This document was too large to scan as a single document. It has been divided into smaller sections.

Section 1 of 4

Document Information			
Document #	DOE/RL-2004-85	REV	DFTA
Title	FEASIBILITY STUDY FOR THE 200-PW-2 URANIUM RICH PROCESS WASTE GROUP & 200-PW-4 GENERAL PROCESS CONDENSATE WASTE GROUP OU [DRAFT A]		
Date	05/08/2006		
Originator		ORG CO	DOE-RL
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- [x] Report
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Sheet 1 of 1

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DOE/RL-2004-85
Draft A

Feasibility Study for the 200-PW-2 Uranium-Rich Process Waste Group and the 200-PW-4 General Process Condensate Group Operable Units

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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APPENDICES

FIGURES

TABLES

TERMS

ARAR	applicable or relevant and appropriate requirement
ASD	ammonia scrubber distillate
BCG	biota concentration guide
bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CLARC	cleanup levels and risk calculations (Ecology 94-145, *Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation; CLARC, Version 3.1*)
CNT	condensate neutralization tank
COC	contaminant of concern
COPC	contaminant of potential concern
Core Zone	exclusive-use boundary
DOE	U.S. Department of Energy
ORP	U.S. Department of Energy, Office of River Protection
DST	double-shell tank
Ecology	Washington State Department of Ecology
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ET	evapotranspiration
FS	feasibility study
FY	fiscal year
GRA	general response action
HAB	Hanford Advisory Board
HCP	*Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE/EIS-0222-F)
HF RCRA Permit	*Hanford Facility RCRA Permit*
HHRA	human health risk assessment
HQ	hazard quotient
HRLS	High-Rate Logging System
HSW	high-salt waste
IC	institutional controls
Implementation Plan	*200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (DOE/RL-98-28)
IMUST	inactive miscellaneous underground storage tank
ISV	in situ vitrification
K_d	distribution coefficient
MCL	maximum contaminant level
MDA	minimum detectable activity
MDL	minimum detection level
mm/yr	millimeter per year

NEPA	*National Environmental Policy Act of 1969*
NMLS	Neutron-Moisture Logging System
NPH	normal petroleum hydrocarbon
NPL	"National Priorities List" (40 CFR 300, Appendix B)
OM	order of magnitude
OU	operable unit
PC	process condensate
PFP	Plutonium Finishing Plant
PNNL	Pacific Northwest National Laboratory
POC	point of compliance
PRG	preliminary remediation goal
PUREX	Plutonium-Uranium Extraction (Plant or process)
QC	quality control
RAO	remedial action objective
RBC	risk-based concentration
RCRA	*Resource Conservation and Recovery Act of 1976*
REDOX	Reduction-Oxidation (Plant or process)
RESRAD	RESidual RADioactivity (dose model) (ANL 2002)
RI	remedial investigation
RI Report	*Remedial Investigation Report for the 200-PW-2 Uranium-Rich Process Waste Group and the 200-PW-4 General Process Condensate Group Operable Units* (DOE/RL-2004-25)
RI/FS	remedial investigation/feasibility study
RL	U.S. Department of Energy, Richland Operations Office
RMA	Radioactive Material Area
ROD	record of decision
RPP	RCRA past-practice
SGL	spectral gamma logging
SGLS	Spectral Gamma Logging System
SLERA	screening-level ecological risk assessment
STOMP	Subsurface Transport Over Multiple Phases (modeling code)
TBP	tributyl phosphate
TPH	total petroleum hydrocarbon
Tri-Parties	U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TRU	waste materials contaminated with more than 100 nCi/g of transuranic materials having half-lives longer than 20 years)
TSD	treatment, storage, and/or disposal (unit)
UNH	uranyl nitrate hexahydrate
UO_3	uranium trioxide
UPR	unplanned release
URM	Underground Radioactive Material (area or posting)
V/H	vertical/horizontal
VCP	vitrified clay pipeline
WAC	*Washington Administrative Code*
WESF	Waste Encapsulation and Storage Facility

WIDS	*Waste Information Data System* database
WIPP	Waste Isolation Pilot Plant
Work Plan	*Uranium-Rich/General Process Condensate and Process Waste Group Operable Units RI/FS Work Plan and RCRA TSD Unit Sampling Plan; Includes: 200-PW-2 and 200-PW-4 Operable Units* (DOE/RL-2000-60)

METRIC CONVERSION CHART

Into Metric Units			Out of Metric Units		
If You Know	*Multiply By*	*To Get*	*If You Know*	*Multiply By*	*To Get*
Length			**Length**		
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
Area			**Area**		
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	0.0836	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
Mass (weight)			**Mass (weight)**		
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
Volume			**Volume**		
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			
Temperature			**Temperature**		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius	Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity			**Radioactivity**		
picocuries	37	Millibecquerel	millibecquerel	0.027	picocuries

1.0 INTRODUCTION

The Hanford Site, managed by the U.S. Department of Energy (DOE), encompasses approximately 1,517 km^2 (586 mi^2) in the Columbia Basin of south-central Washington State. In 1989, the U.S. Environmental Protection Agency (EPA) placed the 100, 200, 300, and 1100 Areas at the Hanford Site on the 40 *Code of Federal Regulations* (CFR) 300, "National Oil and Hazardous Substances Pollution Contingency Plan," Appendix B, "National Priorities List" (NPL) pursuant to the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). The 200 Areas NPL Site consists of the 200 West Area and 200 East Area (Figure 1-1). The 200 Areas contain waste management facilities, inactive irradiated fuel reprocessing facilities, and the 200 North Area, which formerly was used for interim storage and staging of irradiated fuel.

The 200 Areas NPL site includes a region referred to as the Central Plateau, consisting of approximately 800 waste sites currently organized into 23 waste site groups, called operable units (OU). Two of the 23 waste site groups are the 200-PW-2 and the 200-PW-4 OUs, the subject of this feasibility study (FS). All of the 200-PW-2 and 200-PW-4 OU waste sites are located in the 200 East and 200 West Areas (Figures 1-2 through 1-5) and lie within the industrial exclusive land-use boundary identified in DOE/EIS-0222-F, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (Figure 1-1). The source facilities discharging waste to the 200-PW-2 and 200-PW-4 OU waste sites are identified in Figure 1-6.

Submittal of this FS and associated proposed plan for the 200-PW-2 and 200-PW-4 OU waste sites by April 30, 2006, will meet Interim Milestone M-015-43C, "Submit 200-PW-2 OU Feasibility Study/Proposed RCRA Permit Modification Including the Past Practice Waste Sites in the 200-PW-4 General Process Waste Group of the Hanford Federal Facility Agreement and Consent Order" (*Hanford Federal Facility Agreement and Consent Order* [Tri-Party Agreement]) (Ecology et al. 1989). Further, submittal of this FS containing closure planning information for the 200-PW-2 and 200-PW-4 OU *Resource Conservation and Recovery Act of 1976* (RCRA) treatment, storage, and/or disposal (TSD) units will satisfy Interim Milestone M-020-33, "Submit 216-A-10 Crib, 216-A-36B Crib, 216-A-37-1 Crib, and 207-A South Retention Basin Closure/Post Closure Plans to Ecology in Coordination with the Feasibility Study for the 200-PW-2 Uranium-Rich Process Waste Group Operable Unit (To Be Coordinated Under M-15-43C)."

Table 1-1 identifies all of the 200-PW-2 and 200-PW-4 OU waste sites within the scope of this FS. This includes waste sites investigated in accordance with DOE/RL-2000-60, *Uranium-Rich/General Process Condensate and Process Waste Group Operable Units RI/FS Work Plan and RCRA TSD Unit Sampling Plan; Includes: 200-PW-2 and 200-PW-4 Operable Units* (Work Plan) and reported in the remedial investigation (RI) document, DOE/RL-2004-25, *Remedial Investigation Report for the 200-PW-2 Uranium-Rich Process Waste Group and the 200-PW-4 General Process Condensate Group Operable Units* (RI Report). The 200-PW-2 and 200-PW-4 OUs consist of 34 RCRA past-practice (RPP) sites and 4 RCRA TSD units. These waste sites predominately are cribs, trenches, french drains, basins, and ditches where liquid process waste was disposed to the soil column. Table 1-2 also identifies waste sites that were investigated in the Work Plan but subsequently reassigned to the 200-UW-1 OU for remediation in accordance with Tri-Party Agreement Change Package C-03-01 and the Tri-Party Agreement waste site reclassification process (RL-TPA-90-0001, *Tri-Party Agreement Handbook Management Procedures*).

1.1 PURPOSE

The purpose of this FS is to develop and evaluate alternatives for remediation of the waste sites in the 200-PW-2 and 200-PW-4 OUs that will address potential risks to human health and the environment from these sites and to function as a supporting document for the proposed plan (DOE/RL-2004-86, *Proposed Plan for the 200-PW-2 (Uranium-Rich Process Waste Group) and 200-PW-4 (General Process Condensate Group)* OUs. This FS refines preliminary applicable or relevant and appropriate requirements (ARAR), remedial action objectives (RAO), and general response actions (GRA) initially identified in DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (Implementation Plan). Technology screening and development of alternatives initially performed in the Implementation Plan are herein reviewed and refined, as necessary, based on the site-specific data reported in the RI Report (DOE/RL-2004-25) and other sources of existing information. The initial remedial alternative development provides the basis for developing a focused range of viable alternatives for the 200-PW-2 and 200-PW-4 OU waste sites (e.g., no action; removal, treatment, and disposal; containment) appropriate to address site-specific conditions. The alternatives are evaluated against the nine CERCLA evaluation criteria defined in EPA/540/G-89/004, *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final*, OSWER 9355.3-01. The FS evaluation serves as the basis for identifying preferred remedial alternative(s). The preferred alternatives will be presented to the public for review and comment in DOE/RL-2004-86. Following public review, the Washington State Department of Ecology (Ecology), EPA, and DOE Richland Operations Office (RL) will prepare a CERCLA record of decision (ROD) that identifies the remedial alternative(s) to be implemented for the 200-PW-2 and 200-PW-4 OU waste sites.

Information in this FS and related documents also will be used to support closure of the RCRA TSD units (Table 1-1). RCRA TSD unit substantive closure requirements are met through preparation of closure documentation and modification(s) to WA7890008967, *Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 8, for the Treatment, Storage, and Disposal of Dangerous Waste* (HF RCRA Permit), Dangerous Waste Portion, also presented for public review and comment. Section 1.3 of this FS provides additional discussion of integration of RCRA closure activities with CERCLA remedial actions.

1.2 SCOPE

This FS addresses remediation of 38 waste sites within the 200-PW-2 or 200-PW-4 OUs (Table 1-1). These sites include 34 RPP sites, and 4 RCRA TSD units within the industrial exclusive land-use boundary. Cleanup of the 200-PW-2 and 200-PW-4 OU waste sites is a source control action addressing contaminated soil and structures (e.g., tanks) associated with cribs, trenches, ditches, basins, french drains, and unplanned releases (UPR). The scope of this FS does not include the remediation of groundwater beneath these waste sites. Although the

CERCLA action is required to be protective of groundwater in accordance with the RAOs (Chapter 3.0), contaminated groundwater beneath 200-PW-2 and 200-PW-4 OU waste sites has been and continues to be addressed under the following groundwater OUs: 200-PO-1 (A Plant sites), 200-BP-5 (B and C Plant sites), 200-UP-1 (S Plant sites), and 200-ZP-1 (T Plant sites) (DOE/RL-2004-25).

1.3 CERCLA AND RCRA INTEGRATION

The Tri-Party Agreement directs cleanup programs for co-located RCRA and CERCLA sites to integrate the requirements of RCRA and CERCLA regulations so that cleanup activities are performed in a consistent manner and meet all applicable regulatory requirements. Details of this integration are provided in Article IV and Section 5.5 of the Tri-Party Agreement. Additionally, the Implementation Plan (DOE/RL-98-28) provides a discussion of RCRA/CERCLA integration for the Central Plateau. This FS implements the RCRA/CERCLA integration process presented in the Implementation Plan and the Tri-Party Agreement.

Closure activities for the four RCRA TSD units located within the 200-PW-2 and 200-PW-4 OUs (216-A-10 Crib, 216-A-36B Crib, 207-A South Retention Basin, and the 216-A-37-1 Crib) are discussed in Chapter 8.0, Section 8.2 and closure plans are provided in Appendix E of this FS. Upon closure plan approval, Ecology will separately issue a draft permit modification for incorporation of these TSD units into the HF RCRA Permit. The modification could consist of adding to the HF RCRA Permit unit-specific chapter(s) in Part V, Unit Specific Conditions for Units Undergoing Closure, and attachment(s). The Part V chapter identifies all permit requirements for each TSD unit consistent with the CERCLA ROD. The attachment consists of the enforceable sections from applicable CERCLA documents or other supporting documents corresponding to specific RCRA TSD closure plan requirements. The Part V permit conditions and attachment(s) become an enforceable part of the HF RCRA Permit. Changes to the chapters and attachments are subject to the HF RCRA Permit modification process.

