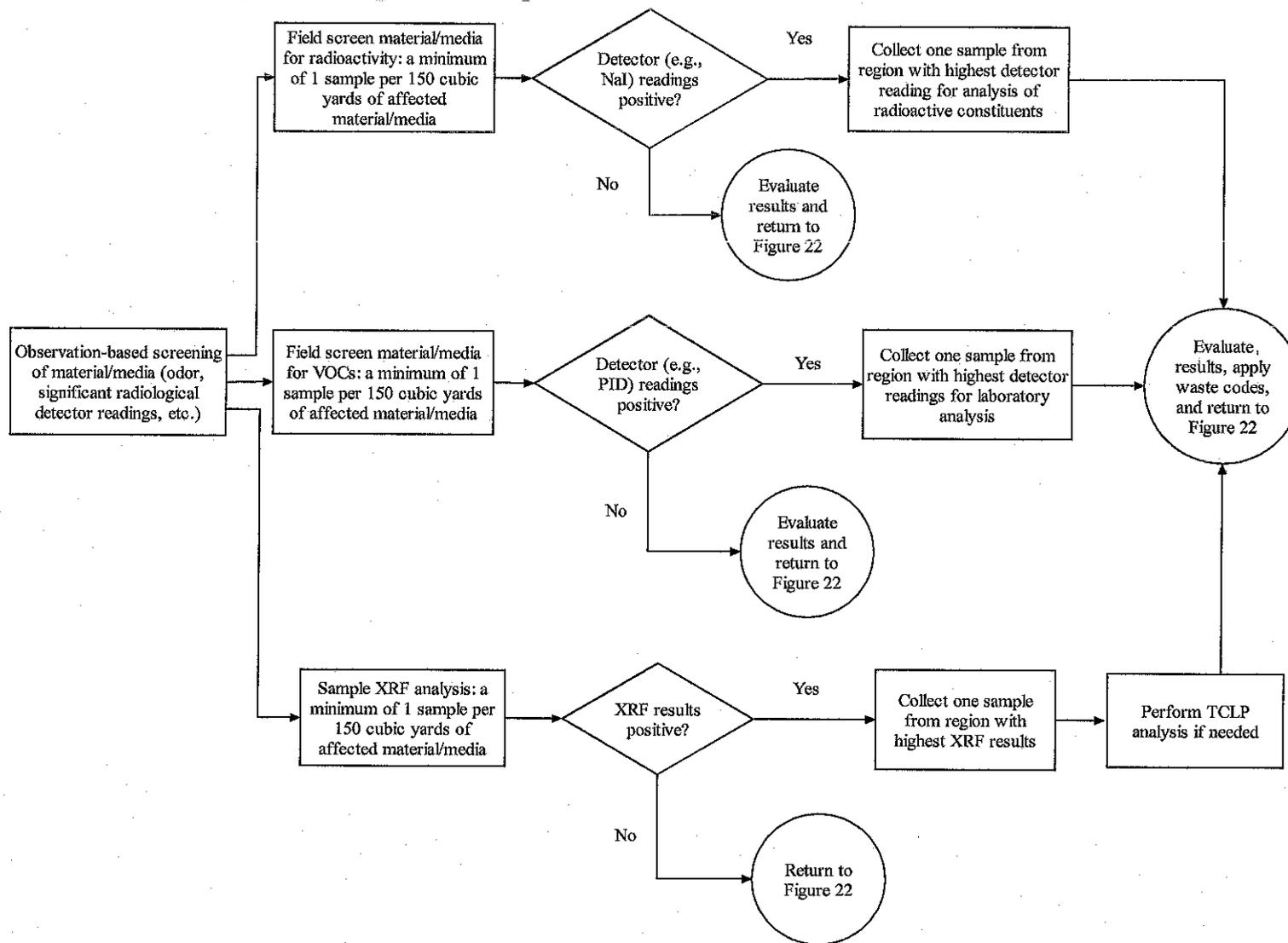


Figure 22. Logic Flow Diagram for Disposition of Material/Media.



ERDF = Environmental Restoration Disposal Facility.  
IH = industrial health.

Figure 23. Logic Flow Diagram for Characterization of Waste Material/Media.



NaI = sodium iodide.  
 PID = photoionization detector.  
 TCLP = toxicity characteristic leaching procedure.  
 VOC = volatile organic compound.  
 XRF = X-ray fluorescence.

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Table 1. 200-UR-1 Operable Unit Sites Identified for Inclusion Under Scope of this Sampling and Analysis Plan.

200-E-26	200-W-14	UPR-200-E-10	UPR-200-N-1	UPR-600-12
200-E-29	200-W-53	UPR-200-E-11	UPR-200-N-2	600-262
200-E-43	200-W-54	UPR-200-E-12	UPR-200-W-3	600-275
200-E-53	200-W-63	UPR-200-E-20	UPR-200-W-4	
200-E-109	200-W-64	UPR-200-E-33	UPR-200-W-23	
200-E-115	200-W-67	UPR-200-E-43	UPR-200-W-41	
200-E-117	200-W-80	UPR-200-E-50	UPR-200-W-44	
200-E-121	200-W-81	UPR-200-E-69	UPR-200-W-46	
200-E-124	200-W-83	UPR-200-E-88	UPR-200-W-58	
200-E-125	200-W-86	UPR-200-E-89	UPR-200-W-65	
200-E-128	200-W-90	UPR-200-E-101	UPR-200-W-67	
200-E-129	200-W-106	UPR-200-E-112	UPR-200-W-73	
200-E-130		UPR-200-E-143	UPR-200-W-96	
200-E-139			UPR-200-W-116	

Table 2. Contaminants of Concern for 200-UR-1 Operable Unit. (2 Pages)

Radioactive Constituents		
Americium-241	Neptunium-237	Tritium <sup>b</sup>
Carbon-14	Nickel-63	Uranium-233/234
Cesium-137	Niobium-94 <sup>a</sup>	Uranium-235/236
Cobalt-60	Plutonium-238	Uranium-238
Europium-152	Plutonium-239/240	
Europium-154	Strontium-90	
Europium-155	Technetium-99	
Chemical Constituents – Metals		
Antimony	Copper	Silver
Arsenic	Hexavalent chromium	Vanadium
Barium	Lead	Zinc
Beryllium	Mercury	
Cadmium	Nickel	
Chromium	Selenium	
Chemical Constituents – Other Inorganics		
Cyanide	Nitrate/Nitrite	
Fluoride	Sulfate	

Table 2. Contaminants of Concern for 200-UR-1 Operable Unit. (2 Pages)

<b>Chemical Constituents – Volatile Organics</b>		
Acetone	1,1-dichloroethane	Toluene
Acetonitrile	1,2-dichloroethane	1,1,1-trichloroethane (TCA)
Benzene	Dichloromethane (methylene chloride)	1,1,2-trichloroethane
1-butanol (n-butyl alcohol)	Ethylbenzene halogenated	Trans-1,2-dichloroethylene
2-butanone (MEK)	hydrocarbons	Tetrachloroethylene (PCE)
Carbon tetrachloride	Hexane	Trichloroethylene (TCE)
Chlorobenzene	Methyl isobutyl ketone (MIBK)	Vinyl chloride
Cis-1,2-dichloroethylene	Perchloroethylene	Xylenes
Cyclohexane	Tetrahydrofuran	
<b>Semivolatile Organics</b>		
AMSCO <sup>c</sup> tributyl phosphate dilutant	Normal paraffin hydrocarbon	Tributyl phosphate and derivatives (mono, bi)
Cyclohexanone	Paint thinner	
Diesel fuel	Phenol	
Dodecane	Polychlorinated biphenyls	
Hydraulic fluids (greases)	Shell E-2342 (naphthalene and paraffin)	
Kerosene <sup>d</sup>		
Naphthylamine	Soltrol-170 (C <sub>10</sub> H <sub>22</sub> to C <sub>6</sub> to H <sub>34</sub> ; purified kerosene)	

<sup>a</sup>Contaminant of concern applicable to Plutonium Finishing Plant area only.

<sup>b</sup>Constituent will be retained only at liquid spill sites.

<sup>c</sup>Product of Allen Maintenance Supply Company Inc.

<sup>d</sup>Analyzed as kerosene total petroleum hydrocarbon.

Table 3. Summary of Potential 200-UR-1 Operable Unit Radionuclide Soil Preliminary Cleanup Levels.

Contaminant	Removal Action Objective – Protection from Direct Exposure <sup>a,b</sup>		Removal Action Objective – Groundwater Protection (pCi/g)
	Preliminary CUL for Radionuclides (pCi/g) 15 mrem/yr Industrial (Inside Core Zone)	Preliminary CUL for Radionuclides (pCi/g) 15 mrem/yr Unrestricted (Outside Core Zone)	
Americium-241	210	31.1	TBD
Carbon-14	33,100	5.16	TBD
Cesium-137	25	6.2	TBD
Cobalt-60	5.2	1.4	TBD
Europium-152	12	3.3	TBD
Europium-154	11	3.0	TBD
Europium-155	518	125	TBD
Neptunium-237	59.2	2.5	TBD
Nickel-63	3,070,000	4,026	TBD
Niobium-94 <sup>c</sup>	8.25	2.43	TBD
Plutonium-238	155	37.4	TBD
Plutonium-239/240	245	33.9	TBD
Strontium-90	2,500	4.5	TBD
Technetium-99	12,000	15	TBD
Tritium <sup>d</sup>	471	400	TBD
Uranium-233/234	267	1.1	TBD
Uranium-235/236	101	1.0	TBD
Uranium-238	267	1.1	TBD

NOTE: Values in the table are CULs based on the generic site model. Site-specific values will be calculated for site closeout verification using site-specific information. Lowest CUL value for each radionuclide is indicated by shading.

<sup>a</sup>Direct-exposure values represent soil activities for individual radionuclides that would meet the removal action objective for cumulative risk (i.e.,  $10^{-4}$  to  $10^{-6}$  risk) from exposure to contaminated waste/soil. Values will be lower for multiple radionuclides to achieve the same risk endpoint. Listed values are calculated by RESRAD and apply to the top 4.6 m (15 ft).

<sup>b</sup>In the shallow zone, cleanup must achieve the direct-exposure removal action objective.

<sup>c</sup>Contaminant of concern applicable to Plutonium Finishing Plant area only.

<sup>d</sup>Constituent will be retained only at liquid spill sites.

ANL, 2002, *RESRAD for Windows*, Version 6.21.

CUL = cleanup level.

RESRAD = RESidual RADioactivity (dose model) (ANL 2002).

TBD = to be determined.

Table 4. Summary of 200-UR-1 Operable Unit Nonradionuclide Soil Preliminary Cleanup Levels. (3 Pages)

Contaminant	Removal Action Objective – Protection from Direct Exposure		Ecological Protection <sup>a</sup>		Removal Action Objective – Groundwater Protection <sup>1</sup>
	Preliminary CULs for Nonradionuclides (mg/kg) Industrial (Inside Core Zone)	Preliminary CULs for Nonradionuclides (mg/kg) Unrestricted (Outside Core Zone)	Unrestricted Land Use (mg/kg) (Outside Core Zone)	Industrial or Commercial Site (mg/kg) (Inside Core Zone)	
<b>Inorganic Chemical Constituents (mg/kg)</b>					
Antimony	1,400	32	b	b	5.4
Arsenic	87.5	0.667	20 <sup>c</sup>	20 <sup>c</sup>	20 <sup>m</sup>
Barium	245,000	5,600	1,250	1,320	923
Beryllium	7,000	16	25	b	63.2
Cadmium	3,500	80	25	36	0.81 <sup>n</sup>
Chromium (III)	No limit	120,000	42 <sup>d</sup>	135 <sup>d</sup>	2000
Copper	130,000	2,960	100	550	22 <sup>n</sup>
Hexavalent chromium	18.4 <sup>e</sup>	2 (inhalation)	--	--	18.4 <sup>e</sup>
Lead	1000	250	220	220	3000
Mercury	1,050	24	9 <sup>f</sup>	9 <sup>f</sup>	2.1
			0.7 <sup>g</sup>	0.7 <sup>g</sup>	
Molybdenum	17,500	400	b	71	32.3
Nickel	70,000	1,600	100	1,850	130
Selenium	17,500	400	0.8	0.8	13.6
Silver	17,500	400	b	b	5.2
Thallium	245	5.6	--	--	1.59
Vanadium	24,500	560	26	b	2,240
Zinc	No limit	24,000	270	570	5,940
Cyanide	70,000	1,600	--	--	0.80
Nitrate/nitrite	350,000	8,000	--	--	40
<b>Organic Chemical Constituents (mg/kg)</b>					
Acetone	No limit	72,000	--	--	3.2
Acetonitrile	21,000	480	--	--	0.282
Benzene	2,390	18.2	--	--	0.028
Benzyl alcohol	No limit	24,000	--	--	19.2
Bromodichloromethane	2,120	16.1	--	--	0.00368
n-butyl alcohol (1-butanol)	350,000	8,000	--	--	6.62
Carbon tetrachloride	1,010	7.69	--	--	0.0031
Chlorobenzene	70,000	1,600	--	--	0.874
Chloroform (trichloromethane)	21,500	164	--	--	0.0381

Table 4. Summary of 200-UR-1 Operable Unit Nonradionuclide Soil Preliminary Cleanup Levels. (3 Pages)

Contaminant	Removal Action Objective – Protection from Direct Exposure		Ecological Protection <sup>a</sup>		Removal Action Objective – Groundwater Protection <sup>1</sup>
	Preliminary CULs for Nonradionuclides (mg/kg) Industrial (Inside Core Zone)	Preliminary CULs for Nonradionuclides (mg/kg) Unrestricted (Outside Core Zone)	Unrestricted Land Use (mg/kg) (Outside Core Zone)	Industrial or Commercial Site (mg/kg) (Inside Core Zone)	
Cis/Trans-1,2-dichloroethylene	35,000	80	--	--	0.36
Cyclohexanone	No limit	400,000	--	--	344
1,1-dichloroethane	350,000	8,000	--	--	4.37
1,2-dichloroethane	1,444	11	--	--	0.0022
Dichloromethane (methylene chloride)	17,500	133	--	--	0.0254
p-dichlorobenzene	5,470	41.7	--	--	0.03
Ethyl benzene	350,000	8,000	--	--	6.05
Ethyl ether	70,000	16,000	--	--	9.09
Hexane	210,000	4,800	--	--	96.2
Methyl isobutyl ketone (MIBK hexone)	280,000	6,400	--	--	310
Methyl ethyl ketone (MEK)	2,100,000	48,000	--	--	21.8
Perchloroethylene (tetrachloroethene)	2,570	19.6	--	--	0.0091
Phenol	1,050,000	24,000	--	--	44
Pseudo cumenen (1,2,4-trimethyl benzene)	175,000	4,000	--	--	--
Tetrahydrofuran	3,500	80	--	--	--
Toluene	700,000	16,000	--	--	7.27
1,1,1-trichloroethane (TCA)	3,150,000	72,000	--	--	1.58
1,1,2-trichloroethane	2,300	17.5	--	--	0.00427
Tetrachloroethylene (PCE)	2,570	19.6	--	--	0.0091
Trichloroethylene (TCE)	11,900	90.9	--	--	0.026
Vinyl chloride	87.5	0.667	--	--	0.000184
Xylenes	700,000	16,000	--	--	9.14
<b>Other Constituents (mg/kg)</b>					
Polyaromatic hydrocarbons	Compound-specific	Compound-specific	--	--	--
Pesticides	Compound-specific	Compound-specific	--	--	--
Total petroleum hydrocarbon	2,000	2,000	200 <sup>h</sup>	12,000 <sup>h</sup>	2,000
			460 <sup>i</sup>	15,000 <sup>i</sup>	
Polychlorinated biphenyls	10 <sup>j</sup>	0.5 <sup>j</sup>	2 <sup>k</sup>	2 <sup>k</sup>	0.21

Table 4. Summary of 200-UR-1 Operable Unit Nonradionuclide Soil Preliminary Cleanup Levels. (3 Pages)

Contaminant	Removal Action Objective – Protection from Direct Exposure		Ecological Protection <sup>a</sup>		Removal Action Objective – Groundwater Protection <sup>1</sup>
	Preliminary CULs for Nonradionuclides (mg/kg) Industrial (Inside Core Zone)	Preliminary CULs for Nonradionuclides (mg/kg) Unrestricted (Outside Core Zone)	Unrestricted Land Use (mg/kg) (Outside Core Zone)	Industrial or Commercial Site (mg/kg) (Inside Core Zone)	
Hydraulic fluids (greases)	2,000	2,000	--	--	--
Kerosene, normal paraffins, paint thinner	2,000	2,000	--	--	2,000

NOTE: Lowest CUL value for each analyte is indicated by shading.

<sup>a</sup>From WAC 173-340-900, Table 749-2. Use of Table 749-2 in accordance with an agreement with Washington State Department of Ecology.

<sup>b</sup>Safe concentration has not yet been established. See WAC 173-340-7492(2)(c).

<sup>c</sup>The ecological screening in Table 749-2 provides different values for Arsenic III and Arsenic V. The laboratories used cannot make these isomer distinctions; therefore, the most conservative value has been adopted.

<sup>d</sup>Chromium (total) value from Table 749-2.

<sup>e</sup>Hexavalent chromium concentration that is protective of groundwater.

<sup>f</sup>Inorganic mercury.

<sup>g</sup>Organic mercury.

<sup>h</sup>Gasoline range organics.

<sup>i</sup>Diesel range organics.

<sup>j</sup>Compliance is based on the sum of all aroclors detected.

<sup>k</sup>Polychlorinated biphenyl mixtures (total).

<sup>l</sup>WAC 173-340-747 soil concentrations protective of groundwater based on Method B values for groundwater from the CLARC Version 3.1 tables.

<sup>m</sup>Statewide background for arsenic.

<sup>n</sup>Value is less than Hanford Site soil background. Therefore, the soil background concentration is used as the preliminary CUL.

Ecology 94-145, *Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation; CLARC, Version 3.1.*

WAC 173-340-747, "Deriving Soil Concentrations for Ground Water Protection."

WAC 173-340-900, "Tables."

WAC 173-340-7492, "Simplified Terrestrial Ecological Evaluation Procedures."

CLARC = cleanup levels and risk calculations (Ecology 94-145).

CUL = cleanup level.

WAC = *Washington Administrative Code.*

Table 5. 200-UR-1 Operable Unit Unplanned Release Decision Rules.

DR #	Application	DR
1	RTD	If the sample mean activity of radionuclides (Table 3) within the cover <sup>a</sup> soil sample for a decision unit results in a direct radiological exposure dose greater than or equal to 15 mrem/yr above background (based on the conceptual site model and RESRAD modeling [ANL 2002] or leach rate testing), remove the radiologically contaminated soil in the decision unit. Otherwise, use the cover soils as backfill.
2	RTD	If the sample mean concentrations of chemical constituents within the cover <sup>a</sup> soil sample for a decision unit are equal to or greater than the CUL values in Table 4, remove the chemically contaminated soils in the decision unit. Otherwise, use the cover soils as backfill.
3a	RI/FS	If the sample mean activity of radionuclides (Table 3) within the shallow zone soil sample results in a direct radiological exposure dose greater than or equal to 15 mrem/yr above background (based on the conceptual site model and RESRAD modeling [ANL 2002] or leach rate testing), evaluate response alternatives in an FS, or evaluate the site for closeout with no removal action.
4a	RI/FS	If sample mean concentrations of chemical constituents within the shallow zone soil sample are equal to or greater than the CUL values in Table 4, evaluate response alternatives in an FS, or evaluate the site for closeout with no removal action.
5	Verification	If the sample mean activity of radionuclides (Table 3) within the shallow zone soil sample for a decision unit results in a direct radiological exposure dose greater than or equal to 15 mrem/yr above background (based on the conceptual site model and RESRAD modeling [ANL 2002] or leach rate testing), remove/dispose of the radiologically contaminated soils in the decision unit. Otherwise, initiate waste site closeout.
6a	Verification	If the sample mean concentrations of chemical constituents within the shallow zone or cover <sup>a</sup> soil samples are equal to or greater than the CUL <sup>b</sup> values in Table 4, remove/dispose of the chemically contaminated soils in the decision unit. Otherwise, initiate waste site closeout.
6b	Verification	If the maximum detected sample concentrations of chemical constituents within the soil samples from the shallow zone or cover <sup>a</sup> soil samples are equal to or greater than two times the CUL <sup>b</sup> values in Table 4, remove the chemically contaminated soils in the decision unit. Otherwise, initiate waste site closeout.
6c	Verification	If 10% of the detected sample concentrations of chemical constituents within the soil samples from the shallow zone or cover <sup>a</sup> soil samples are equal to or greater than the limiting CUL <sup>b</sup> values in Table 4, remove the chemically contaminated soils in the decision unit. Otherwise, initiate waste site closeout.