1.4 FEASIBILITY STUDY REPORT ORGANIZATION

The essential elements of the FS process are presented in Chapters 1.0 through 8.0 and Appendices A though G and are summarized as follows. The detailed cost analysis that supports Chapters 6.0, 7.0, and 8.0 will be released as a separate document.

- Chapter 1.0 presents the purpose, scope, and regulatory framework for the FS, as well as this overview of report organization.

- Chapter 2.0 presents descriptions of the physical setting and natural resources; provides an overview of existing waste site information including characterization data and site conceptual models for representative waste sites; establishes the logic for grouping analogous waste sites and applying the analogous waste site approach; and summarizes risk evaluations.

- Chapter 3.0 discusses land-use assumptions and develops the overall cleanup objectives and media-specific preliminary remediation goals (PRG) for the waste sites.
- Chapter 4.0 refines the technologies identified for these OUs and waste sites in the Implementation Plan (DOE/RL-98-28) by evaluating new information on existing technologies or promising and relevant emerging technologies.
- Chapter 5.0 describes the remedial alternative development process, initially conducted as part of the Implementation Plan (DOE/RL-98-28) development, and uses that information in concert with site-specific data from the RI to refine the remedial alternatives to be carried forward for detailed and comparative analyses.
- Chapter 6.0 presents a detailed analysis of each of the remedial alternatives against the standard CERCLA evaluation criteria and DOE policy.
- Chapter 7.0 presents the comparative analysis of the remedial alternatives and identifies relative advantages and disadvantages, based on the CERCLA evaluation criteria. The results of this analysis provide a basis for selecting a remedial alternative for each representative waste site and its analogous waste sites.
- Chapter 8.0 summarizes the conclusions of the FS. This chapter also presents the preferred alternatives and path forward for remediation of the 200-PW-2 and 200-PW-4 OU waste sites and for closure of the 200-PW-2 and 200-PW-4 OU TSD units.
- Chapter 9.0 contains references for the main text of the report; each appendix contains its own reference section.
- Appendix A presents the results of the 216-S-7 Crib RI.
- Appendix B includes current photographs of the waste sites.
- Appendix C presents an analysis of regulatory requirements and available guidance with respect to the 200-PW-2 and 200-PW-4 OUs.
- Appendix D presents the human health and ecological risk evaluations, including the methodology, results, and uncertainties. This appendix also includes further risk evaluations pertaining to ambient air risk screening (Attachment A) and inadvertent intruder scenario (Attachment B).
- Appendix E presents rationale for removing contaminants of potential concern (COPC) from consideration as contaminants of concern (COC).
- Appendix F presents cost estimate backup information.
- Appendix G provides an evaluation of potential human-health and radiological risk at shallow analogous waste sites.

Figure 1-1. The Hanford Site and the General Location of 200-PW-2 and 200-PW-4 Operable Unit Waste Sites.

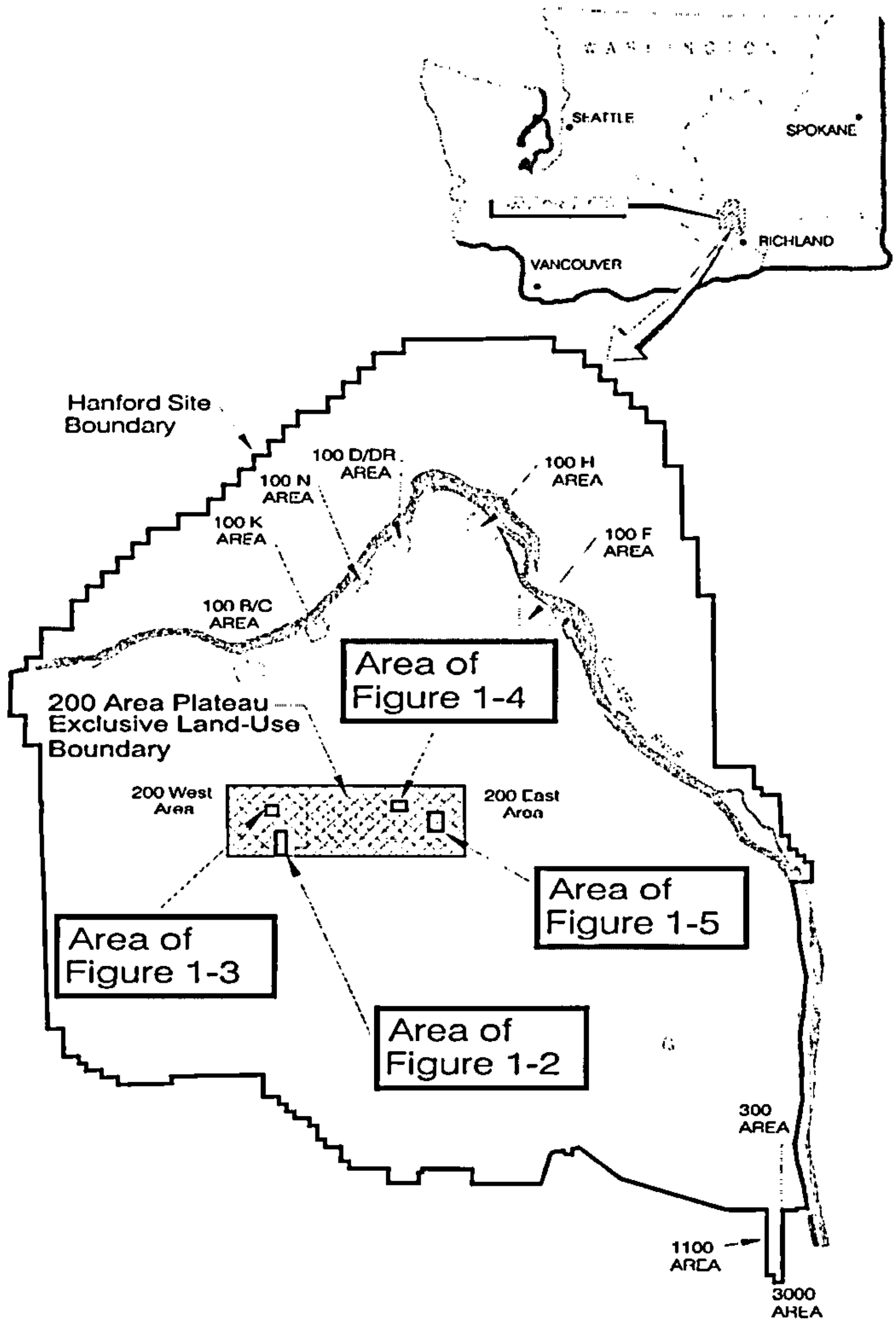

Table 1-1. 200-PW-2 and 200-PW-4 Operable Unit Waste Sites within the Feasibility Study Scope. (2 Pages)

Operable Unit	Site Code	Site Type	Category
200-PW-2	216-A-36A	Crib	RPP
200-PW-2	216-A-36B	Crib	TSD
200-PW-2	216-B-12	Crib	RPP
200-PW-2	216-B-60	Crib	RPP
200-PW-2	216-C-1	Crib	RPP
200-PW-2	216-S-1&2	Crib	RPP
200-PW-2	216-S-7	Crib	RPP
200-PW-2	216-S-8	Trench	RPP
200-PW-2	270-E-1	Neutralization tank	RPP
200-PW-2	UPR-200-E-17	Unplanned release	RPP
200-PW-2	UPR-200-E-39	Unplanned release	RPP
200-PW-2	UPR-200-E-64	Unplanned release	RPP
200-PW-2	UPR-200-W-36	Unplanned release	RPP
200-PW-4	207-A SOUTH	Retention basin	TSD
200-PW-4	209-E-WS-3	Valve pit and hold-up tank	RPP
200-PW-4	216-A-34	Ditch	RPP
200-PW-4	216-A-37-1	Crib	TSD
200-PW-4	216-A-45	Crib	RPP
200-PW-4	216-C-3	Crib	RPP
200-PW-4	216-C-5	Crib	RPP
200-PW-4	216-C-7	Crib	RPP
200-PW-4	216-C-10	Crib	RPP
200-PW-4	216-S-4	French drain	RPP
200-PW-4	216-S-22	Crib	RPP
200-PW-4	216-S-23	Crib	RPP
200-PW-4	216-T-20	Trench	RPP
200-PW-4	UPR-200-E-145	Unplanned release	RPP

Sources: DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*; DOE/RL-2000-60, *Uranium-Rich/General Process Condensate and Process Waste Group Operable Units RI/FS Work Plan and RCRA TSD Unit Sampling Plan; Includes: 200-PW-2 and 200-PW-4 Operable Units*; and DOE/RL-2004-25, *Remedial Investigation Report for the 200-PW-2 Uranium-Rich Process Waste Group and the 200-PW-4 General Process Condensate Group Operable Units.*

RCRA = *Resource Conservation and Recovery Act of 1976.*
RPP = RCRA past-practice (unit).
TSD = treatment, storage, and/or disposal (unit).

Table 1-2. Former 200-PW-2 and 200-PW-4 Operable Unit Waste Sites Reassigned to the 200-UW-1 Operable Unit.

Operable Unit	Site Code	Site Type	Category
200-PW-2	200-W-42	Radioactive process sewer	RPP
200-PW-2	216-U-1&2	Crib	RPP
200-PW-2	216-U-5	Trench	RPP
200-PW-2	216-U-6	Trench	RPP
200-PW-2	216-U-8	Crib	RPP
200-PW-2	216-U-12	Crib	TSD
200-PW-2	241-U-361	Settling tank	RPP
200-PW-2	UPR-200-W-19	Unplanned release	RPP
200-PW-2	UPR-200-W-163	Unplanned release	RPP
200-PW-2	270-W	Neutralization tank	RPP
200-PW-4	216-U-16	Crib	RPP
200-PW-4	216-U-17	Crib	RPP

Sources: DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*; DOE/RL-2000-60, *Uranium-Rich/General Process Condensate and Process Waste Group Operable Units RI/FS Work Plan and RCRA TSD Unit Sampling Plan; Includes: 200-PW-2 and 200-PW-4 Operable Units*; and DOE/RL-2004-25, *Remedial Investigation Report for the 200-PW-2 Uranium-Rich Process Waste Group and the 200-PW-4 General Process Condensate Group Operable Units.*

RCRA = *Resource Conservation and Recovery Act of 1976.*
RPP = RCRA past-practice (unit).
TSD = treatment, storage, and/or disposal (unit).

2.0 BACKGROUND INFORMATION

This chapter provides background information for the 200-PW-2 Uranium-Rich Process Waste Group OU and the 200-PW-4 General Condensate Waste Group OU. The information includes OU background and history; physical setting; natural resources; representative waste site description, characterization, and contamination; evaluation of analogous waste sites; and risk assessment summary, including an evaluation of ecological significance.

2.1 OPERABLE UNITS BACKGROUND AND HISTORY

This section describes the background and history of the waste-generating processes and facilities contributing waste to the 200-PW-2 and 200-PW-4 OU waste sites (Table 1-1).

2.1.1 Buildings and Ancillary Facilities

The Hanford Site, established in 1943, was constructed and operated to produce plutonium for nuclear weapons using production reactors and chemical reprocessing plants. In March 1943, construction began on three reactor facilities (B, D, and F Reactors) in the 100 Area and on three chemical processing facilities (B, T, and U Plants) in the 200 East and 200 West Areas. Operations in the 200 East and 200 West Areas mainly were related to separation of special nuclear materials from spent nuclear fuel (i.e., fuel withdrawn from a nuclear reactor following irradiation). Operations at the following main 200 Areas processing facilities (Figure 1-6) produced process distillate, drainages, and various condensates that were sent to 200-PW-2 and 200-PW-4 OU waste sites for disposal.

T Plant. Construction of the 221-T (Canyon) Building (T Plant) was completed in 1944. From 1945 to 1956, T Plant operations consisted of inorganic chemical separation of weapons-grade plutonium from irradiated uranium fuel rods using the bismuth phosphate/lanthanum fluoride process. The bismuth/phosphate process was an inorganic, step-wise precipitation process for separating plutonium from uranium and fission products from dissolved fuel rod solutions that was conducted in the 221-T Canyon Building. The process used sodium hydroxide to remove aluminum cladding and concentrated nitric acid to dissolve the fuel rods. Bismuth phosphate, bismuth oxynitrate, hydrogen peroxide, sodium dichromate, ferrous hydroxide, ferrous ammonium sulfates, and phosphoric, sulfuric, and nitric acids were chemicals used in the process to create a dilute plutonium solution. The lanthanum/fluoride process, also performed in the 221-T Canyon Building, further purified the dilute plutonium solution and used sodium metabismuthate, phosphoric, oxalic, nitric, and hydrofluoric acids, and lanthanum salt to create a concentrated solution. The solution was sent to the 231-Z Plutonium Isolation Plant, where further purification treatments and evaporation converted the solution into a final product of plutonium nitrate paste.