<sup>a</sup>Decision subunit definitions and sizes as stated in Table 13.

<sup>b</sup>CULs are applied to unplanned releases within the Core Zone via an industrial land-use scenario. CULs are applied to unplanned releases outside the Core Zone using a rural-residential land-use scenario.

ANL, 2002, *RESRAD for Windows*, Version 6.21.

CUL = cleanup level.

DR = decision rule.

FS = feasibility study.

RESRAD = RESidual RADioactivity (dose model) (ANL 2002).

RI/FS = remedial investigation/feasibility study.

RTD = removal, treatment, and disposal.

Table 6. Radiological Analytical Performance Requirements. (2 Pages)

Chemical Abstracts Service #	Analyte	Survey or Analytical Method	Human-Health Action Levels		Groundwater Protection (pCi/g) <sup>e</sup>	Required Detection Limits <sup>a</sup> (pCi/g)	Precision Required	Accuracy Required
			15 mrem/yr Residential (pCi/g)	15 mrem/yr Industrial (pCi/g)				
14596-10-2	Americium-241	AmAEA <sup>b</sup>	31.1	210	N/A	1	±30% <sup>c</sup>	70-130 <sup>c</sup>
14762-75-5	Carbon-14	C-14 separation - LSC (low level)	5.16	33,100	N/A	5	±30% <sup>c</sup>	70-130 <sup>c</sup>
10045-97-3	Cesium-137	GEA	6.2	25	N/A	0.1	±30% <sup>c</sup>	70-130 <sup>c</sup>
10198-40-0	Cobalt-60	GEA	1.4	5.2	N/A	0.05	±30% <sup>c</sup>	70-130 <sup>c</sup>
14683-23-9	Europium-152	GEA	3.3	12	N/A	0.1	±30% <sup>c</sup>	70-130 <sup>c</sup>
15585-10-1	Europium-154	GEA	3.0	11	N/A	0.1	±30% <sup>c</sup>	70-130 <sup>c</sup>
14391-16-3	Europium-155	GEA	125	518	N/A	0.1	±30% <sup>c</sup>	70-130 <sup>c</sup>
13994-20-2	Neptunium-237	NpAEA <sup>b</sup>	2.5	59.2	N/A	1	±30% <sup>c</sup>	70-130 <sup>c</sup>
13981-37-8	Nickel-63	Ni-63 separation - LSC	4,026	3,070,000	N/A	30	±30% <sup>c</sup>	70-130 <sup>c</sup>
14681-63-1	Niobium-94 <sup>d</sup>	GEA	2.43	8.25	N/A	1	±30% <sup>c</sup>	70-130 <sup>c</sup>
13981-16-3	Plutonium-238	PuAEA <sup>b</sup>	37.4	155	N/A	1	±30% <sup>c</sup>	70-130 <sup>c</sup>
Pu-239/240	Plutonium-239/240	PuAEA <sup>b</sup>	33.9	245	N/A	1	±30% <sup>c</sup>	70-130 <sup>c</sup>
13982-63-3	Radium-226	GEA	N/A	7.9	N/A	0.2	±30% <sup>c</sup>	70-130 <sup>c</sup>
Rad-Sr	Strontium-90	Sr-89,90 - GPC	4.5	2,500	N/A	1	±30% <sup>c</sup>	70-130 <sup>c</sup>
14133-76-7	Technetium-99	Tc-99 separation - LSC	15	12,000	N/A	15	±30% <sup>c</sup>	70-130 <sup>c</sup>
10028-17-8	Tritium	H-3 - LSC	400	471	N/A	400	±30% <sup>c</sup>	70-130 <sup>c</sup>
13966-29-5	Uranium-233/234	UAEA <sup>b</sup>	1.1	267	N/A	1	±30% <sup>c</sup>	70-130 <sup>c</sup>
15117-96-1	Uranium-235/236		1.0	101	N/A	1	±30% <sup>c</sup>	70-130 <sup>c</sup>
U-238	Uranium-238		1.1	267	N/A	1	±30% <sup>c</sup>	70-130 <sup>c</sup>

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Table 6. Radiological Analytical Performance Requirements. (2 Pages)

Chemical Abstracts Service #	Analyte	Survey or Analytical Method	Human-Health Action Levels		Groundwater Protection (pCi/g) <sup>e</sup>	Required Detection Limits <sup>a</sup> (pCi/g)	Precision Required	Accuracy Required
			15 mrem/yr Residential (pCi/g)	15 mrem/yr Industrial (pCi/g)				
N/A	Gross cesium-137 counts	Portable sodium iodide detector	--	--	N/A	3.1	N/A	N/A
N/A	Gross alpha	Portable contamination detector	--	--	N/A	100 d/min/ 100 cm <sup>2</sup>	N/A	N/A
N/A	Gross beta/gamma	Portable contamination detector	--	--	N/A	5,000 d/min/ 100 cm <sup>2</sup>	N/A	N/A

<sup>a</sup>Units are in pCi/g (radioisotopes) unless otherwise specified.

<sup>b</sup>AmAEA, NpAEA, PuAEA, ThAEA, UAEA = chemical separation, electro/microprecipitation deposition, AEA via Si barrier detector.

<sup>c</sup>Accuracy criteria for associated batch laboratory control sample percent recoveries. Except for GEA, additional analysis-specific evaluations also performed for matrix spikes, tracers, and carriers as appropriate to the method. Precision criteria for batch laboratory replicate sample analyses.

<sup>d</sup>Contaminant of concern analysis only applicable to Plutonium Finishing Plant area.

<sup>e</sup>Groundwater protection radionuclide values based on RESRAD modeling of drinking water exposure, with the entire vadose zone presumed to be contaminated. Groundwater protection may be evaluated using STOMP code or another model to predict movement of contaminants through the vadose zone.

ANL, 2002, *RESRAD for Windows*, Version 6.21.

PNNL-12034, *STOMP, Subsurface Transport Over Multiple Phases, Version 2.0, User's Guide*.

AEA = alpha energy analysis.

d/min = disintegrations per minute.

GEA = gamma energy analysis.

GPC = gas proportional counter.

LSC = liquid scintillation counting.

N/A = not applicable.

RESRAD = RESidual RADioactivity (dose model) (ANL 2002).

STOMP = Subsurface Transport Over Multiple Phases (PNNL-12034).

Table 7. Nonradiological Analytical Performance Requirements. (5 Pages)

CAS #	Analyte	Survey or Analytical Method <sup>a</sup>	Human-Health Action Levels		Ecological Protection		Groundwater Protection (mg/kg)	Required Detection Limits <sup>b</sup> (mg/kg)	Precision Required	Accuracy Required
			Method B Residential (mg/kg)	Method C Industrial (mg/kg)	Unrestricted Land Use (mg/kg) (Outside Core Zone)	Industrial or Commercial Site (mg/kg) (Inside Core Zone)				
7440-36-0	Antimony	EPA Method 6010	32	1,400	°	°	5.4	6	±30% <sup>d</sup>	70-130 <sup>d</sup>
7440-38-2	Arsenic	EPA Method 6010 (Trace ICP)	0.667	87.5	20 <sup>o</sup>	20 <sup>o</sup>	20	1	±30% <sup>d</sup>	70-130 <sup>d</sup>
7440-39-3	Barium	EPA Method 6010	5,600	245,000	1,250	1,320	923	20	±30% <sup>d</sup>	70-130 <sup>d</sup>
7440-41-7	Beryllium	EPA Method 6010	16	7,000	25	°	63.2	0.5	±30% <sup>d</sup>	70-130 <sup>d</sup>
7440-43-9	Cadmium	EPA Method 6010	0.5	3,500	25	36	0.81	0.5	±30% <sup>d</sup>	70-130 <sup>d</sup>
7440-47-3	Chromium (III)	EPA Method 6010	120,000	No limit	42 <sup>f</sup>	135 <sup>f</sup>	2000	1	±30% <sup>d</sup>	70-130 <sup>d</sup>
7440-50-8	Copper	EPA Method 6010	2,960	130,000	100	550	22	2.5	±30% <sup>d</sup>	70-130 <sup>d</sup>
18540-29-9	Hexavalent chromium	EPA Method 7196	18.4 <sup>e</sup>	18.4 <sup>e</sup>	--	--	18.4 <sup>e</sup>	0.5	±30% <sup>d</sup>	70-130 <sup>d</sup>
7439-92-1	Lead	EPA Method 6010	10.2	1000	220	220	3000	10	±30% <sup>d</sup>	70-130 <sup>d</sup>
7439-97-6	Mercury	EPA Method 7471	0.33	1,050	9 <sup>h</sup>	9 <sup>h</sup>	2.1	0.2	±30% <sup>d</sup>	70-130 <sup>d</sup>
					0.7 <sup>i</sup>	0.7 <sup>i</sup>				
7439-98-7	Molybdenum	EPA Method 6010	400	17,500	°	°	32.3	2	±30% <sup>d</sup>	70-130 <sup>d</sup>
7440-02-0	Nickel	EPA Method 6010	1,600	70,000	100	1.850	130	4	±30% <sup>d</sup>	70-130 <sup>d</sup>
7782-49-2	Selenium	EPA Method 6010 (Trace ICP)	400	17,500	0.8	0.8	13.6	1 <sup>j</sup>	±30% <sup>d</sup>	70-130 <sup>d</sup>
7440-22-4	Silver	EPA Method 6010	400	17,500	°	°	5.2	2	±30% <sup>d</sup>	70-130 <sup>d</sup>
7440-28-0	Thallium	EPA Method 6010	5.6	245	--	--	1.59	5	±30% <sup>d</sup>	70-130 <sup>d</sup>