B Plant. Construction of the 221-B Canyon Building (B Plant) was completed in 1945 and was similar to T Plant. The B Plant operated from 1945 to 1952, also using the bismuth phosphate/lanthanum fluoride process to separate plutonium from irradiated fuel rods. From

1952 to 1963, the B Plant was used for various waste treatment operations. In 1963, B Plant began operations to recover cesium, strontium, and rare earth metals from Plutonium-Uranium Extraction (PUREX) Plant and Reduction-Oxidation (REDOX) Plant high-level double-shell tank (DST) waste using an acid oxalate precipitation process. Solvent extraction using a variation of the tributyl phosphate (TBP) process ion-exchange columns also was used to recover cesium and technetium isotopes. In 1968, the Waste Encapsulation and Storage Facility (WESF) was constructed at the west end of the B Plant and designated the 225-B Facility. WESF contained a thermal evaporation concentrator to concentrate low-level radioactive waste, including DST waste and low-level waste from miscellaneous sumps and drains in the 40 WESF process cells of the 221-B Canyon Building. The concentrator also processed waste produced by the cleanout of process vessels at the 221-B Building and WESF through 1986.

S Plant. The 202-S Canyon Building (S Plant) was constructed in 1956 and operated until 1967 using the REDOX solvent extraction separations process to separate plutonium from decladded, dissolved fuel rods and to recover unspent uranium. Methyl isobutyl ketone (hexone) was used in the separations process. Hexone and aluminum nitrate nonahydrate in nitric acid in ion-exchange columns were used to extract uranium and plutonium from the dissolved fuel rod solution, to separate plutonium from uranium, and to refine resultant uranium and plutonium solutions. The dissolved fuel rod solution was concentrated and sent to the S/SX Tank Farms for storage. REDOX cladding waste and high-level waste sent to the 241-S-101 and 241-S-104 Tanks was often self-boiling, and from 1953 to 1956, vapors were collected and routed through condensers. REDOX (202-S Canyon Building) mainly contained aqueous and organic solvent extraction waste from several REDOX process sources that were slightly acidic and contained fission products including Cs-137, Ru-106, Sr-90, Pu-239, and uranium. The REDOX process waste stream also consisted of large volumes of aluminum nitrate, zirconium oxide, sodium fluoride, sodium nitrate, and potassium fluoride. Other waste associated with the REDOX process included chromate, sodium sulfate, and ferric hydroxide compounds. The presence of additional radionuclides including tritium and Co-60 were reported in REDOX waste streams. Process drainage; process distillate drainage; and miscellaneous offgas condensate waste streams from the silver reactor, air sparger, ruthenium tetraoxide scrubber, nitric acid recovery, radioiodine offgas treatment, waste treatment condensers, solvent recovery, and 240 and 241 Vault (waste treatment/storage) (DOE/RL-91-60, *S Plant Source Aggregate Area Management Study Report*) were sent to the cribs and trenches. In 1967, the 293-S Building (Offgas Treatment and Recovery Facility) was constructed for backup filtration for radioactive iodine removal in combination with recovery of nitric acid vapors using a caustic scrubber system from dissolved fuel rod solutions. The facility was deactivated in 1969.

A Plant. The 202-A Canyon Building (A Plant) was constructed in 1955 and operated from 1955 to 1972 and again from 1983 to 1990 separating plutonium from irradiated fuel rods using the PUREX process. The PUREX process used TBP in ion-exchange columns. The PUREX Plant also was used to reprocess uranium fuel, which yielded uranium, neptunium, and plutonium oxides. Waste streams generated at the PUREX Plant or in the supporting 202-A, 203-A, 206-A, 293-A, 294-A, and 295-A Buildings mainly were aqueous and organic solvent extraction waste from PUREX process sources, including process drainage; process distillate drainage; miscellaneous offgas condensates from the acid absorbers, ammonia scrubber, nitric acid fractionalization, waste treatment condensers, solvent recoveries, and nitric acid storage; and waste treatment/storage waste streams (DOE/RL-92-04, *PUREX Plant Source Aggregate*

Area Management Study Report). The ammonia scrubber distillate (ASD) waste contained Am-241, Co-60, Pu-239, Sr-90, tritium, Sn-113, I-129, Cs-137, Pm-147, and U-238. Hazardous chemicals used in A Plant operations include sodium nitrate used to regenerate ion-exchange columns, sodium hydroxide used for decontamination applications, and the antifoam agent used in the evaporator vessel. Chemical contaminants included ammonium fluoride, ammonium nitrate, and sodium dichromate. PUREX waste generally was routed to the A Tank Farms including the 241-AW-102 Tank, which fed the 242-A Evaporator.

C Plant. The 201-C Process Building (C Plant, Hot Semiworks Plant) was constructed in 1944 as a pilot plant for tests of the REDOX process before startup of the S Plant. The Hot Semiworks Plant and ancillary facilities generated REDOX waste and, after 1954, PUREX waste that was high-salt waste, process condensates, and material described as "cold-run" waste from the REDOX and PUREX processes. The C Plant waste generated during the REDOX process included coating waste from decladding of aluminum-clad fuel rods in a boiling sodium nitrate/sodium hydroxide solution. The process produced a waste stream consisting primarily of uranium, plutonium, sodium hydroxide, sodium aluminate, sodium nitrate and nitrite, and sodium silicate. The waste solution was transferred to a tank separate from the high-level waste. Later during the REDOX processes, Zircaloy-clad fuels were used and were declad using an ammonium nitrate-ammonium fluoride mixture. The coating waste from the aluminum and Zircaloy-clad fuels was neutralized with caustic soda. Strontium, cerium, cesium, and promethium recovery experimental runs also were conducted in the 201-C Building. The Critical Mass Laboratory (209-E Building) conducted criticality experiments with plutonium nitrate and enriched uranium solutions from 1960 to 1983. The 209-E Critical Mass Laboratory generated mostly acidic radioactive liquid waste containing mainly Cs-137, Ru-106, Sr-90, plutonium, uranium, and some nitrates (DOE/RL-92-18, *Semiworks Plant Source Aggregate Area Management Study Report*). No high-level waste was identified in available literature as having been generated at the 209-E Critical Mass Laboratory. Criticality research also was conducted with solid nuclear materials and fuels, such as plutonium blocks, uranium blocks and slabs, and fuel assemblies from the Fast Flux Test Facility and other reactors (DOE/RL-92-04).

U Plant. The 221-U Canyon Building (U Plant) was constructed in 1944 with a design similar to that of the T and B Plants to use a bismuth phosphate separation process to extract plutonium from fuel rods. Until 1951, the U Plant was used as a training facility for the T and B Plants bismuth/phosphate process operators using only water and generating no waste streams. From 1952 until 1958, the Uranium Recovery Project used the TBP process to recover uranium for reuse in the reactors from bismuth/phosphate process waste stored in the single-shell tanks. From 1958 to 1972, the U Plant converted uranyl nitrate hexahydrate (UNH) to uranium trioxide (UO_3) in the 224-U Building. The UO_3 was converted offsite to uranium metal for reuse as reactor fuel. The Uranium Recovery Project and UO_3 waste generated in the 221-U, 224-UA, and 224-U Buildings included aqueous and organic solvent extraction waste. This waste also included process drainage, process distillate drainage, and miscellaneous offgas condensates from the 291-U-1 Stack, waste treatment condensers, nitric acid and solvent recovery, the 241 and 244 Vaults (waste treatment/storage), and 224-U storm drainage waste streams.

242-A Evaporator. The 242-A Evaporator was constructed in 1977 and currently is operating as the primary waste concentrator for Hanford Site mixed waste stored and treated in the DST system. PUREX waste types from the A Tank Farms that were routed to the 241-AW-102 Tank fed the 242-A Evaporator. The feed consisted of unprocessed and processed waste from various sources including PUREX (decladding, ammonia scrubber, 204-AR Tank Car, etc.), B Plant (complexed or Sr-90/Cs-137 recovery waste and aging waste), DST farms (recycled slurry and salt-well pumping waste), and miscellaneous waste (Plutonium Finishing Plant, laboratory, 100-N Area phosphate and sulfate waste). The 242-A Evaporator potentially could have received 300 and 400 Area laboratory waste, 100-N Area, and Plutonium Finishing Plant waste. Evaporation treatment of the waste removes water and most volatile organics. Two waste streams leave the 242-A Evaporator following the treatment process. The first waste stream consists of concentrated slurry that is pumped back into the DST System (AN, AW, and/or AP Tank Farms). The second waste stream is process condensate that until 1989 was routed through condensate filters for treatment, storage, and sampling at the 207-A South Retention Basin before release to the 216-A-37-1 Crib for disposal. The 242-A Evaporator also released large quantities of steam condensate that initially was not contaminated but that over time, because of heating/cooling coil failures and operational errors, resulted in individual release events, making cribs the preferred waste-disposal sites for steam condensate streams.

2.1.2 Operable Unit Descriptions

DOE/RL-96-81, *Waste Site Groupings for 200 Area Soil Investigations*, describes the grouping of 200 Areas waste sites based on process. The consolidated 200-PW-2 and 200-PW-4 OUs include the waste sites that managed or disposed of waste initially categorized by the Implementation Plan (DOE/RL-98-28) and DOE/RL-96-81 as process condensate, process waste, or both. The 200-PW-2 and 200-PW-4 OUs were consolidated into one FS because these OUs received waste streams from similar processes having similar quantities of key contaminants and as a result, the contaminant distribution beneath these waste sites is expected to be similar. Because of the relatively small quantities of radionuclides, these waste streams typically were disposed to underground sites such as cribs and trenches.

The waste sites in the 200-PW-2 and 200-PW-4 OUs received liquid waste streams from the previously listed processing. The U Plant waste sites associated with this waste stream are being addressed on a regional basis as part of the 200-UW-1 source OU. The following sections briefly identify the buildings and processes discharging effluent to the 200-PW-2 OU and 200-PW-4 OU waste sites. Additional information on the history of operations, primary waste-generating processes, and liquid waste-disposal practices at the various processing areas is provided in the Work Plan (DOE/RL-2000-60, Section 2.2.1) and Appendix H of the Implementation Plan (DOE/RL-98-28).

2.1.2.1 200-PW-2 Uranium-Rich Process Waste Group Operable Unit Description

The 200-PW-2 OU consists of 24 waste sites (i.e., primarily cribs and trenches but also includes neutralization tanks, UPRs, and a french drain) located in the 200 East and 200 West Areas (Table 1-1). Those waste sites primarily received process condensate waste generated during the dissolution of fuel rods containing large quantities of uranium (U-238) and some fission products occurring at the 221/224 Uranium Recovery Process project (U Plant), the 224 U/UO_3 Program for PUREX (A Plant), REDOX (S Plant) process facilities, and the Hot Semiworks Plant (C Plant). The 200-PW-2 OU waste sites also received uranium-rich solutions from the S Plant and A Plant cold-startup phase before operation began. Other contaminants associated with the uranium-rich process condensates are present in limited quantities. The primary chemical separation processes were similar in that organic compounds (e.g., hexone or TBP) were used to separate plutonium and/or uranium from the process solutions in solvent extraction columns. Plutonium is common in process waste cribs. Larger quantities of fission products (cesium and strontium) are found in process condensate waste sites but in limited quantity in process waste sites. The sites in this group also could have received high salt or acidic waste. Nitrate was reported for many streams, except that several process condensate cribs contained small quantities. Nitric acid was reported for several of the more highly contaminated process condensate streams. Sodium-rich compounds, ammonium carbonate, and ammonium nitrates also are reported.

A significant number of the waste sites in this group received potentially acidic liquid waste. Acidic characteristics are known to facilitate uranium mobilization in the soil column, facilitating groundwater impact at several sites. Many waste sites received enough process condensate to have washed the moderately mobile contaminants to groundwater. However, at several cribs (e.g., 216-S-1&2), contaminant migration might be attributable partially to flow along a crib monitoring well where casing failure provided waste stream access to the inside of the well and resulted in groundwater contamination. Groundwater contamination beneath a crib frequently was used as a reason for ceasing discharges to that site.