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Table 7. Nonradiological Analytical Performance Requirements. (5 Pages)

CAS #	Analyte	Survey or Analytical Method <sup>a</sup>	Human-Health Action Levels		Ecological Protection		Groundwater Protection (mg/kg)	Required Detection Limits <sup>b</sup> (mg/kg)	Precision Required	Accuracy Required
			Method B Residential (mg/kg)	Method C Industrial (mg/kg)	Unrestricted Land Use (mg/kg) (Outside Core Zone)	Industrial or Commercial Site (mg/kg) (Inside Core Zone)				
7440-62-2	Vanadium	EPA Method 6010	560	24,000	26	°	2,240	5	±30% <sup>d</sup>	70-130 <sup>d</sup>
7440-66-6	Zinc	EPA Method 6010	24,000	No limit	270	570	5,940	2	±30% <sup>d</sup>	70-130 <sup>d</sup>
57-12-5	Cyanide	EPA Method 9010 total cyanide	1,600	70,000	--	--	0.80	2	±30% <sup>d</sup>	70-130 <sup>d</sup>
NO <sub>3</sub> /NO <sub>2</sub> -N	Nitrate/nitrite	IC 300 Modified and 353.1	8,000	350,000	--	--	40	0.75	±30% <sup>d</sup>	70-130 <sup>d</sup>
<b>Organic Chemical Constituents (mg/kg or as noted)</b>										
67-64-1	Acetone	EPA Method 8260	72,000	No limit	--	--	3.2	0.02	±30% <sup>d</sup>	70-130 <sup>d</sup>
75-05-8	Acetonitrile	EPA Method 8260	480	21,000	--	--	0.282	0.1	±30% <sup>d</sup>	70-130 <sup>d</sup>
71-43-2	Benzene	EPA Method 8260	18.2	2,390	--	--	0.028	0.005	±30% <sup>d</sup>	70-130 <sup>d</sup>
100-51-6	Benzyl alcohol	EPA Method 8260/8270	24,000	No limit	--	--	19.2	0.33	±30% <sup>d</sup>	70-130 <sup>d</sup>
75-27-4	Bromo-dichloro-methane	EPA Method 8260	16.1	2,120	--	--	0.00368	0.005	±30% <sup>d</sup>	70-130 <sup>d</sup>
71-36-3	n-butyl alcohol (1-butanol)	EPA Method 8015	8,000	350,000	--	--	6.62	5	±30% <sup>d</sup>	70-130 <sup>d</sup>
56-23-5	Carbon tetrachloride	EPA Method 8260	7.69	1,010	--	--	0.0031	0.005	±30% <sup>d</sup>	70-130 <sup>d</sup>
108-90-7	Chlorobenzene	EPA Method 8260	1,600	70,000	--	--	0.874	0.005	±30% <sup>d</sup>	70-130 <sup>d</sup>
67-66-3	Chloroform (trichloro-methane)	EPA Method 8260	164	21,500	--	--	0.0381	0.005	±30% <sup>d</sup>	70-130 <sup>d</sup>
156-59-2/ 156-60-5	Cis/Trans-1,2-Dichloro-ethylene	EPA Method 8260	80	35,000	--	--	0.36	0.005	±30% <sup>d</sup>	70-130 <sup>d</sup>

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Table 7. Nonradiological Analytical Performance Requirements. (5 Pages)

CAS #	Analyte	Survey or Analytical Method <sup>a</sup>	Human-Health Action Levels		Ecological Protection		Groundwater Protection (mg/kg)	Required Detection Limits <sup>b</sup> (mg/kg)	Precision Required	Accuracy Required
			Method B Residential (mg/kg)	Method C Industrial (mg/kg)	Unrestricted Land Use (mg/kg) (Outside Core Zone)	Industrial or Commercial Site (mg/kg) (Inside Core Zone)				
108-94-1	Cyclohexanone	EPA Method 8270	400,000	No limit	--	--	344	TIC <sup>k</sup>	N/A	N/A
75-34-3	1,1-dichloroethane	EPA Method 8260	8,000	350,000	--	--	4.37	0.01	±30% <sup>d</sup>	70-130 <sup>d</sup>
107-06-2	1,2-dichloroethane	EPA Method 8260	11	1,444	--	--	0.0022	0.005	±30% <sup>d</sup>	70-130 <sup>d</sup>
75-09-2	Dichloromethane (methylene chloride)	EPA Method 8260	133	17,500	--	--	0.0254	0.005	±30% <sup>d</sup>	70-130 <sup>d</sup>
106-46-7	p-Dichlorobenzene	EPA Method 8270	41.7	5,470	--	--	0.03	0.33	±30% <sup>d</sup>	70-130 <sup>d</sup>
100-41-4	Ethyl benzene	EPA Method 8260	8,000	350,000	--	--	6.05	0.005	±30% <sup>d</sup>	70-130 <sup>d</sup>
60-29-7	Ethyl ether	EPA Method 8015	16,000	70,000	--	--	9.09	5	±30% <sup>d</sup>	70-130 <sup>d</sup>
10-54-3	Hexane	EPA Method 8260	4,800	210,000	--	--	96.2	TIC <sup>k</sup>	±30% <sup>d</sup>	70-130 <sup>d</sup>
108-10-1	Methyl isobutyl ketone (MIBK hexone)	EPA Method 8260	6,400	280,000	--	--	310	0.01	±30% <sup>d</sup>	70-130 <sup>d</sup>
78-93-3	Methyl ethyl ketone (MEK)	EPA Method 8260	48,000	No limit	--	--	21.8	0.01	±30% <sup>d</sup>	70-130 <sup>d</sup>
127-18-4	Perchloroethylene (tetrachloroethene)	EPA Method 8260	19.6	2,570	--	--	0.0091	0.005	±30% <sup>d</sup>	70-130 <sup>d</sup>
108-95-2	Phenol	EPA Method 8270	24,000	No limit	--	--	44	0.33	±30% <sup>d</sup>	70-130 <sup>d</sup>
95-63-6	Pseudocumene (1,2,4-trimethyl benzene)	EPA Method 8260	4,000	175,000	--	--	--	TIC <sup>k</sup>	±30% <sup>d</sup>	70-130 <sup>d</sup>

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Table 7. Nonradiological Analytical Performance Requirements. (5 Pages)

CAS #	Analyte	Survey or Analytical Method <sup>a</sup>	Human-Health Action Levels		Ecological Protection		Groundwater Protection (mg/kg)	Required Detection Limits <sup>b</sup> (mg/kg)	Precision Required	Accuracy Required
			Method B Residential (mg/kg)	Method C Industrial (mg/kg)	Unrestricted Land Use (mg/kg) (Outside Core Zone)	Industrial or Commercial Site (mg/kg) (Inside Core Zone)				
109-99-9	Tetrahydrofuran	EPA Method 8260	80	3,500	--	--	--	0.05	±30% <sup>d</sup>	70-130 <sup>d</sup>
108-88-3	Toluene	EPA Method 8260	16,000	700,000	--	--	7.27	0.005	±30% <sup>d</sup>	70-130 <sup>d</sup>
71-55-6	1,1,1-trichloroethane (TCA)	EPA Method 8260	72,000	No limit	--	--	1.58	0.005	±30% <sup>d</sup>	70-130 <sup>d</sup>
79-00-5	1,1,2-Trichloroethane	EPA Method 8260	17.5	2,300	--	--	0.00427	0.005	±30% <sup>d</sup>	70-130 <sup>d</sup>
127-18-4	Tetrachloroethylene (PCE)	EPA Method 8260	19.6	2,570	--	--	0.0091	0.005	±30% <sup>d</sup>	70-130 <sup>d</sup>
79-01-6	Trichloroethylene (TCE)	EPA Method 8260	90.9	11,900	--	--	0.026	0.005	±30% <sup>d</sup>	70-130 <sup>d</sup>
75-04-1	Vinyl chloride	EPA Method 8260	0.667	87.5	--	--	0.000184	0.01	±30% <sup>d</sup>	70-130 <sup>d</sup>
1330-20-7	Xylenes	EPA Method 8260	16,000	700,000	--	--	9.14	0.01	±30% <sup>d</sup>	70-130 <sup>d</sup>
<b>Other Constituents (mg/kg or as noted)</b>										
N/A	Polyaromatic hydrocarbons	EPA Method 8310	Compound-specific	Compound-specific	--	--	--	0.015 <sup>l</sup>	±30% <sup>d</sup>	70-130 <sup>d</sup>
N/A	Pesticides	EPA Method 1311/8081	Compound-specific	Compound-specific	--	--	--	Compound-specific	±30% <sup>d</sup>	70-130 <sup>d</sup>
		EPA Method 8081						0.005 <sup>m</sup>	±30% <sup>d</sup>	70-130 <sup>d</sup>
N/A	Total petroleum hydrocarbon	EPA Method 8015/WTPH 418.1	2,000	2,000	200 <sup>n</sup>	12,000 <sup>n</sup>	2,000	5	±30% <sup>d</sup>	70-130 <sup>d</sup>
					46 <sup>o</sup>	15,000 <sup>o</sup>				
N/A	Polychlorinated biphenyls	EPA Method 8082	0.5	10	2 <sup>p</sup>	2 <sup>p</sup>	0.21	0.02	±30% <sup>d</sup>	70-130 <sup>d</sup>
N/A	Hydraulic fluids (heavy oil and greases)	EPA Method 1664A/9070	2,000	2,000	--	--	--	200	±30% <sup>d</sup>	70-130 <sup>d</sup>

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Table 7. Nonradiological Analytical Performance Requirements. (5 Pages)

CAS #	Analyte	Survey or Analytical Method <sup>a</sup>	Human-Health Action Levels		Ecological Protection		Groundwater Protection (mg/kg)	Required Detection Limits <sup>b</sup> (mg/kg)	Precision Required	Accuracy Required
			Method B Residential (mg/kg)	Method C Industrial (mg/kg)	Unrestricted Land Use (mg/kg) (Outside Core Zone)	Industrial or Commercial Site (mg/kg) (Inside Core Zone)				
8008-20-6	Kerosene, normal paraffins, paint thinner	NWTPH-Dx modified for kerosene range	2,000	2,000	--	--	2,000	5	±30% <sup>d</sup>	70-130 <sup>d</sup>

<sup>a</sup>For 4-digit EPA methods, see SW-846. For EPA Methods 300.0 and 353.1, see EPA/600/4-79/020.