This OU includes two RCRA TSD unit waste sites, the 216-A-10 and the 216-A-36B Cribs, that have Tri-Party Agreement-required closure plans (Chapter 8.0) scheduled in the year 2006 (M-20-33).

S Plant 200-PW-2 Operable Unit Waste Sites. The S Plant liquid waste generated by offgas treatment systems during the REDOX process included 291-S Stack drainage stored in cell drainage receiver tank (D-1) and the process condensate receiver tank (D-2) containing significant quantities of uranium that was routed to the 216-S-1&2 Cribs and the 216-S-7 Crib. The 216-S-8 Trench received similar waste from earlier startup and cold runs using nonirradiated fuel. Condensate or condensed offgases from the waste concentrator and condensate from the uranium and plutonium concentrators contained very low levels of radioactive wastes. These streams were combined and routed through a condensate stripper to remove residual methylisobutyl ketone, which was returned to the solvent recovery process. The aqueous product stream was evaporated to the extent possible, sampled, and disposed of in the 216-S-1&2 Cribs and the 216-S-7 Crib if it met acceptable limits.

The 200-W-22 site is an underground radioactive material area. This site is the area where aboveground portions of the S Plant UNH processing facilities were removed in 1983. This left buried concrete and metal materials from the 203-S Basin, 204-S Basin, 205-S Vault, 205-S Building base pad, the REDOX-to-the-tank-farm concrete pipe trench, and the REDOX chemical sewer system. UPR-200-W-36 is an unplanned release identified in 1955 to a ruptured test well 299-W22-3 casing in the 216-S-1&2 Cribs.

A Plant 200-PW-2 Operable Unit Waste Sites. The A Plant generated ASD waste that was collected in the ammonia catch tank and boiled, and the resulting condensate was sent to the 216-A-36A and 216-A-36B Cribs. Decladding operations generated ammonia gas as a byproduct, which was mixed with water to form ammonium hydroxide. This waste, which included ammonium fluoride and ammonium nitrate, subsequently was sent to the 216-A-36B Crib for disposal. From 1955 to 1983, low-level liquid condensate waste from various process condensers and filters was routed to the 200-E-58 Neutralization Tank and from there disposed to the 216-A-10, 216-A-5, 216-A-3, and 216-A-28 Cribs and the 216-A-22 French Drain. The 216-A-45 Crib operated from 1987 to 1991, disposing of process condensate from 202-A Canyon Building that was acidic and contained uranium and nitrate that previously had been disposed to the 216-A-10 Crib. The 216-A-1 Crib and the 216-A-18, 216-A-19, and 216-A-20 Trenches received the same waste from earlier cold-run startup using nonirradiated uranium fuel that provided the greatest quantities of uranium. The UPR-200-E-17 site was a spill to the surface of the 216-A-22 French Drain sometime between 1955 and 1959 of an unknown volume of UNH.

UPR-200-E-145, initiated in 1993, is the site of a past-practice release of waste from a buried, vitrified clay pipeline that until 1957 carried waste from the 216-A-8 Proportional Sample Pit 2 to the 216-A-34 Ditch.

C Plant 200-PW-2 Operable Unit Waste Sites. REDOX process waste was sent to C Plant for testing or processing, and the resulting C Plant liquid waste was sent to several waste sites, including the 216-C-1 Crib and the 216-C-3 Crib (a 200-PW-4 OU waste site), which received acidic radioactive waste between 1953 and 1957 (DOE/RL-92-18). Process condensate waste from the 201-C Process Building (Hot Semiworks Plant) and unspecified waste from the 201-C Process Building hot-shop sink (DOE/RL-92-18) was sent to several waste sites and the 241-CX-71 Neutralization Tank. This tank received acidic waste from the 201-C Building before waste was discharged to the 216-C-1, 216-C-3, and the 216-C-5 Cribs. The 216-C-10 Crib operated from 1964 to 1969 and received process condensate and acidic liquid waste from the 201-C Building containing strontium, cerium, cesium, and promethium from strontium and rare-earth metal recovery experiments.

The 209-E-WS-3 site is the 209-E Critical Mass Laboratory Valve Pit and Hold-Up Tank (209-E-TK-111) that in 1960 began storing condensate from the 209-E Facility before it was released to the 216-C-7 Crib.

B Plant 200-PW-2 Operable Unit Waste Sites. WESF cell drainage from water washdowns in 1967 of the 40 WESF process cells was collected in the liquid collection system that drained to the 216-B-60 Crib, which is now inaccessible since being covered over by the addition of WESF at B Plant. From 1967 to 1973, process condensate from the thermal evaporation concentrator in Cell 23 went to the 216-B-12 Crib and, starting in 1973, went to the 216-B-62 Crib (not a 200-PW-2 or 200-PW-4 OU waste site). The 270-E-1 Neutralization Tank operated from 1952 to 1957 as part of the 270-E Neutralization Facility to neutralize acidic process condensate from the 221-B and 224-B facilities that had been discharged to the 216-B-12 Crib. U Plant/UO_3 operations also provided waste to the 216-B-12 Crib. UPR-200-E-64 is a near-surface soil contamination (speck contamination) originating from insect and wind transport of surface contamination from a "swab riser" for underground pipeline in the vicinity of, but not necessarily associated with, the 270-E-1 Neutralization Tank. UPR-200-E-39 is the site of a one-time release in February 1968 of PUREX ASD waste containing uranium and fission products from the vent filter at the 216-A-36B Crib Sampler Shack. The volume is unknown but expected to be limited.

2.1.2.2 200-PW-4 General Process Condensate Group Operable Unit Description

The 200-PW-4 OU consists of 14 waste sites (i.e., primarily cribs, but also including a retention basin, a trench, an unplanned release, a valve pit, and a french drain) located in the 200 East and 200 West Areas (Table 1-1). The 200-PW-4 OU general process condensate group served as the catch-all for sites with small inventories and includes sites that received or transferred general process drainage, process distillate discharge, and miscellaneous condensate waste with lower concentrations of chemical and radiological constituents than the minimum values used for inclusion of sites into other groups. The 200-PW-4 OU waste consists of general process drainage, process distillate discharge, and miscellaneous condensates containing low inventories of radionuclides and low-salt, neutral/basic liquids discharged by many 200 Areas processing facilities. Sites in this group are expected to have received only low levels of radiological contaminants (i.e., cesium, plutonium, strontium, technetium, plutonium, and uranium) and organics. Inorganic content is not reported, with the exception of several streams receiving low levels of nitrates. Although having levels relatively low in contaminant concentrations, liquid volumes discharged to several cribs are significant (e.g., the 216-A-37-1 Crib, which received more than 300,000,000 L of wastewater).

The process condensates were vapors collected from thermally hot process steps, condensed, and subsequently discharged to the ground. Contaminants were carried along as minor constituents in the vapor phase and condensed with the water vapor before release. The condensate originated from large volumes of steam required to heat or boil process solutions for effective chemical reactions at REDOX, PUREX, U Plant, T Plant, and C Plant and several other contributing tank farm-related facilities, such as the 242-A Evaporator and the S and A Tank Farms. This OU also includes two RCRA TSD units.

C Plant 200-PW-4 Operable Unit Waste Sites. The 216-C-3 Crib and the 216-C-5 Crib contain the highest inventories of uranium, the primary contaminant. Cribs in this group generally received either high-salt or acidic waste. The 216-C-3 Crib received a large volume of acidic waste with small amounts of fission products. The 216-C-5 Crib received high-salt waste from cold runs in the 201-C Building.

Between 1953 and 1954, the same REDOX radioactive and acidic waste that went to the 216-C-1 Crib (200-PW-2 OU) also went to the 216-C-3 Crib and the 216-S-23 Crib. The same PUREX neutral-to-basic pH process condensate and cold oven waste that went to the 216-C-1 Crib also went to the 216-C-5 Crib. The 241-CX-71 Neutralization Tank waste was discharged to the 216-C-1 Crib and the 216-C-5 Crib. The 209-E Critical Mass Laboratory process waste was routed to the 209-E-WS-3 Valve Pit and Hold-Up Tank, where waste was sampled and ultimately routed to the 216-C-7 Crib.

S Plant 200-PW-4 Operable Unit Waste Sites. From 1953 to 1956, vapors from self-boiling REDOX cladding waste and high-level waste in the 241-S-101 and 241-S-104 Tanks were collected and disposed to the 216-S-4 French Drain, which was reported to contain more fission products because the REDOX process condensate came from the cascade tanks in the S Tank

Farms. The 216-S-4 French Drain and the 216-S-23 Crib might have received significant amounts of short-lived beta-emitting fission products, but there is no record of any residual amounts. Process condensates from the 293-S Process Plant Building radioactive-iodine caustic scrubber-system operation were routed to the 216-S-22 Crib.

A Plant 200-PW-4 Operable Unit Waste Sites. The same PUREX process waste that went to the 200-PW-2 OU A-waste sites (216-A-3, 216-A-5, 216-A-10, and 216-A-28 Cribs and the 216-A-22 French Drain) also went to the 216-A-45 Crib. The 216-A-34 Ditch also received A Tank Farm condensate waste from the 241-A-431 Tank Farm Ventilation Building.

The 207-A South Retention Basin was used for interim storage of the 242-A Evaporator steam condensate for sampling. Effluent was discharged to the 216-A-37-1 Crib if the analytical results were within applicable regulatory limits. The 207-A South Retention Basin and the 216-A-37-1 Crib are RCRA TSD units.

The 216-T-20 Trench received radioactively contaminated nitric acid from the 241-TX-155 Diversion Box Catch Tank at the T Plant in 1952. The catch tank was used to transfer plant process waste to various tank farm facilities, cribs, and trenches via underground transfer lines.

2.1.3 RCRA Treatment, Storage, and Disposal Units

This section identifies the four 200-PW-2/200-PW-4 OU RCRA TSD units and briefly discusses aspects pertinent to designation and operation of these waste sites as RCRA TSD units. More detail of these sites is presented in Section 2.4. These units are not actively receiving waste and will be closed under interim status. Closure of these units is discussed in Chapter 8.0.

2.1.3.1 200-PW-2 Operable Unit Treatment, Storage, and Disposal Units

The 200-PW-2 OU includes the 216-A-10 Crib and 216-A-36B Crib RCRA TSD units.

The 216-A-10 Crib received process condensate from the PUREX Canyon Building. The crib was a percolation unit used to dispose of liquid waste to the soil column. The crib last received waste in March 1987. The 216-A-10 Crib was designated a RCRA TSD unit because of the corrosive characteristic of the waste stream it received. Liquid waste included an acidic waste stream (D002) from the process distillate discharge from the PUREX Plant and corrosive waste (D002) process distillate. The design capacity for the 216-A-10 Crib was 272,500 L (72,000 gal) per day. This unit ceased operations on March 31, 1987. A Part A, Form 3 (Rev. 0), for this unit was submitted to Ecology in 1987 (DOE/RL-88-21, *Hanford Facility Dangerous Waste Part A Permit Application*) as a protective filing.

The 216-A-36B Crib is an extension of the original 216-A-36 Crib, which operated in 1965 to dispose of PUREX ASD from the 202-A Canyon Building to the soil column. The 216-A-36 Crib was extended in 1966, and the original portion was bypassed after 6 months of operation because of the rapid buildup of fission products within the first 30 m (100 ft) of the crib. The old and the new portions were designated the 216-A-36A and 216-A-36B Cribs, respectively. The 216-A-36 Crib was isolated by a vertical grout barrier between the highly contaminated "A" crib segment and less contaminated "B" crib segment. A smaller diameter pipeline was inserted inside the original 216-A-36A pipeline, effectively moving the discharge point 3.65 m (12 ft) south of the grout barrier and bypassing the 'A' segment. The 216-A-36B Crib section continued to receive ASD during decladding operations. The ASD waste was a state-only toxic dangerous waste (WT02), based on ammonia in the waste stream (RHO-CD-673, *Handbook 200 Areas Waste Sites*). The receipt of this waste resulted in the crib's designation as a RCRA TSD unit and submittal of the original RCRA Part A, Form 3 (Rev. 0), to Ecology (DOE/RL-88-21) in the fall of 1987. The 216-A-36A and 216-A-36B Cribs are considered to be one waste management unit. A RCRA interim status groundwater-indicator parameter evaluation program has been in operation at the crib since May 1988.

2.1.3.2 200-PW-4 Operable Unit Treatment, Storage, and Disposal Units

The 207-A South Retention Basin and the 216-A-37-1 Crib are the two 200-PW-4 OU RCRA TSD units.

The 207-A South Retention Basin was used for interim storage of 242-A Evaporator condensate and began storage operations in 1977. The basin consists of three separate concrete open cells. The original RCRA Part A permit application (Part A), Form 3 (Rev. 0), was submitted to Ecology in 1987 (DOE/RL-88-21). The 242-A Evaporator process condensate was designated as dangerous waste, because the waste was derived from a waste containing spent halogenated and nonhalogenated solvents (waste codes F001, F002, F003, F004, and F005), and for the toxicity of ammonia (WT02, state-only, toxic, dangerous waste). After sampling and analysis, 207-A South Retention Basin effluent was discharged to the 216-A-37-1 Crib for disposal to the soil column.

The 216-A-37-1 Crib began operations in March 1977 and was used to percolate the 242-A Evaporator process condensate to the soil column. The original RCRA Part A, Form 3 (Rev. 0), was submitted to Ecology in 1987 (DOE/RL-88-21). Discharge of evaporator process condensate to the crib was terminated on April 12, 1989, when it was determined that evaporator process condensate contained or could have contained dangerous waste regulated under WAC 173-303, "Dangerous Waste Regulations," because of the presence of spent halogenated and nonhalogenated solvents (F001, F002, F003, F004, and F005), and for the toxicity of ammonia (WT02, toxic, state-only).

2.2 PHYSICAL SETTING

The following sections briefly describe the meteorology, topography, and hydrogeologic frameworks for the 200-PW-2 and 200-PW-4 OU waste sites. This discussion summarizes information provided in the Work Plan (DOE/RL-2000-60) and the RI Report (DOE/RL-2004-25).

2.2.1 Meteorology

The Hanford Site lies east of the Cascade Mountains and has a semiarid climate caused by the rain-shadow effect of the mountains. Climatological data are monitored at the Hanford

Meteorological Station and other locations throughout the Hanford Site. From 1945 through 2001, the recorded maximum temperature was 45 °C (113 °F), and the recorded minimum temperature was –30.6 °C (–23 °F) (PNNL-6415, *Hanford Site National Environmental Policy Act (NEPA) Characterization*). The two extremes occurred during August and February, respectively. The monthly average temperature ranged from a low of –0.24 °C (31.7 °F) in January to a high of 24.6 °C (76.3 °F) in July. The annual average relative humidity is 54 percent (PNNL-6415).

Most precipitation occurs during late autumn and winter, with more than half of the annual amount occurring from November through February (PNNL-6415). Normal annual precipitation is 17.7 cm (6.98 in.). Because this area typically receives less than 25.5 cm (10 in.) of precipitation a year, the climate is considered to be semiarid (PNNL-6415).

The prevailing wind direction at the Hanford Monitoring Station is from the northwest during all months of the year (PNNL-6415). Monthly average wind speeds are lowest during the winter months and average about 3 m/s (6 to 7 mi/h). The highest average wind occurs during the summer and is about 4 m/s (8 to 9 mi/h). The record wind gust was 35.7 m/s (80 mi/h) in 1972.

2.2.2 Topography

The Hanford Site is located in the Pasco Basin on the Columbia Plateau. The 200 West Area is located on the 200 Areas Central Plateau near the center of the Hanford Site. The 200 Areas Central Plateau is the common reference used to describe the Cold Creek Bar – a relatively flat, prominent terrace that trends generally east to west with elevations between 198 and 230 m (650 to 755 ft) above mean sea level. The Cold Creek Bar formed during the cataclysmic flooding events of the Missoula floods, which ended approximately 13,000 years ago.

More details regarding stratigraphy, including stratigraphy diagrams and general location information of representative waste sites, are presented in the Work Plan (DOE/RL-2000-60).

2.2.3 Geology

The Hanford Site is underlain by basalt of the Columbia River Basalt Group and a sequence of suprabasalt sediments. From oldest to youngest, major geologic units of interest are the Elephant Mountain Basalt Member, the Ringold Formation, the Cold Creek unit (formerly Plio-Pleistocene unit, early "Palouse" soil, caliche layer, or pre-Missoula gravels), and the Hanford formation. A generalized stratigraphic column for the 200 East and 200 West Areas is shown in Figure 2-1. Figures 2-2 through 2-6 show the locations of the 200-PW-2 and 200-PW-4 OU representative waste site boreholes.

The Elephant Mountain Basalt Member is bedrock beneath the OUs and consists of a medium- to fine-grained tholeitic basalt with abundant microphenocrysts of plagioclase (DOE/RW-0164-F, *Consultation Draft, Site Characterization Plan, Reference Repository Location, Hanford Site, Washington*). Basalt is overlain by the Ringold Formation over most of the 200 East Area and all of the 200 West Area. The Ringold Formation consists of an interstratified sequence of unconsolidated clay, silt, sand, and granule to cobble gravel deposited by the ancestral Columbia

River. The fluvial-lacustrine Ringold Formation is informally divided into several units; these are (from oldest to youngest) the fluvial gravel and sand of unit A, the buried soil horizons and lake deposits of the lower mud sequence, the fluvial sand and gravel of unit E, and the lacustrine mud of the upper Ringold unit.

The Cold Creek unit overlies the Ringold Formation in the 200 West Area (DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for Post-Ringold Formation Sediments Within the Central Pasco Basin*). In the 200 East Area, near the B, BX, and BY Tank Farms, the Cold Creek unit overlies basalt where the Ringold Formation is not present.

In the 200 East Area, the Cold Creek unit previously was interpreted to be the Hanford formation/Plio-Pleistocene (HNF-5507, *Subsurface Conditions Description of the B-BX-BY Waste Management Area*). The Hanford formation/Plio-Pleistocene was interpreted to be equivalent or partially equivalent to the Plio-Pleistocene unit in the 200 West Area or to represent the earliest ice age flood deposits overlain by a locally thick sequence of fine-grained non-flood deposits (HNF-5507).

The Cold Creek unit is divided into five lithofacies (DOE/RL-2002-39). The five lithofacies units are differentiated based on grain size, sedimentary structure, sorting, fabric, and mineralogy as follows:

- Fine-grained, laminated to massive
- Fine- to coarse-grained, calcium carbonate cemented
- Coarse-grained, multilithic
- Coarse-grained, angular, basaltic
- Coarse-grained, round basaltic lithofacies.

Descriptions of the five lithofacies units, depositional environments, and association with previous site nomenclature are shown in Table 2-1. More detailed descriptions of the lithofacies units are presented in DOE/RL-2002-39.

The Hanford formation overlies the Cold Creek unit in the 200 Areas. Where the Ringold Formation and Cold Creek unit are not present in the 200 East Area, the Hanford formation overlies basalt. The Hanford formation consists of unconsolidated gravel, sand, and silt deposited by cataclysmic floodwaters. These deposits consist of gravel-dominated and sand-dominated facies. The gravel-dominated facies consist of cross-stratified, coarse-grained sands and granule-to-boulder gravel. The gravel is uncemented and matrix poor. The sand facies consists of well-stratified fine- to coarse-grained sand and granule gravel. Silt content is variable and could be interbedded with the sand. Where the silt content is low, an open-framework texture is common. An upper and lower gravel unit and a middle sand facies are present in the study area.

The cataclysmic floodwaters that deposited sediments of the Hanford formation also locally reshaped the topography of the Pasco Basin. The floodwaters deposited a thick sand and gravel bar constituting the higher southern portion of the 200 Areas, informally known as the 200 Areas Plateau. In the waning stages of the ice age, these floodwaters also eroded a channel north of the 200 Areas in the area currently occupied by the 216-A-25 Gable Mountain Pond. These floodwaters removed all of the Ringold Formation from this area and deposited Hanford formation sediments directly over basalt.

Holocene-aged deposits overlie the Hanford formation and are dominated by eolian sheets of sand, forming a thin veneer across the site except in localized areas where these are absent. Surficial deposits consist of very fine- to medium-grained sand to occasionally silty sand. Silty deposits less than 1 m (3 ft) thick also have been documented at waste sites where fine-grained windblown material settled out through standing water over many years.

2.2.4 Hydrostratigraphy

A detailed discussion of the hydrostratigraphy in the areas of the representative waste sites is contained in the Work Plan (DOE/RL-2000-60). This section summarizes this information. The vadose zone is the unsaturated region between the ground surface and the water table. In the vicinity of the 200 Areas, the vadose zone thickness ranges from 62 m (206 ft) in the 200 West Area to 105 m (345 ft) in the BC Controlled Area south of the 200 East Area fence.

Details of performance of the aquifer and recharge rates are contained in PNL-10285, *Estimated Recharge Rates at the Hanford Site*, and in PNL-5506, *Hanford Site Water Table Changes 1950 Through 1980 – Data Observation and Evaluation*. Recharge to the unconfined aquifer in the 200 Areas is from artificial and natural sources. Any natural recharge originates from precipitation. Estimates of recharge from precipitation on the Hanford Site range from 0 to 10 cm/yr (0 to 4 in/yr) and largely depend on soil texture and the type and density of vegetation. For areas where the ground cover is assumed to remain undisturbed, a recharge rate of 3.5 mm/yr was assumed, which is within the range of values reported for shrub-steppe ground cover. For the disturbed areas above the waste sites (i.e., stabilization cover), a recharge rate of 1.44 cm/yr was assumed.

Artificial recharge occurred when effluents such as cooling water and process wastewater were disposed to the ground. PNL-5506 reports that between 1943 and 1980, 6.33×10^{11} L (1.67×10^{11} gal) of liquid waste was discharged to the soil column. Most sources of artificial recharge are halted now. The continuing artificial recharge largely is limited to liquid discharges from sanitary sewer system drain fields, two state-approved land disposal structures, and 140 small-volume uncontaminated miscellaneous streams. A state-approved land disposal site is located 366 m (1,200 ft) north of the 200 West Area exclusion fence and receives liquid waste treated at the 200 Areas Effluent Treatment Facility in the 200 East Area (*Waste Information Data System, 600-211, General Summary Report*).

While the liquid waste-disposal facilities were operating, many localized areas of saturation or near saturation were created in the soil column. With the reduction of artificial recharge in the 200 Areas, these locally saturated soil columns are dewatering. As the soil column dewaters, the moisture flux decreases. Residual moisture in the vadose zone, however, could remain for some time. In the absence of artificial recharge, the potential for recharge from precipitation becomes a primary driving force for contaminant movement in the vadose zone.

The unconfined aquifer in the 200 Areas occurs in the Hanford formation, the Cold Creek unit, and the Ringold Formation. Groundwater in the unconfined aquifer flows from areas where the water table is higher (west of the Hanford Site) to areas where the water table is lower (Columbia River) (PNNL-13788, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*). In general, groundwater flow through the 200 Areas Central Plateau occurs in a predominantly easterly direction, from the 200 West Area to the 200 East Area.

Historical discharges to the ground greatly altered the groundwater flow regime, especially around the 216-U-10 (U Pond) in the 200 West Area and the 216-B-3 (B Pond) in the 200 East Area of the 200-CW-5 and 200-CW-1 OUs, respectively. Discharges to the 216-U-10 Pond resulted in a groundwater mound developing in excess of 26 m (85 ft). Discharges to the 216-B-3 Pond created a hydraulic barrier to groundwater flow coming from the 200 West Area, deflecting it to the north through the gap between Gable Mountain and Gable Butte, or south of the 216-B-3 Pond. As the hydraulic effects of these two artificial recharge sites diminish, groundwater flow is expected to acquire a more easterly course through the 200 Areas, with some flow possibly continuing through Gable Gap (BHI-00469, *Hanford Sitewide Groundwater Remediation Strategy – Groundwater Contaminant Predictions*).

2.3 NATURAL RESOURCES

Natural resources in the study area vicinity include vegetation and wildlife resources. Biological and ecological information aids in evaluating impacts to the environment from contaminants in the soils, including potential effects of implementing remedial actions and identification of sensitive habitats and species. This section also considers cultural and aesthetic resources and socioeconomics associated with activities in the 200 Areas.

Survey data collected in 2000 and 2001 for the 200 Areas Central Plateau as part of the Ecological Compliance Assessment Project were compiled to support Central Plateau ecological evaluations (DOE/RL-2001-54, *Central Plateau Ecological Evaluation*). The information includes plant community descriptions, identification of plant and wildlife species, and avian census data. Designated levels of habitat under DOE/RL-96-32, *Hanford Site Biological Resources Management Plan*, including rare plant populations, are identified and mapped. The data were collected before the "24 Command Fire" occurred in 2000, as shown in Section 2.3.2. The fire, however, did not impact any waste sites being considered in this FS.