<sup>b</sup>Detection limits are based on optimal conditions in a standard fixed laboratory. Interferences and matrix effects may degrade the values shown.

<sup>c</sup>Safe concentration has not yet been established. See WAC 173-340-7492(2)(c).

<sup>d</sup>Accuracy criteria is the minimum for associated batch laboratory control sample percent recoveries. Laboratories must meet statistically based control if more stringent. Additional analyte-specific evaluations also performed for matrix spikes, and surrogates as appropriate to the method. Precision criteria for batch laboratory replicate matrix spike analyses.

<sup>e</sup>The ecological screening Table 749-2 provides different values for Arsenic III and Arsenic V. The laboratories used cannot make these isomer distinctions; therefore, the most conservative value has been adopted.

<sup>f</sup>Chromium (total) value from Table 749-2.

<sup>g</sup>Hexavalent chromium concentration that is protective of groundwater.

<sup>h</sup>Inorganic mercury.

<sup>i</sup>Organic mercury.

<sup>j</sup>Special arrangements will be made with the laboratory to achieve detection limit needed for ecological action level for selenium.

<sup>k</sup>This compound will be reported as a TIC if present in detectable quantities. Analytical methodologies shown can be calibrated for these compounds at extra expense and may be required if significant quantities are discovered. Establishment of required detection limits is not appropriate for these compounds at this time.

<sup>l</sup>The calculated action level is below established analytical methodology capabilities. The analytical detection limits would be used for working-action levels and would be periodically reviewed to determine if lower detection limit capabilities are available.

<sup>m</sup>Maximum detection limit for pesticides, except for chlordanes.

<sup>n</sup>Gasoline range organics.

<sup>o</sup>Diesel range organics.

<sup>p</sup>Polychlorinated biphenyl mixtures (total).

EPA/600/4-79/020, *Methods of Chemical Analysis of Water and Wastes*.

SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A*.

WAC 173-340-7492, "Simplified Terrestrial Ecological Evaluation Procedures."

CAS = Chemical Abstracts Service.

EPA = U.S. Environmental Protection Agency.

IC = ion chromatography.

ICP = inductively coupled plasma.

N/A = not applicable.

NWTPH-Dx = Northwest total petroleum hydrocarbon-diesel extended.

TIC = tentatively identified compound.

WAC = *Washington Administrative Code*.

WTPH = Washington State Department of Health total petroleum hydrocarbons.

Table 8. Sample Preservation, Containers, and Holding Time Guidelines.

Analytes	Matrix	Bottle		Volume <sup>a</sup>	Preservation	Packing Requirements	Holding Time
		Number	Type				
<b>Radionuclides</b>							
Americium AEA	Soil	1	G/P	10 g	None	None	6 months
Gamma spectroscopy	Soil	1	G/P	1,500 g	None	None	6 months
Carbon-14	Soil	1	G/P	10g	None	None	6 months
Isotopic plutonium	Soil	1	G/P	10 g	None	None	6 months
Isotopic thorium	Soil	1	G/P	6 g	None	None	6 months
Isotopic uranium	Soil	1	G/P	10 g	None	None	6 months
Neptunium-237	Soil	1	G/P	10 g	None	None	6 months
Nickel-63	Soil	1	G/P	6 g	None	None	6 months
Radiogenic strontium	Soil	1	G/P	10 g	None	None	6 months
Technetium-99	Soil	1	G/P	6 g	None	None	6 months
Tritium – H-3	Soil	1	G	100 g	None	None	6 months
<b>Chemicals</b>							
Alcohols, glycols, and ketones – 8015	Soil	3	G	40 mL	None	Cool 4 °C	14 days
IC anions – 300.0	Soil	1	G/P	250 g	None	Cool 4 °C	28 days/ 48 hours
ICP metals – 6010A (target analytical list + add-on)	Soil	1	G/P	125 g	None	None	6 months
Hexavalent chromium – 7196	Soil	1	P	60 g	None	Cool 4 °C	30 days
Mercury – 7471 (cold vapor)	Soil	1	G	125 g	None	None	28 days
PCBs – 8082	Soil	1	G	250 g	None	Cool 4 °C	14/40 days <sup>b</sup>
Semivolatile organic analyte – 8270A (target compound list)	Soil	1	G	250 g	None	Cool 4 °C	14/40 days <sup>b</sup>
Sulfides – 9030	Soil	1	G	40 g	None	Cool 4 °C	7 days
Total petroleum hydrocarbons – kerosene range	Soil	1	G	200 g	None	Cool 4 °C	14 days
Methanol – VOA – 8015	Soil	1	G	50 g	None	Cool 4 °C	14 days
VOA – 8260A (target compound list)	Soil	1	G	50 g	None	Cool 4 °C	14 days

<sup>a</sup>Optimal volumes, which may be adjusted downward to accommodate the possibility of small sample recoveries. Minimum sample size will be defined on the Sampling Authorization Form.

<sup>b</sup>14/40 indicates 14 days holding time for extraction/40 days holding time for analysis (times are sequential).

For EPA Method 300.0, see EPA/600/4-79/020, *Methods of Chemical Analysis of Water and Wastes*. For 4-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A*.

- AEA = alpha energy analysis.
- EPA = U.S. Environmental Protection Agency.
- G = glass.
- IC = ion chromatography.
- ICP = inductively coupled plasma.
- P = plastic.
- PCB = polychlorinated biphenyl.
- VOA = volatile organic analyte.

Table 9. Conceptual Site Models for Sampling Design.

Conceptual Site Model Category	Release Type and Contaminant Depth Interval	Physical Settings
1	<u>Animal Droppings, Vegetation Material, and Windblown Particulates</u> (0 to 0.3 m [0 to 1 ft] depth interval of suspected contamination)	Outlying areas
2	<u>Small Spill/Leak Sites</u> (0 to 0.3 m [0 to 1 ft] depth interval of suspected contamination)	Roadways Railroads Storage yards
3	<u>Moderate Spill/Leak Sites</u> (0 to 2 m [0 to 6.6 ft] depth interval of suspected contamination)	Roadways Railroads Storage yards
4	<u>Larger Spill/Leak Sites</u> (0 to 4.6 m [0 to 15 ft] depth interval of suspected contamination)	Unique locations/areas

Table 10. Potential Radiological Survey Instruments and Properties. (2 Pages)

Measurement	Instrument	Applications/Potential Limitations	Approximate Minimum Detectable Concentration or Activity for Cs-137 (Static Measurement)	Approximate Minimum Detectable Concentration or Activity for Cs-137 (Moving Measurement)
Gross gamma	Portable sodium iodide detector	Hand-held detectors (i.e., 2- by 2-in. or 3- by 3-in. sodium iodide crystals), gamma detectors; insensitive to alpha/beta radiations; correlation required to convert instrument response to Cs-137 levels in pCi/g.	5 pCi/g (BHI-01319)  TBD for use in BC Controlled Area	30 pCi/g Cs-137 at 2 in/s (BHI-01319)  TBD for use in BC Controlled Area
	Tractor-mounted plastic scintillators	Large area detectors (~30 cm by 1 m) mounted in an array on a tractor, view a larger area than hand-held detectors; insensitive to alpha/beta radiations; correlation required to convert instrument response to Cs-137 levels in pCi/g.	TBD for use in BC Controlled Area	25 pCi/g (estimated) at 2 mi/h  TBD for use in BC Controlled Area
	Large sodium iodide detectors	Large sodium iodide crystals ~4 by 4 by 16 in.; must be mounted to an all-terrain vehicle, trailer, and/or jogging stroller; very sensitive gamma detectors; larger field of view than hand-held detectors, more maneuverable than tractor; insensitive to alpha/beta radiations; correlation required to convert instrument response to Cs-137 levels in pCi/g.	0.91 pCi/g Th-232 1.1 pCi/g Ra-226 with 4-second count (FEMP-2582)  TBD for use in BC Controlled Area	Varies with survey speed  TBD for use in BC Controlled Area
Gamma spectroscopy	HPGe detector	HPGe detectors offer high-resolution gamma spectrometry measurements; liquid nitrogen cooled, setup required; correlation required to convert instrument response to Cs-137 levels in pCi/g.	0.12 pCi/g Th-232 0.14 pCi/g Ra-226 with 5- to 15-minute count (FEMP-2582)  TBD for Cs-137 in BC Controlled Area	Not applicable

Table 10. Potential Radiological Survey Instruments and Properties. (2 Pages)

Measurement	Instrument	Applications/Potential Limitations	Approximate Minimum Detectable Concentration or Activity for Cs-137 (Static Measurement)	Approximate Minimum Detectable Concentration or Activity for Cs-137 (Moving Measurement)
Gross beta/gamma	Portable contamination detector	Hand-held, 100 cm <sup>2</sup> scintillation detector, low-efficiency gamma detection capability, beta particles are easily shielded by soil/concrete; contamination may be missed during surveys if contamination is not present on the surface.	Varies for Cs-137/Sr-90 based on count rate and background	1000 d/min/100 cm <sup>2</sup> at 2 in/s for Cs-137/Sr-90 (BHI-01319)
	Pancake GM	Hand-held, ~15 cm <sup>2</sup> Geiger-Müller tube, very small field of view; long history of use for surveys.	4,000 d/min/100 cm <sup>2</sup> (~600 d/min/probe area) Cs-137 5-second count time (HNF-13536)	7,300 d/min/100 cm <sup>2</sup> (~1095 d/min/probe area) Cs-137 at 2 in/s (HNF-13536)
	Micro-rem	Hand-held, tissue-equivalent scintillator, capable of measuring very low dose rates; does not quantify amount of radioactivity present.	~5 $\mu$ rem/h Uniform field (PNNL-MA-562)	Not applicable

BHI-01319, *Data Assessment Report for the Sampling and Analysis Activities Conducted to Support Reoposting the 200 B/C Contaminated Area.*

FEMP-2582, *The Deployment of an Innovative Real-Time Radiological Soil Characterization System.*

HNF-13536, *PHMC Radiological Control Procedures*, Section 6.1.1, "GM Portable Survey Instrument."

PNNL-MA-562, *Radiation Protection Instrument Manual*, Chapter 9.0, "Bicron Micro Rem Meter."

d/min = disintegrations per minute.

GM = Geiger-Müller.

HPGe = high-purity germanium.

TBD = to be determined.

Table 11. Potential Chemical Field-Screening Measurement Methods. (3 Pages)

Variable	Potentially Appropriate Measurement Method <sup>a</sup>	Possible Limitations or Reservations
Arsenic	X-ray fluorescence <sup>b</sup>	DL (75 mg/kg)
Barium	X-ray fluorescence <sup>b</sup>	DL (300 mg/kg)
Cadmium	X-ray fluorescence <sup>b</sup>	DL (75 mg/kg)
Chlorine (chlorinated compounds)	X-ray fluorescence <sup>b</sup>	Calibration and correlation to compound of interest; DL is unknown
Chromium (total)	X-ray fluorescence <sup>b</sup>	DL (400 mg/kg)

Table 11. Potential Chemical Field-Screening Measurement Methods. (3 Pages)

Variable	Potentially Appropriate Measurement Method <sup>a</sup>	Possible Limitations or Reservations
Chromium (VI)	Water extraction and colorimetric analysis	Interferences (iron) and soil alkalinity. DL (2 to 5 mg/kg).
Lead	X-ray fluorescence <sup>b</sup>	DL (100 mg/kg)
Mercury	Mercury vapor monitor	DL associated with soil concentrations well above the preliminary cleanup level.
Mercury	Immunoassay	DL (0.5 mg/kg). Results reported within a prespecified range. Analysis takes 15 to 30 minutes.
Mercury	X-ray fluorescence <sup>b</sup>	DL (100 mg/kg)
Selenium	X-ray fluorescence <sup>b</sup>	DL (200 mg/kg)
Silver	X-ray fluorescence <sup>b</sup>	DL (100 mg/kg)
Zinc	X-ray fluorescence <sup>b</sup>	DL (400 mg/kg)
Sulfate	X-ray fluorescence <sup>b</sup>	Calibration and correlation to elemental sulfur required.
Polyaromatic hydrocarbons	Immunoassay	DL (1 to 5 mg/kg). Results reported within a prespecified range. Analysis takes 15 to 30 minutes.
Polychlorinated biphenyls	Immunoassay	DL (0.1 to 0.3 mg/kg). Results reported within a prespecified range. Analysis takes 15 to 30 minutes.
Pesticides	Immunoassay	DL approximately 10 mg/kg. Need to know specific pesticide of interest. Results reported within a prespecified range. Analysis takes 15 to 30 minutes.
Total petroleum hydrocarbons	Immunoassay	DL (5 to 10 mg/kg). Results reported within a prespecified range. Need to know if gasoline or diesel products. Analysis takes 15 to 30 minutes.
VOCs	Colorimetric tube	Tube capability must be compared to the site-specific need to determine if field detection limits would be sufficient for the VOC of interest. Need to know specific VOCs of interest.
VOCs	Flame ionization detector (e.g., Foxboro OVA 128) <sup>c</sup>	DL (1 to 5 mg/kg, methane-equivalent). Instrument capability must be compared to the site-specific need to determine if field detection limits would be sufficient for the VOC of interest. Need to know specific VOCs of interest. Limited to hydrogen containing compounds.
VOCs	Photoacoustic infrared analyzer (e.g., B&K 1302) <sup>d</sup>	Instrument capability must be compared to the site-specific need to determine if field detection limits would be sufficient for the VOC of interest. Need to know specific VOCs of interest.
VOCs	Photoionization detector (e.g., thermo analytical organic vapor monitor)	DL (1 to 5 mg/kg, isobutylene-equivalent). Instrument capability must be compared to the site-specific need to determine if field detection limits would be sufficient for the VOC of interest. Need to know specific VOCs of interest. Limited to photoionizing compounds at 10.6 eV.

Table 11. Potential Chemical Field-Screening Measurement Methods. (3 Pages)

Variable	Potentially Appropriate Measurement Method <sup>a</sup>	Possible Limitations or Reservations
VOCs	Portable gas chromatograph with photoionization detector (e.g., Photovac 10S Plus) <sup>c</sup>	DL (sub-mL/m <sup>3</sup> levels depending on VOC of interest). Instrument capability must be compared to the site-specific need to determine if field detection limits would be sufficient for the VOC of interest. Need to know specific VOCs of interest. Limited to photoionizing compounds at 11.7 eV.
VOCs	Transportable mass spectrometer	Instrument use requires extensive training. Capital cost and setup are high; operational cost is moderate.

<sup>a</sup>Other methods may be identified and implemented in conjunction with technology development.

<sup>b</sup>Metals by X-ray fluorescence require calibration to site-specific soils. Detection of chromium, aluminum, and sulfur could be greatly enhanced (50 to 100 mg/kg) with the purchase of a silicon lithium detector with Fe-55 source at a cost of about \$20,000. Requires management of radioactive source (i.e., Am-241, Cm-244, or Fe-55).

<sup>c</sup>Foxboro and OVA 128 are trademarks of The Foxboro Company, Foxboro, Massachusetts.

<sup>d</sup>B&K 1302 is a trademark of Brüel and Kjær, Nærum, Denmark.

<sup>e</sup>Photovac 10S Plus is a trademark of Photovac, Inc., Waltham, Massachusetts.

DL = detection limit.

VOC = volatile organic compound.

Table 12. Sampling Objectives Frequencies, and Basis for Removal, Treatment, and Disposal Sites.

Sampling Objectives	Physical Samples	
	Number of Samples	Basis
Soil stabilization cover	Divide pile into decision units <sup>a</sup> and collect representative samples per decision unit. Collect 50 discrete aliquots per each multi-increment representative sample. <sup>b</sup>	Overburden pile sampling for statistical evaluation.
Site verification (shallow) (0 to 4.6 m [15 ft])	Divide area into decision units <sup>a</sup> and collect representative samples per decision unit. Collect 50 discrete aliquots per each multi-increment representative sample. <sup>b</sup>	Shallow zone cleanup verification samples for statistical evaluation.
Backfill	No samples.	Radiation survey.

<sup>a</sup>Based on the size of the waste site. Refer to Table 13.

<sup>b</sup>Refer to Table 14.

Table 13. Number of Decision Subunits Based on Exposed Waste Site Area.

Decision Units	Waste Site Area	Number of Decision Subunits
Soil stabilization cover stockpiles	Very small area of exposed cover (<100 m <sup>2</sup> [1,076 ft <sup>2</sup> ])	1
	Small area of exposed cover (>100 m <sup>2</sup> [1,076 ft <sup>2</sup> ] but <500 m <sup>2</sup> [5,380 ft <sup>2</sup> ])	2
	Small-medium area of exposed cover (>500 m <sup>2</sup> [5,380 ft <sup>2</sup> ] but <1000 m <sup>2</sup> [10,760 ft <sup>2</sup> ])	4
	Medium-large area of exposed cover (>1000 m <sup>2</sup> [10,760 ft <sup>2</sup> ] area of exposed overburden) but <10,000 m <sup>2</sup> [107,600 ft <sup>2</sup> ])	6
	Large area of exposed cover (> 10,000 m <sup>2</sup> [107,600 ft <sup>2</sup> ])	8
Site verification (shallow zone) (0 to 4.6 m [15 ft])	Very small area of exposed surface after excavation (<100 m <sup>2</sup> [1,076 ft <sup>2</sup> ])	1
	Small area of exposed surface after excavation (>100 m <sup>2</sup> [1,076 ft <sup>2</sup> ] but <500 m <sup>2</sup> [5,380 ft <sup>2</sup> ])	2
	Small-medium area of exposed surface after excavation (>500 m <sup>2</sup> [5,380 ft <sup>2</sup> ] but <1000 m <sup>2</sup> [10,760 ft <sup>2</sup> ])	4
	Medium-large area of exposed surface after excavation (>1000 m <sup>2</sup> [10,760 ft <sup>2</sup> ] but <10,000 m <sup>2</sup> [107,600 ft <sup>2</sup> ])	6
	Large area of exposed surface after excavation (>10,000 m <sup>2</sup> [107,600 ft <sup>2</sup> ])	8

Table 14. Sampling Frequency Based on Size of Remediated Waste Site.

Exposed Surface Area After Excavation	Total Number of Decision Subunits	Total Number of Aliquots (Increments) for Entire Site	Total Number of Representative (Multi-Incremental) Samples for Entire Site
Very small area of exposed surface after excavation (<100 m <sup>2</sup> [1,076 ft <sup>2</sup> ])	1	100	1
Small area of exposed surface after excavation (>100 m <sup>2</sup> [1,076 ft <sup>2</sup> ] but <500 m <sup>2</sup> [5,380 ft <sup>2</sup> ])	2	200	2
Small-medium area of exposed surface after excavation (>500 m <sup>2</sup> [5,380 ft <sup>2</sup> ] but <1000 m <sup>2</sup> [10,760 ft <sup>2</sup> ])	4	400	4
Medium-large area of exposed surface after excavation (>1000 m <sup>2</sup> [10,760 ft <sup>2</sup> ] but <10,000 m <sup>2</sup> [107,600 ft <sup>2</sup> ])	6	600	6
Large area of exposed surface after excavation (>10,000 m <sup>2</sup> [107,600 ft <sup>2</sup> ])	8	800	8

Table 15. Confirmatory or Verification Sampling Requirements for Candidate Removal, Treatment, and Disposal Sites. (3 Pages)