2.3.1 Vegetation

Vegetation in the study area is characterized by native shrub-steppe, interspersed with large areas of disturbed ground dominated by annual grasses and forbs. In the native shrub-steppe, the dominant shrub is big sagebrush (*Artemisia tridentata*). The understory is dominated by the native perennial, Sandberg's bluegrass (*Poa sandbergii*), and the introduced annual, cheatgrass (*Bromus tectorum*). Other shrubs typically present include rabbitbrush (*Chrysothamnus spp.*), spiny hopsage (*Grayia spinosa*), and antelope bitterbrush (*Purshia tridentata*). Other native bunchgrasses present include Indian ricegrass (*Oryzopsis hymenoides*) and needle-and-thread grass (*Stipa comata*). Common herbaceous species include turpentine cymopteris (*Cymopteris terebinthinus*), globemallow (*Sphaeralcea munroana*), balsamroot (*Balsamorhiza careyana*), milkvetch (*Astragalus spp.*), yarrow (*Achillea millefolium*), dwarf evening primrose (*Camissonia* *pygmaea*), and daisy (*Erigeron spp.*). Dwarf evening primrose is a rare plant that was not encountered in the study area.

Many waste disposal and storage sites in the 200 Areas are backfilled with clean soil and planted with crested or Siberian wheatgrass (*Agropyron cristatum* and *Agropyron sibericum*, respectively) to stabilize surface soil, control soil moisture, or displace more invasive deep-rooted species like Russian thistle (PNNL-6415). The area associated with the waste sites addressed in this FS is highly disturbed. This disturbed habitat primarily is the result of mechanical and operational disturbance. The outlying habitats also are disturbed as a result of range fires, clearing, and construction activities. Because of the disturbed nature and the low quality of habitat providing little forage and cover, the sites generally are not capable of supporting ecological populations.

2.3.2 Wildlife

The largest mammal frequenting the study area is the mule deer (*Odocoileus hemionus*). Mule deer are much more common along the Columbia River; the few foraging throughout the 200 Areas make up a distinct group called the Central Population (PNNL-11472, *Hanford Site Environmental Report for Calendar Year 1996*).

A large elk herd (*Cervus canadensis*) currently resides on the Fitzner-Eberhardt Arid Lands Ecology Reserve. Elk, which are more dependent on open grasslands for forage, seek the cover of sagebrush and other shrub species during the summer months. The Rattlesnake Hills herd of elk inhabiting the Hanford Site primarily occupies the Arid Lands Ecology Reserve and private lands adjoining the reserve to the south and west. Elk occasionally are seen in the 200 Areas and just south of them and have been sighted at the White Bluffs boat launch on the Hanford Site. The herd tends to congregate on the Arid Lands Ecology Reserve in the winter and disperses during the summer months to higher elevations on the Arid Lands Ecology Reserve, private land to the west of the Arid Lands Ecology Reserve, and the Yakima Training Center. In March 2000, about 200 elk were removed from the Arid Lands Ecology Reserve and relocated, and another 31 elk were removed during 2002. Special hunts adjacent to the Hanford Site in 2000 accounted for the removal of 207 additional elk. The 24 Command Fire in June 2000 temporarily destroyed nearly all of the elk forage on the Arid Lands Ecology Reserve. The herd moved onto unburned private land west of the Hanford Site, to unburned areas in the center of the Hanford Site, and along the Columbia River near the 100 B/C and 100-K Areas. Elk have returned to burned areas as the vegetation recovers (PNNL-6415).

Experienced biologists reported sighting a cougar (*Felis concolor*) on the Arid Lands Ecology Reserve during the elk relocation in March 2000, supplementing anecdotal accounts of other observations of the presence of a cougar on the Hanford Site (PNNL-6415).

Other mammals common to the 200 Areas are badgers (*Taxidea taxus*), coyotes (*Canis latrans*), Great Basin pocket mice (*Perognathus parvus*), northern pocket gophers (*Thomomys talpoides*), and deer mice (*Peromyscus maniculatus*). Badgers are known for their digging ability and have been suspected of excavating contaminated soil at 200 Areas radioactive waste sites (BNWL-1794, *Distribution of Radioactive Jackrabbit Pellets in the Vicinity of the B-C Cribs, 200 East Area, USAEC Hanford Reservation*). The majority of badger diggings are a result of food searches, especially for other burrowing mammals such as pocket gophers and mice. Pocket gophers, Great Basin pocket mice, and deer mice are abundant herbivores in the 200 Areas. These small mammals can excavate significant amounts of soil as they construct their burrows (e.g., Hakonson et al. 1982, "Disturbance of a Low-Level Waste Burial Site Cover by Pocket Gophers"). Mammals associated with buildings and facilities include Nuttall's cottontails (*Sylvilagus nuttallii*), house mice (*Mus musculus*), Norway rats (*Rattus norvegicus*), and various bat species.

Common bird species in the study area include the starling (*Sturnus vulgaris*), horned lark (*Eremophila alpestris*), meadowlark (*Sturnella neglecta*), western kingbird (*Tyrannus verticalis*), rock dove (*Columba livia*), black-billed magpie (*Pica pica*), and raven (*Corvus corax*). Burrowing owls (*Athene cunicularia*) commonly nest in the 200 Areas in abandoned badger or coyote holes, or in open-ended stormwater pipes along roadsides in more industrialized areas. Loggerhead shrike (*Lanius ludovicianus*) and sage sparrow (*Amphispiza belli*) are common nesting species in habitats dominated by sagebrush. Long-billed curlews (*Numenius americanus*) have been observed nesting on inactive waste sites.

Reptiles common to the study area include gopher snakes (*Pituophis melanoleucus*) and sideblotched lizards (*Uta stansburiana*). Rattlesnakes (*Crotalus viridis*) also were observed. Reptile sightings are not widespread, with only 23 observations of side-blotched lizards at 316 sites surveyed during a 2001 Ecological Compliance Assessment Project survey (DOE/RL-2001-54, Appendix B).

Three of the most common groups of insects include darkling beetles, grasshoppers, and ants. Ants are known to burrow up to 2.7 m (9 ft) into the vadose zone and to bring contaminants to the surface.

2.3.3 Species of Concern

The Hanford Site is home to a number of species of concern, but many of these are associated with the Columbia River and its shoreline. Two Federally protected species were observed at the Hanford Site, the Aleutian Canada goose (*Branta canadensis leucopareia*) and the bald eagle (*Haliaeetus leucocephalus*). Both depend on the river corridor and rarely are seen in the Central Plateau. As migratory birds, these species also are protected under the *Migratory Bird Treaty Act* (1918).

Several threatened, endangered, and candidate species are found in and near the 200 Areas. These species include the ferruginous hawk (*Buteo regalis*), burrowing owl, loggerhead shrike, long-billed curlew, and sage sparrow. Plant species of concern (which include those listed as state endangered, threatened, sensitive, and monitored) that could occur in the study area include dwarf evening primrose, which was not encountered in the vicinity, and Piper's daisy (*Erigeron piperianus*) (WNHP 1998, *Washington Rare Plant Species by County*).

Plant and animal species of concern, their designations, and the places of their occurrence can change over time. At this time, it is not anticipated that remediation of the 200-PW-2 and 200-PW-4 OUs will affect any species of concern. However, incorporating the needs of these species into project planning will help mitigate any potential effects. Especially important is avoiding, where possible, undisturbed shrub-steppe habitat, because this is important to many species of concern. The undisturbed shrub-steppe in the Central Plateau was designated as Level 3 habitat in DOE/RL-96-32, which requires mitigation of any disturbance (e.g., through avoidance and minimization) and possibly rectification and compensation. More detailed direction on protecting Level 3 habitats and species of concern is provided in DOE/RL-96-32. In addition, site-specific environmental surveys, required before ground disturbance can occur, serve as a final check to ensure that ecological resources are adequately protected.

2.3.4 Cultural Resources

A comprehensive archaeological survey of the 200 Areas found artifacts in conjunction with areas of high topographic relief and in the vicinity of sources of permanent water, but few artifacts associated with open, inland flats (PNL-7264, *Archaeological Survey of the 200 East and 200 West Areas, Hanford Site, Washington*). In the 200 West Area, the only culturally sensitive area identified is the historic White Bluffs Road crossing the northwest corner of the Hanford Site. The report concluded that additional cultural resource reviews are required only for proposed projects within 100 m (328 ft) of this road. No waste sites associated with the OUs involved in this FS are within 100 m (328 ft) of this road (PNL-7264).

PNL-7264 addressed only undisturbed portions of the 200 Areas and did not address facilities and structures. The *National Historic Preservation Act of 1966* requires agencies to consult with the State Historic Preservation Officer and the Advisory Council on Historic Preservation to ensure that all potentially significant cultural resources, including structures and associated sites, were adequately identified, evaluated, and considered in planning for a proposed undertaking (e.g., remediation, renovation, or demolition) (DOE/RL-97-56, *Hanford Site Manhattan Project and Cold War Era Historic District Treatment Plan*).

DOE/RL-97-56 was developed to address historic preservation requirements and to determine the eligibility of historic properties for the "National Register of Historic Places" (36 CFR 60). DOE/RL-97-56 evaluated and classified waste sites and structures on the Hanford Site, including those in the 200 Areas, and proposed recommendations. Treatment options were determined using 36 CFR 60.4, "Criteria for Evaluation." No waste sites in the OUs subject to this FS were recommended for individual documentation as contributing properties. Sites beginning with "216" (e.g., 216-A-19 Trench, 216-C-7 Crib) were categorized as "noncontributing/exempt properties" (i.e., properties exempted from documentation requirements as potential historic sites) (DOE/RL-97-56).

No cultural resources were directly associated with OU waste sites (PNL-7264, DOE/RL-97-56, PNNL-6415); however, to assess the potential impact to resources outside the waste site boundary, site-specific cultural resource reviews are required for each waste site before remediation or other ground-disturbing activities begin. Based on information available, these reviews are likely to result in a finding of "no potential to cause effect." In addition to the site-specific review, a cursory field review of plant and animal life could be conducted in concert with this activity.

2.3.5 Aesthetics, Visual Resources, and Noise

With the exception of Rattlesnake Mountain, land on the Hanford Site generally is flat with little relief. Rattlesnake Mountain, rising to 1,060 m (3,478 ft) above mean sea level, forms the southwestern boundary of the Hanford Site, and Gable Mountain and Gable Butte are the highest landforms on the Hanford Site. The view toward Rattlesnake Mountain visually is pleasing, especially in the springtime when wildflowers are in bloom. Large rolling hills are located to the west and far north. The Columbia River, flowing across the northern part of the Hanford Site and forming the eastern boundary, generally is considered scenic.

Studies on the Hanford Site on the propagation of noise are concerned primarily with occupational noise at work sites. Environmental noise levels were not extensively evaluated because of the remoteness of most Hanford Site activities and isolation from receptors covered by Federal or state statutes. Most industrial facilities on the Hanford Site are located far enough away from the Hanford Site boundary that noise levels at the boundary are not measurable or are indistinguishable from background noise levels (PNNL-6415).

2.3.6 Socioeconomics

Activity on the Hanford Site plays a dominant role in the socioeconomics of the Tri-Cities and other parts of Benton and Franklin counties. Any major changes in Hanford Site activity potentially affect the Tri-Cities and other areas of Benton and Franklin Counties. Unless otherwise specifically cited, data in this section were collected from interviews with the referenced organization.

The Hanford Site is the largest single source of employment in the Tri-Cities. During fiscal year (FY) 2002, an average of 10,892 employees were employed by the DOE, Office of River Protection (ORP) and its prime contractor CH2M HILL Hanford Group, Inc.; RL and its prime contractor Fluor Hanford, Inc.; Battelle Memorial Institute; Bechtel Hanford, Inc.; and the Hanford Environmental Health Foundation. The FY 2002 year-end employment on the Hanford Site was 10,938, up from 10,670 in FY 2001. In addition to these totals, Bechtel National, Inc., and its prime subcontractor Washington Group International, employed 3,013 at the end of FY 2002, up from 1,350 at the end of FY 2001. In December 2000, ORP awarded a contract to Bechtel National, Inc., to design, build, and start waste treatment facilities for the glassification of liquid radioactive waste. According to the Washington State Labor Market and Economic Analysis, the annual average number of employees on the Hanford Site is down considerably from a peak of 19,200 in FY 1994, but still represents 15 percent of the 94,000 total jobs in the economy.

In addition to the Hanford Site, other key employers in the area are as follows:

- Energy Northwest
- The agricultural community (including ConAgra food processing plants)
- Tyson Foods (formerly Iowa Beef Processing)
- Areva NP – Advanced Nuclear Products (formerly Siemens, Inc., and Framatome ANP)
- Boise Cascade Corporation, Paper and Corrugated Container Divisions
- Burlington Northern and Santa Fe Railroads.

Tourism and government transfer payments to retirees in the form of pension benefits also are important contributors to the local economy.