Site Code	CSM	Physical State of Waste Released	Estimated Waste Site Area (m <sup>2</sup> )	Samples			Laboratory Analyses (R=radiological COCs <sup>a</sup> C=Chemical COCs <sup>b</sup> )
				Number of Decision Units for Entire Site	Total Number of Increments (Aliquots) for Entire Site	Total Number of Multi-Increment Representative Samples for Entire Site	
200-E-109	1	Solid	39,492	8	800	8	R
200-E-115	1	Solid	84	1	100	1	R
200-E-117	1	Solid	9	1	100	1	R
200-E-121	1	Solid	4,876	6	600	6	R
200-E-124	1	Solid	294	2	200	2	R
200-E-125	2	Unknown	30	1	100	1	R,C
200-E-128	3	Unknown	2	1	100	1	R,C
200-E-129	2	Unknown	22	1	100	1	R,C
200-E-130	2	Unknown	60	1	100	1	R,C
200-E-139	2	Unknown	7,880	6	600	6	R,C
200-E-26	4	Liquid	334	2	200	2	R,C
200-E-29	1	Solid	4,609	6	600	6	R
200-E-43	3	Liquid	3,276	6	600	6	R,C
200-E-53	1	Solid	10,000	6	600	6	R
200-W-14	3	Liquid	360	2	200	2	C
200-W-53	4	Solid	144,708	8	800	8	R
200-W-54	1	Solid	67,500	8	800	8	R
200-W-63	2	Liquid	585	4	400	4	R,C
200-W-64	2	Liquid	14	1	100	1	R,C
200-W-67	1	Solid	1,800	6	600	6	R
200-W-80	1	Solid	218	2	200	2	R
200-W-81	1	Solid	394	2	200	2	R
200-W-83	2	Unknown	139	2	200	2	R,C

Table 15. Confirmatory or Verification Sampling Requirements for Candidate Removal, Treatment, and Disposal Sites. (3 Pages)

Site Code	CSM	Physical State of Waste Released	Estimated Waste Site Area (m <sup>2</sup> )	Samples			Laboratory Analyses (R=radiological COCs <sup>a</sup> C=Chemical COCs <sup>b</sup> )
				Number of Decision Units for Entire Site	Total Number of Increments (Aliquots) for Entire Site	Total Number of Multi-Increment Representative Samples for Entire Site	
200-W-86	2	Unknown	9	1	100	1	R,C
200-W-90	2	Unknown	56	1	100	1	R,C
200-W-106	2	Unknown	330	2	200	2	R,C
600-275	3	Liquid/Solid	15,750	8	800	8	R,C
UPR-200-E-10	3	Liquid/Solid	N/A	--	--	--	R,C
UPR-200-E-101	1	Solid	312	2	200	2	R
UPR-200-E-11	3	Liquid	N/A	--	--	--	R,C
UPR-200-E-112	3	Liquid	N/A	--	--	--	R,C
UPR-200-E-12	3	Liquid	N/A	--	--	--	R,C
UPR-200-E-143	1	Solid	4,645	6	600	6	R
UPR-200-E-20	3	Liquid	N/A	--	--	--	R,C
UPR-200-E-33	2	Liquid	N/A	--	--	--	R,C
UPR-200-E-43	3	Liquid	N/A	--	--	--	R,C
UPR-200-E-50	1	Solid	3,135	6	600	6	R
UPR-200-E-69	3	Liquid	N/A	--	--	--	R,C
UPR-200-E-88	3	Liquid	N/A	--	--	--	R,C
UPR-200-E-89	1	Solid	12,150	8	800	8	R
UPR-200-N-1	3	Liquid	223	2	200	2	R,C
UPR-200-N-2	2	Unknown	37	1	100	1	R,C
UPR-200-W-116	1	Solid	8,100	6	600	6	R
UPR-200-W-23	3	Solid	28	1	100	1	R
UPR-200-W-3	3	Unknown	3	1	100	1	R,C
UPR-200-W-4	2	Unknown	N/A	--	--	--	R,C

Table 15. Confirmatory or Verification Sampling Requirements for Candidate Removal, Treatment, and Disposal Sites. (3 Pages)

Site Code	CSM	Physical State of Waste Released	Estimated Waste Site Area (m <sup>2</sup> )	Samples			Laboratory Analyses (R=radiological COCs <sup>a</sup> C=Chemical COCs <sup>b</sup> )
				Number of Decision Units for Entire Site	Total Number of Increments (Aliquots) for Entire Site	Total Number of Multi-Increment Representative Samples for Entire Site	
UPR-200-W-41	3	Liquid	N/A	--	--	--	R,C
UPR-200-W-44	3	Solid	46	1	100	1	R,C
UPR-200-W-46	1	Solid	N/A	--	--	--	R,C
UPR-200-W-58	1	Solid	N/A	--	--	--	R,C
UPR-200-W-65	1	Solid	114	2	200	2	R,C
UPR-200-W-67	1	Solid	7	1	100	1	R
UPR-200-W-73	3	Liquid	2,231	6	600	6	R,C
UPR-200-W-96	3	Liquid	N/A	--	--	--	R,C
UPR-600-12	3	Liquid	16	1	100	1	R,C
600-262	4	Liquid	59	1	100	1	R,C

<sup>a</sup>See Table 6.

<sup>b</sup>See Table 7.

COC = contaminant of concern.

CSM = conceptual site model.

N/A = not applicable.

Table 16. Existing Analytical Data for Cesium-137 and Strontium-90 Collected in the BC Controlled Area Soils.

BC Controlled Area Conceptual Site Model Zones	Sampled Depth	Sample Number	Cs-137 (pCi/g)	Sr-90 (pCi/g)	Cs/Sr
<b>Zone A</b>					
A	1 cm	S1	787	1100	0.72
A	1 cm	S2	94.6	196	0.48
A	1 cm	S3	71.6	201	0.36
A	1 cm	S4	64	152	0.42
A	1 cm	S5	69.4	203	0.34
A	0.3 m	A-1	893	1600	0.56
A	1 m	A-1	113	200	0.57
A	0.3 m	A-2	12.1	170	0.07
A	1 m	A-2	1.52	6.4	0.24
A	0.3 m	A-3	3.1	5	0.62
A	1 m	A-3	6.28	19	0.33
<b>Zone A Sample Average</b>			<b>192</b>	<b>350</b>	<b>0.43</b>
<b>Zone B</b>					
B	1 cm	S6	41.3	88.8	0.47
B	1 cm	S7	2290	3420	0.67
B	1 cm	S11	3.8	24.6	0.15
B	1 cm	S12	1.49	1.1	1.35
B	1 cm	S13	0.748	2.24	0.33
<b>Zone B Sample Average</b>			<b>467</b>	<b>707</b>	<b>0.60</b>
<b>Zone C</b>					
C	1 cm	S8	0.664	0.494	1.34
C	1 cm	S9	0.318	0.347	0.92
C	1 cm	S10	0.566	1.13	0.50
<b>Zone C Sample Average</b>			<b>0.52</b>	<b>0.66</b>	<b>0.92</b>
<b>Sample Average for all Zones</b>			<b>234</b>	<b>389</b>	<b>0.55</b>
<b>Hanford Site Background</b>			<b>1.05</b>	<b>0.178</b>	<b>5.9</b>

Table 17. Soil-Sampling Requirements. (2 Pages)

Sampling Area	Criteria for Selection of Driven Soil Probe Locations <sup>a</sup>	Geophysical Logging Intervals	Criteria for Soil Sampling Location Selection <sup>a</sup>	Vertical Soil Sample Depth Intervals at Each Location (ft)	Number of Soil Samples	Radionuclides
Area bounded by 41 pCi/g isopleth	10 locations with highest Cs-137 concentrations based on surface survey results	Measurement every 0.5 ft in depth to depth of 10 ft	Collect soil samples at logging locations with the highest concentration of Cs-137 at the lowest depth. Two soil sample locations in each of the high, intermediate, and low concentration probe locations.	Four vertical sample intervals (0.0-0.5, 0.5-1.0, 2.5-3.5, 6.0-7.0)	8	Cs-137 Sr-90
	10 locations with intermediate Cs-137 concentrations based on surface survey results				8	
	10 locations with lowest Cs-137 concentrations based on surface survey results				8	
Area between 12 and 41 pCi/g isopleths	8 locations with highest Cs-137 concentrations based on surface survey results	Measurement every 0.5 ft in depth to depth of 10 ft	Collect soil samples at logging locations with the highest concentration of Cs-137 at the lowest depth. Two soil sample locations in each of the high, intermediate, and low concentration probe locations.	Contingent sample interval <sup>b</sup> (9.0-10.0)	8	Cs-137 Sr-90
	8 locations with intermediate Cs-137 concentrations based on surface survey results				8	
	8 locations with lowest Cs-137 concentrations based on surface survey results				8	

Table 17. Soil-Sampling Requirements. (2 Pages)

Sampling Area	Criteria for Selection of Driven Soil Probe Locations <sup>a</sup>	Geophysical Logging Intervals	Criteria for Soil Sampling Location Selection <sup>a</sup>	Vertical Soil Sample Depth Intervals at Each Location (ft)	Number of Soil Samples	Radionuclides
Entire area					Total characterization soil samples = 48	Cs-137 Sr-90
					Quality control rinsate samples = 3 <sup>c</sup>	
					Quality control duplicate samples = 3	
					<b>Total number of samples = 54</b>	

<sup>a</sup>Geophysical logging and sampling locations will be selected to provide as much lateral coverage of the site as possible.

<sup>b</sup>A contingent sample will be collected from the 9.0 to 10.0 ft depth interval at all locations. Laboratory analysis only will be performed if detections for Cs-137 or Sr-90 occur within the 6.0 to 7.0 ft sample interval.

<sup>c</sup>Rinsate results recorded as total gross gamma and total gross beta.

Table 18. Waste Designation Constituents.

Contaminants of Concern
<b><u>Radiological Constituents to be Determined by Analysis:</u></b> Curium-242, Tin-126
<b><u>Radiological Constituents to be Determined by Calculation:</u></b> Actinium-227, Americium-242, Americium-243, Barium-137m, Bismuth-210, Cadmium-113m, Cesium-135, Curium-244, Curium-245, Curium-246, Curium-247, Curium-248, Europium-150, Iron-55, Lead-210, Molybdenum-93, Nickel-59, Niobium-93m, Palladium-107, Plutonium-241, Plutonium-242, Plutonium-244, Promethium-147, Protactinium-231, Protactinium-233, Radium-224, Samarium-147, Samarium-151, Selenium-79, Thallium-204, Thorium-228, Thorium-229, Thorium-230, Tin-121, Uranium-232, Uranium-233, Uranium-236, Yttrium-90
<b><u>Inorganic Chemical Constituents:</u></b> Boron, Thallium
<b><u>Organic Chemical Constituents:</u></b> Benzyl alcohol, Bromodichloromethane, 1,1-dichloroethylene, Ethyl ether, Freon-11 (trichloromonofluoromethane), Hexone, 1,2,3,4-tetra-hydroquinoline, Isopropyl Alcohol, Methanol, p-dichlorobenzene
<b><u>Herbicides:</u></b> 2,4-D, 2,4-DB, 2,4,5-T, 2,4,5-TP (silvex), Dicamba, Dichloroprop, DNBP
<b><u>Pesticides:</u></b> 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, Aldrin, Alpha-BHC, Alpha-chlordane, Beta-BHC, Delta-BHC, Dieldrin, Endosulfan I, Endosulfan II, Endosulfan sulfate, Endrin, Endrin aldehyde, Endrin ketone, Gamma-BHC (lindane), Heptachlor, Heptachlor epoxide, Methoxychlor, Toxaphene

Table 19. Waste Management Analytical Requirements. (3 Pages)

Chemical Abstracts Service #	Analyte	Survey or Analytical Method <sup>d</sup>	Waste Designation Action Level (pCi/g or mg/kg or as noted)	Required Detection Limits <sup>a</sup> (pCi/g or mg/kg)	Precision Required	Accuracy Required
<b>Radiological Constituents (pCi/g)</b>						
15510-73-3	Curium-242	AmAEA <sup>b</sup>	1	1	±30% <sup>c</sup>	70-130 <sup>c</sup>
15832-50-5	Tin-136	HPGe/GeLi		1	±30% <sup>c</sup>	70-130 <sup>c</sup>
<b>Inorganic Chemical Constituents (mg/kg or as noted)</b>						
7440-42-8	Boron	EPA Method 6010	<sup>e</sup>	2	±30% <sup>c</sup>	70-130 <sup>c</sup>
7440-28-0	Thallium	EPA Method 6010	5.6E+3	5	±30% <sup>c</sup>	70-130 <sup>c</sup>
<b>Organic Chemical Constituents (mg/kg or as noted)</b>						
67-56-1	Methanol	EPA Method 8015	0.75 mg/L TCLP	1	±30% <sup>c</sup>	70-130 <sup>c</sup>
<b>Herbicides (mg/kg)</b>						
94-75-7	2,4-D	EPA Method 8151	<sup>e</sup> 10 mg/L TCLP <sup>f</sup> 10 mg/kg <sup>g</sup>	400	±30% <sup>c</sup>	70-130 <sup>c</sup>
94-82-6	2,4-DB	EPA Method 8151	<sup>e</sup>	100	±30% <sup>c</sup>	70-130 <sup>c</sup>
93-76-5	2,4,5-T	EPA Method 8151	<sup>e</sup> 7.9 mg/kg <sup>g</sup>	20	±30% <sup>c</sup>	70-130 <sup>c</sup>
93-72-1	2,4,5-TP (silvex)	EPA Method 8151	<sup>e</sup> 1 mg/L TCLP <sup>f</sup> 7.9 mg/kg <sup>g</sup>	20	±30% <sup>c</sup>	70-130 <sup>c</sup>

Table 19. Waste Management Analytical Requirements. (3 Pages)

Chemical Abstracts Service #	Analyte	Survey or Analytical Method <sup>d</sup>	Waste Designation Action Level (pCi/g or mg/kg or as noted)	Required Detection Limits <sup>a</sup> (pCi/g or mg/kg)	Precision Required	Accuracy Required
1918-00-9	Dicamba	EPA Method 8151	°	100	±30% <sup>c</sup>	70-130°
120-36-5	Dichloroprop	EPA Method 8151	°	100	±30% <sup>c</sup>	70-130°
88-85-7	Dinitro-o-sec-butylphenol	EPA Method 8151	° 2.5 mg/kg <sup>g</sup>	12	±30% <sup>c</sup>	70-130°
<b>Pesticides (mg/kg)</b>						
72-54-8	4,4'-DDD	EPA Method 8081	° 0.087 mg/kg <sup>g</sup>	3.3	±30% <sup>c</sup>	70-130°
72-55-9	4,4'-DDE	EPA Method 8081	° 0.087 mg/kg <sup>g</sup>	3.3	±30% <sup>c</sup>	70-130°
50-29-3	4,4'-DDT	EPA Method 8081	° 0.087 mg/kg <sup>g</sup>	3.3	±30% <sup>c</sup>	70-130°
309-00-2	Aldrin	EPA Method 8081	° 0.066 mg/kg <sup>g</sup>	1.65	±30% <sup>c</sup>	70-130°
319-84-6	Alpha-BHC	EPA Method 8081	° 0.066 mg/kg <sup>g</sup>	1.65	±30% <sup>c</sup>	70-130°
5103-71-9	Alpha-chlordane	EPA Method 8081	°	16.5	±30% <sup>c</sup>	70-130°
319-85-7	Beta-BHC	EPA Method 8081	° 0.066 mg/kg <sup>g</sup>	1.65	±30% <sup>c</sup>	70-130°
319-86-8	Delta-BHC	EPA Method 8081	° 0.066 mg/kg <sup>g</sup>	1.65	±30% <sup>c</sup>	70-130°
60-57-1	Dieldrin	EPA Method 8081	° 0.13 mg/kg <sup>g</sup>	3.3	±30% <sup>c</sup>	70-130°
959-98-8	Endosulfan I	EPA Method 8081	° 0.066 mg/kg <sup>g</sup>	1.65	±30% <sup>c</sup>	70-130°
33213-65-9	Endosulfan II	EPA Method 8081	° 0.13 mg/kg <sup>g</sup>	3.3	±30% <sup>c</sup>	70-130°
1031-07-8	Endosulfan sulfate	EPA Method 8081	° 0.13 mg/kg <sup>g</sup>	3.3	±30% <sup>c</sup>	70-130°
72-20-8	Endrin	EPA Method 8081	° 0.02 mg/L TCLP <sup>f</sup> 0.13 mg/kg <sup>g</sup>	3.3	±30% <sup>c</sup>	70-130°
7421-93-4	Endrin aldehyde	EPA Method 8081	° 0.13 mg/kg <sup>g</sup>	3.3	±30% <sup>c</sup>	70-130°
53494-70-5	Endrin ketone	EPA Method 8081	°	3.3	±30% <sup>c</sup>	70-130°
58-89-9	Gamma-BHC (lindane)	EPA Method 8081	° 0.4 mg/L TCLP <sup>f</sup> 0.066 mg/kg <sup>g</sup>	1.65	±30% <sup>c</sup>	70-130°
76-44-8	Heptachlor	EPA Method 8081	° 0.008 mg/L TCLP <sup>f</sup> 0.066 mg/kg <sup>g</sup>	1.65	±30% <sup>c</sup>	70-130°

Table 19. Waste Management Analytical Requirements. (3 Pages)

Chemical Abstracts Service #	Analyte	Survey or Analytical Method <sup>d</sup>	Waste Designation Action Level (pCi/g or mg/kg or as noted)	Required Detection Limits <sup>a</sup> (pCi/g or mg/kg)	Precision Required	Accuracy Required
1024-57-3	Heptachlor epoxide	EPA Method 8081	<sup>e</sup> 0.066 mg/kg <sup>g</sup>	1.65	±30% <sup>c</sup>	70-130 <sup>c</sup>
72-43-5	Methoxychlor	EPA Method 8081	<sup>e</sup> 10 mg/L TCLP <sup>f</sup> 0.18 mg/kg <sup>g</sup>	16.5	±30% <sup>c</sup>	70-130 <sup>c</sup>
8001-35-2	Toxaphene	EPA Method 8081	<sup>e</sup> 0.5 mg/L TCLP <sup>f</sup> 2.6 mg/kg <sup>g</sup>	165	±30% <sup>c</sup>	70-130 <sup>c</sup>

<sup>a</sup>Detection limits are based on optimal conditions in a standard fixed laboratory. Interferences and matrix effects may degrade the values shown.

<sup>b</sup>AmAEA, NpAEA, PuAEA, ThAEA, UAEA = chemical separation, electro/microprecipitation deposition, AEA via Si barrier detector.

<sup>c</sup>Accuracy criteria for associated batch laboratory control sample percent recoveries. Except for gamma energy analysis, additional analysis-specific evaluations also performed for matrix spikes, tracers, and carriers as appropriate to the method. Precision criteria for batch laboratory replicate sample analyses.

<sup>d</sup>4-digit EPA Methods are found in SW-846.

<sup>e</sup>There is no action level for this constituent; it contributes to the Washington State equivalent concentration calculation.

<sup>f</sup>Federal toxic hazardous waste (TCLP).

<sup>g</sup>Treatment standard as an underlying hazardous constituent in accordance with 40 CFR 268.48 for nonwaste waters (applicable value for soils).

40 CFR 268.48, "Land Disposal Restrictions," "Universal Treatment Standards."

SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A.*

AEA = alpha energy analysis.

EPA = U.S. Environmental Protection Agency.

GeLi = germanium-lithium (drifted).

HPGe = high-purity germanium.

TCLP = toxicity characteristic leaching procedure.

Table 20. Key Features of Waste Material/Media Sampling Design for 200-UR-1 Operable Unit Sites.

Material/Media	Sample Collection Methodology	Key Features/Sampling Frequency	Basis for Sampling Design
Observational-based sampling of waste material/media	Waste material/media sampling for offsite analysis.	One sample collected from the location with high field screening results or one sample per media type per 200-UR-1 Operable Unit site.	Dangerous/hazardous waste designation. Analyses could include metals totals, toxicity characteristic leaching procedure, or volatile organic analysis/semivolatile organic analysis, herbicide, and pesticide suite.
Anomalous media	Sampling and analytical requirements to be determined by the Fluor Hanford, Inc., Waste Management representative; the project safety engineer; the project environmental lead; and the analytical lead (or task lead, as appropriate).		

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