An estimated total of 147,600 people lived in Benton County and 51,300 lived in Franklin County during 2002, for a total of 198,900, which is up almost 4 percent from 2000. According to the 2000 Census, population totals for Benton and Franklin Counties were 142,475 and 49,347, respectively. Both Benton and Franklin counties grew at a faster pace than Washington as a whole in the 1990s. The population of Benton County grew 26.6 percent, up from 112,560 in 1990. The population of Franklin County grew 31.7 percent, up from 37,473 in 1990 (Census 2001, *Poverty Thresholds in 2000, by Size of Family and Number of Related Children Under 18 Years*).

Based on the 2000 census, the 80 km (50-mi) radius area surrounding the Hanford Site had a total population of 482,300 and a minority population of 178,500 (PNNL-6415). The ethnic composition of the minority population primarily is White Hispanic (24 percent), self-designated "other and multiple" races (63 percent), and Native American (6 percent). Asians and Pacific Islanders (4 percent) and African Americans (3 percent) make up the rest. The Hispanic population resides predominantly in Franklin, Yakima, Grant, and Adams counties. Native Americans within the 80 km (50-mi) area reside primarily on the Yakama Reservation and upstream of the Hanford Site near the town of Beverly, Washington. PNNL-6415 provides maps showing distributions of minority and low-income populations.

2.4 WASTE SITE DESCRIPTION, CHARACTERIZATION, AND CONTAMINATION

This section describes the seven waste sites selected for characterization to support the 200-PW-2 and 200-PW-4 OU remedial investigation/feasibility study (RI/FS) process as representative waste sites. These waste sites are the 216-A-19 Trench, 216-B-12 Crib, 216-A-10-Crib, 216-A-36B Crib, and 216-S-7 Crib of the 200-PW-2 OU and the 207-A South Retention Basin and 216-A-37-1 Crib of the 200-PW-4 OU. These sites were designated as representative waste sites in DOE/RL-96-81, data quality objective summary reports (BHI-01411, *Remedial Investigation Data Quality Objectives Summary Report for the 200-PW-2 Uranium-Rich Process Waste Group Operable Unit*, for 200-PW-2 and CP-14176, *Remedial Investigation Data Quality Objectives Summary Report for the 200-PW-4 Operable Unit*, for 200-PW-4), and the Implementation Plan (DOE/RL-98-28). These sites were chosen as representative because of the amount of characterization already performed; because they generally are considered worst case (upper bound) or typical of the waste characteristics for the OUs; and because waste stream inventories, effluent volumes received, and the current level of characterization suggest that contaminant inventories are present beneath these sites. This information is used for alignment of analogous waste sites with representative waste sites, following the analogous site approach described in the Implementation Plan (DOE/RL-98-28) and in Section 2.5 of this FS. The 216-U-8 Crib underwent geophysical logging as a part of 200-PW-2 and 200-PW-4 OU RI activities, but was reassigned to the 200-UW-1 OU for remediation and is no longer a site within the 200-PW-2 OU. The remaining 200-PW-2 and

200-PW-4 OU waste sites (Table 1-1) are considered to be analogous to one of these representative waste sites as described in Table 2-2.

2.4.1 Overview of Remedial Investigation Data Collection Activities

This section provides an overview of RI data collection activities performed for representative waste sites of the consolidated 200-PW-2 and 200-PW-4 OUs. Further details for each representative waste site are provided in the following sections. Data were collected to characterize the nature and vertical extent of chemical and radiological contamination and the physical conditions in the vadose zone underlying the historical boundaries of the representative waste sites to support evaluation of risks and to assist in the evaluation, selection, and design of remediation alternatives. The RI needs for the 200-PW-2 and 200-PW-4 OUs were developed and presented in the data quality objectives process summary reports, BHI-01411 and CP-14176, respectively. The RI was conducted during FY 2003 and 2004 in accordance with the Work Plan (DOE/RL-2000-60, Appendix B) for characterization of all representative waste sites except the 216-S-7 Crib. Data collected from the RI representative waste sites are presented in the RI Report (DOE/RL-2004-25, Appendix B). The 216-S-7 Crib was characterized in FY 2004 and 2005 in accordance with the Work Plan (DOE/RL-2000-60, Appendix D), and the RI results are summarized in Appendix A of this FS.

The characterization activities consisted of borehole drilling and sampling, large-diameter push-hole (drive casing) installation, direct-push sampling, surface and borehole geophysical surveys, and sampling and analysis of borehole soils. These activities are described in detail in CP-18666, *200-PW-2 and 200-PW-4 Operable Unit Borehole Summary Report*, and D&D-25034, *200-PW-2 Operable Unit Borehole Summary Report for the 216-S-7 Crib*. The 200-PW-2 and 200-PW-4 OU boreholes from which analytical and/or geophysical logging data were collected are identified in Table 2-3. Except for the 207-A South Retention Basin, both geophysical logging and laboratory characterization data are available for the sites. The locations of new and existing boreholes are shown in Figures 2-2 through 2-6, and analytical results are discussed in the following sections.

2.4.1.1 Borehole Drilling and Geophysical Logging Activities

Five boreholes and five large-diameter push holes initially were drilled and sampled during the 200-PW-2 and 200-PW-4 OU RI at representative waste sites (CP-18666). A sixth borehole (C4557) was drilled for the 216-S-7 Crib, as reported in D&D-25034. At the 207-A South Retention Basin, four shallow borings were drilled to a depth of 6 m (20 ft) below ground surface (bgs) to collect soil samples for laboratory analysis. Soil samples were collected for laboratory analysis through the vadose zone from borehole drill cuttings.

Boreholes were drilled to the top of groundwater using a cable-tool drill rig. The borehole was advanced to total depth using drive barrels and split-spoon samplers. Split-spoon samplers were used as the primary sampling device for collecting chemical, radiological, and physical property samples; however, the drive barrel occasionally was used to collect moisture samples. After total depth was reached, each borehole was decommissioned by removing the temporary casings and backfilling the borehole with silica sand from the bottom to the water table, granular bentonite up to 0.3 to 1 m (1 to 3 ft) bgs, and a concrete surface seal in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells."

The boreholes identified in Table 2-3 also underwent geophysical logging for gamma-emitting radionuclides and neutron moisture content using, as a portion of the logging, a Spectral Gamma-Ray Logging System (SGLS). Existing wells at the 216-S-7 Crib, 299-W22-12 (A7837) and 299-W-13 (A7838), underwent geophysical logging using the SGLS. As the SGLS became saturated from high radiological counts or reached the top end of the reliability curve, a High-Rate Logging System (HRLS) was employed to determine the total activity of the material present. The HRLS provided a continuous radiometric signature of the soils through a single thickness of casing to total drilled depth. Existing boreholes in the vicinity of each waste site were logged in the SGLS before the drilling program began. A neutron moisture-logging tool was employed to provide a direct reading of hydrogen atom distribution and generate a moisture profile of the vadose zone in each borehole, because mobile contaminants move toward groundwater with the moisture front. Results of the borehole geophysical logging conducted in each borehole or push hole are provided in CP-18666 and D&D-25034 (216-S-7 Crib).

Logging information was used to guide sampling and analysis, for safety considerations, and to help confirm contamination information identified by analytical sampling. Logging is continuous with depth, whereas sampling only occurs at discreet depths. Logging data is valuable in confirming the presence of contaminants identified by analytical data but will not be used as the sole method to verify the nature and extent of waste site contamination. Although the geophysical logging data generally correlate well with analytical data for major contaminants and major zones of contamination at the sites, field-generated geophysical logging data are not as reliable as laboratory analytical data. Logging results are subject to the judgment of the personnel involved in taking and interpreting results and are dependent on many borehole variables such as moisture level, distance from surface, thickness of casings, and homogeneity of soil.

2.4.1.2 Soil Sampling and Field Screening

Soil samples were collected from borehole vadose zone material for chemical and radiological analysis and determination of physical properties. Physical property samples were collected at major lithologic changes and as determined by the site geologist. Sample collection was guided by the sample schedule in the Work Plan (DOE/RL-2000-60, Appendices B and D).

Drill cuttings and soil samples collected from the boreholes were screened in the field for radiological and chemical contaminants to assist in selecting sample points, support worker health and safety, and provide sample-shipping information. Chemical contaminants were screened using hand-held vapor analyzers for volatile organic constituents, ammonia, and TBP. Soil samples were screened for alpha and beta-gamma radioactivity before being placed into containers for shipment. Radiological activity greater than two times background was used as an indicator of high contamination.

Soil samples were analyzed selectively for ammonia, anions, hexavalent chromium, total cyanide, metals, nitrate/nitrite, oil and grease, pesticides and herbicides (for investigation-derived waste characterization of near-surface soils), pH, polychlorinated biphenyls, semivolatile organics, total petroleum hydrocarbons, radionuclides, volatile organics, moisture content, particle size distribution, and bulk density (identified in Appendix B, Tables B-1 and B-2, of the Work Plan [DOE/RL-2000-60]). Parameters for the sample analyses performed at the representative waste sites are presented in Tables 2-1 through 2-7 of the RI Report (DOE/RL-2004-25) and Appendix A, Table A2-1 (216-S-7 Crib) of this FS. A total of 217 samples were collected from the boreholes, including quality assurance/quality control (QC) and physical property samples.

The sampling approach generally required a greater sample frequency near the base of each waste site, which tends to be the area of highest contamination. Sample collection was attempted always at depths of 4.6 m (or less) and 7.6 m (15 and 25 ft) bgs to define contamination profiles for remedial designs. Samples to a depth of 4.6 m (15 ft) are critical for evaluation of human-health direct-exposure and terrestrial-wildlife scenarios, whereas deeper samples are applicable to groundwater-protection considerations. Sample intervals generally increased below depths of about 15.2 to 27.4 m (50 to 90 ft) to intervals of 15.2 to 30 m (50 to 100 ft). Samples from depths greater than the base of the waste site are used to verify the conceptual contaminant distribution model and to evaluate remedial action alternatives and groundwater impacts. A spilt-spoon sampler was the primary sampling device used to collect the samples from the boreholes. One liner from selected intervals was analyzed for physical properties. More details regarding site-specific characterization activities are provided in later sections.

2.4.1.3 Other Remedial Investigation Activities

Other RI activities included surface geophysical surveys at all borehole or push locations before drilling began. Borehole locations were surveyed in accordance with approved company procedures by a licensed professional land surveyor. Surveys used ground-penetrating radar to verify waste site location and identify potential underground hazards.

Air monitoring was performed in coordination with the requirements of CCN 0087338, "Environmental Restoration Program ALARACT Demonstration for Drilling – Drilling Activities Outside the Tank Farms Fence Line on the Hanford Site") to ensure and verify that the breathing zone remained free of contamination and the drill crew wore the proper protective equipment.

A quality assurance surveillance was conducted on the direct-push holes installed at the 216-A-10 Crib for placement of the holes, materials and equipment used, driller qualification, hole decommissioning, borehole geophysical logging, and document and record generation. This surveillance found the activities to be satisfactory.

2.4.2 Representative Waste Site Description, Characterization, and Contamination

This section describes the 200-PW-2 and 200-PW-4 OU representative waste sites, the RI characterization activities for each site, and the nature and vertical extent of contamination at these waste sites. This section summarizes data gathered during RI characterization activities described in Chapter 3.0 of the RI Report (DOE/RL-2004-25). The detections listed are of primary waste stream contaminants that typically were identified as COPCs for the sampling activity.

Contaminants are listed at their maximum detected concentration, as reported in the RI Report DOE/RL-2004-25, Appendix A, Table A-1 (Shallow Zone [less than 4.6 m {15 ft}]) and Table A-2 (Deep Zone [surface to groundwater]). The analytical results for these constituents have undergone evaluation for potential human-health and ecological direct-contact risk, risk to groundwater from vadose zone soil contamination, ecological risk, and intruder risk.

2.4.2.1 216-A-19 Trench

This section describes the representative waste site 216-A-19 Trench, site characterization activities, and the nature and extent of contamination found at the site.

2.4.2.1.1 Description

The 216-A-19 Trench (Figure 2-2) is located in the 200 East Area about 800 m (2,625 ft) northwest of the 202-A Building (PUREX Plant), just outside the eastern perimeter fence of the 200 East Area. The 216-A-19 Trench is surrounded (clockwise from the south) by the 216-A-34 Ditch, 216-A-18 Trench, 216-A-24 Crib, and 216-A-20 Trench. When actively receiving waste, the trench was 4.6 m (15 ft) deep with bottom dimensions of approximately 7.6 by 7.6 m (25 by 25 ft) (*Waste Information Data System* [WIDS]). When in operation, trench surface elevation was 199 m (652 ft). The Work Plan (DOE/RL-2000-60, Figure 2-20) contains a configuration diagram of the 216-A-19 Trench.

This trench operated from November 1955 until January 1956. During operation, the trench primarily received effluent containing unirradiated uranium from PUREX startup, some of which contained fission products, and contact condenser cooling water from the 241-A-431 T Tank Farm Ventilation Building containing uranium and nitric acid. Waste from PUREX entered the trench from aboveground piping and might have reached the trench from overflows of the adjacent 216-A-34 Ditch (200-PW-4 OU).

An estimated 38,700 kg (85,317 lb) of uranium in about 1,100,000 L (291,000 gal) of waste were routed to the trench (DOE/RL-96-81 and PNL-6456). Nitrate salts also were disposed of at the site. The radionuclide inventory included Co-60, Sr-90, Cs-137, Pu-239/240, and U-238 (PNL-6456). The 216-A-19 Trench was backfilled following use and later was covered with several meters of fill. The site was surface stabilized again in 1990 with additional fill material (WIDS).

2.4.2.1.2 Characterization Activities

The 216-A-19 Trench was characterized as part of the 200-PW-2 and 200-PW-4 OU RI in accordance with the Work Plan (DOE/RL-2000-60). Borehole C3245 was drilled through the 216-A-19 Trench from the ground surface to the water table to a depth of approximately 78 m (256 ft) bgs. The borehole was begun on April 4, 2003, with the final decommissioning on April 23, 2003. Geophysical logging of the borehole was performed with the SGLS and Neutron-Moisture Logging System (NMLS) on April 7 and 10, 2003.

Drill cuttings and soil samples collected from the borehole were screened in the field for volatile organic constituents, ammonia, TBP, beta-gamma activity, and alpha activity.

Sample collection was guided by the sample schedule in Appendix B of the Work Plan (DOE/RL-2000-60). Soil sample parameters for the 216-A-19 Trench are summarized in Table 2-1 of the RI Report (DOE/RL-2004-25). A total of 28 soil samples were sent for analysis, of which 2 were QC samples (equipment blanks) and 38 were samples of soil obtained from 4.4 to 75.6 m (14.5 to 248 ft) bgs sent for chemical and radiological analysis and determination of physical properties. Data from the characterization activities are presented in the borehole summary report (CP-18666), and analytical results are presented in the RI Report (DOE/RL-2004-25, Appendices A and B) and are discussed further in this section.

2.4.2.1.3 Nature and Extent of Contamination

This section describes the nature and extent of contamination in the 216-A-19 Trench. Contamination was detected in the vadose zone beneath the 216-A-19 Trench in Borehole C3245 to a depth of 75.6 m (248 ft) bgs. Maximum concentrations for all radiological and most chemical contaminants were found near the trench bottom from 4.4 to 5.3 m (14.5 to 17.5 ft) bgs. The surrounding 200-PW-2 and 200-PW-4 OU waste sites, 216-A-34 Ditch (200-PW-4), 216-A-18 Trench (200-PW-2) and the 216-A-20 Trench (200-PW-2), are likely to contain similar contamination. The 216-A-18 Trench and the 216-A-20 Trench have waste receipt histories nearly identical to that of the 216-A-19 Trench. Waste from the 216-A-34 Ditch (241-A-431 Tank Farm Ventilation Building condenser cooling water) is believed to have reached the 216-A-19 Trench and the 216-A-20 Trench. A vertical profile plot of maximum detected contaminant concentrations at the 216-A-19 Trench is shown in Figure 2-7.

The following are maximum concentrations of primary waste stream radionuclides detected in shallow soils at concentrations greater than 1 pCi/g:

- Ni-63 — 17.6 pCi/g at 4.4 m (14.5 ft) bgs
- Total radioactive strontium — 16.1 pCi/g at 4.4 m (14.5 ft) bgs
- Th-234 — 56.8 pCi/g at 4.4 m (14.5 ft) bgs
- U-233/234 — 6.0 pCi/g at 4.4 m (14.5 ft) bgs
- U-238 — 51 pCi/g at 4.4 m (14.5 ft) bgs.

The following are maximum concentrations of primary waste stream radionuclides detected in deep soils at concentrations greater than 1 pCi/g:

- Ni-63 — 17.6 pCi/g at 4.4 m (14.5 ft) bgs
- Total radioactive strontium — 20.0 pCi/g at 5.3 m (17.5 ft) bgs
- Th-234 — 56.8 pCi/g at 4.4 m (14.5 ft) bgs
- U-233/234 — 6.0 pCi/g at 4.4 m (14.5 ft) bgs
- U-238 — 51 pCi/g at 4.4 m (14.5 ft) bgs.

Samples at depths of approximately 4.6 m (15 ft) and below provided Cs-137 results less than the sample minimum detectable activity (MDA) of 0.015 pCi/g. The 90 percent upper confidence background level for Hanford Site soils is about 1.1 pCi/g (DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides*); thus, the levels only are slightly above background at greater depths. No other radionuclides were detected at more than 1 pCi/g at any depth.

The following are maximum concentrations of nonradiological contaminants detected in shallow soils:

• Boron	38.9 mg/kg at 4.4 m (14.5 ft) bgs
• Vanadium	96.1 mg/kg at 4.4 m (14.5 ft) bgs
• Bis(2-ethylhexyl)phthalate	0.660 mg/kg at 4.4 m (14.5 ft) bgs
• TBP	280 mg/kg at 4.4 m (14.5 ft) bgs
• Uranium, total	129 mg/kg at 4.4 m (14.5 ft) bgs.

Pesticides and herbicides used to kill vegetation on the trench surface were tested at 0.15 m (0.5 ft) bgs, and none were detected.

The following are maximum concentrations of nonradiological contaminants detected in deep soils:

• Arsenic	7.0 mg/kg at 4.3 m (14.0 ft) bgs
• Bismuth	36,400 mg/kg at 29.7 m (97.5 ft) bgs
• Boron	38.9 mg/kg at 4.4 m (14.5 ft) bgs
• Manganese	538 mg/kg at 5.3 m (17.5 ft) bgs
• Uranium, total	130 mg/kg at 6.9 m (22.5 ft) bgs
• Nitrate as nitrogen	9,860 mg/kg at 8.4 m (27.5 ft) bgs
• Nitrate and nitrate/nitrite as nitrogen	1,120 mg/kg at 9.9 m (32.5 ft) bgs
• TBP	280 mg/kg at 4.4 m (14.5 ft) bgs.

The radiological and chemical (e.g., nitrates) contaminants found at the 216-A-19 Trench are consistent with the site history indicating that nitrate-containing waste (e.g., nitric acid, nitrate salts) and large quantities of uranium, 387,000 kg (85,700 lb) were disposed of at the site (DOE/RL-2000-60).

SGLS and NMLS logging for Borehole C3245 show that Cs-137, U-238, and U-235 were the only manmade radionuclides detected in this borehole. Cesium-137 was detected near the ground surface, ranging from 0.4 to 40 pCi/g in the top 0.3 to 3.4 m (1 to 11 ft) bgs and again at the depths of 7 m (23 ft) bgs and 58.8 m (194 ft) bgs. Results from 9.9 to 75.6 m (32.5 to 248 ft) bgs range from 0.1 to 7.4 pCi/g. At lower depths, the estimated concentrations were at or below the minimum detection level (MDL) of 0.2 pCi/g. SGLS logging of nearby Borehole 299-E25-10, 18 m (59 ft) north of the trench, did not detect Cs-137 at any depth. Moisture logs indicate no major areas of wetness to act as a moisture front for transport of mobile constituent to groundwater. Processed uranium (U-238) was encountered from 2 to 9.3 m (6.5 to 30.5 ft) bgs, with concentrations ranging between 18 and 560 pCi/g. The maximum concentrations for Cs-137 and U-238 were found at 2.4 m (8 ft) bgs.

The contaminant distribution model (DOE/RL-2000-60, Figure 3-11) predicted that highest contamination would be found at about 5.5 to 10.7 m (18 to 35 ft), medium amounts of contamination to 15.2 m (50 ft) bgs, and low contamination below 15.2 m (50 ft). In general, and except for bismuth, this distribution is confirmed by sample data.

2.4.2.1.4 Potential for Groundwater Impact

The effluent volume (1,100 m^3) discharged at this site did not exceed soil-pore volume (approximately 90 percent of the soil-pore volume of 1,232 m^3). The status of groundwater contamination in the vicinity of the 216-A-19 Trench is described in PNNL-13788. The report indicates that I-129 and tritium exceed groundwater protection standards/guidelines in the vicinity of the trench but does not identify the 216-A-19 Trench as the source (DOE/RL-2000-60). PNNL-14187, *Hanford Site Groundwater Monitoring for Fiscal Year 2002*, does not report exceedances of any groundwater parameters in wells associated with this waste site. Soil sampling data, the volume of effluent discharged, and groundwater monitoring results confirm the conceptual model showing that the 216-A-19 Trench is not likely to have impacted groundwater.

2.4.2.2 216-B-12 Crib

This section describes the representative waste site 216-B-12 Crib, crib characterization activities, and the nature and extent of contamination found at the site.

2.4.2.2.1 Description

The 216-B-12 Crib (Figure 2-3) is located in the 200 East Area about 305 m (1,000 ft) northwest of the 221-B Building. The bottom surface area of the crib is 49 by 15 m (160 by 50 ft); the crib is approximately 8 m (26 ft) deep on one end and 9.2 m (30 ft) deep on the downgradient end. For a configuration diagram of the 216-B-12 Crib, refer to Figure 2-21 of the Work Plan (DOE/RL-2000-60).

The 216-B-12 Crib was constructed in 1952 and consists of a series of three cascading 5 by 5 by 3 m (16- by 16- by 10-ft)-high wooden boxes made from 15 by 20 cm (6- by 8-in.) Douglas Fir in a 9 m (30-ft)-deep excavation. The bottom 4 m (12 ft) of the crib contains 1.3 cm (0.5 in.) of gravel backfill, of which 1.2 m (4 ft) underlie the boxes. The excavation has side slopes of 1:1. It is unclear if the gravel backfill merely surrounds the boxes or also fills the boxes. The unit is considered to have cave-in potential (WHC-IP-0809, *B Plant Aggregate Area Management Study Technical Baseline Report*).

The crib operated from November 1952 to November 1973. During its service history, the 216-B-12 Crib received process condensate from the 221-U, 224-U, and the 221-B Buildings from November 1952 until December 1957. The crib was inactive from December 1957 until May 1967. From May 1967 to November 1967, the crib received liquid waste from the 221-B Building. From November 1967 to November 1973, the crib received additional process condensate via a 15 cm (6-in.) diameter vitrified clay pipe from the 221-B Building. The vitrified clay pipe includes limestone used to neutralize the waste stream. The 216-B-12 Crib was abandoned in November 1973 when the ground above the crib started to subside. At that time, the subsidence was backfilled and the fill line was blanked. In 1974, the crib was stabilized using layers of sand and gravel with a plastic liner to deter vegetation growth. An additional 0.6 m (2 ft) of clean soil was added in 1993 (RHO-CD-673 and WIDS).

The total volume of effluent discharged is estimated to be 520,000,000 L (140,000,000 gal). The waste was low salt and neutral/basic, containing large amounts of uranium and also ammonium nitrate, TBP, and fission products. The radionuclide inventory of the site includes Co-60, Sr-90, Cs-137, Pu-239/240, and U-238. An estimated 21,000 kg (46,300 lb) of uranium, 374 g (1 lb) of plutonium, 716 Ci of Cs-137, and 79.3 Ci of Sr-90 might have been discharged to this site. Records indicate that 180,000 kg (396,832 lb) of ammonium nitrate was disposed of at the site.

2.4.2.2.2 Characterization Activities

Drilling of Borehole C3246 commenced May 29, 2003, and was completed June 24, 2003. Borehole C3246 was drilled through the 216-B-12 Crib from the ground surface to the water table to a depth of approximately 93 m (306 ft). Geophysical logging was performed in Borehole C3246 using the SGLS, the HRLS, and the NMLS on June 5, 9, and 19, 2003.

Drill cuttings and soil samples collected from the borehole were screened in the field for volatile organic constituents, ammonia, TBP, beta-gamma activity, and alpha activity.

A total of 27 samples were sent for analysis, of which 3 were QC samples (equipment blanks) and 24 were obtained from borehole material from 0.2 to 92 m (0.5 to 302 ft) bgs for chemical and radiological analysis and determination of physical properties. Sample collection was guided by the sample schedule in the Work Plan (DOE/RL-2000-60). Soil sample parameters are summarized in Table 2-3 of the RI Report (DOE/RL-2004-25). Data from the characterization activities are presented in the borehole summary report (CP-18666). Analytical results are presented in Appendices A and B of the RI Report, and are discussed further in this section.

2.4.2.2.3 Nature and Extent of Contamination

This section describes the nature and extent of contamination at the 216-B-12 Crib. Contamination was detected in the vadose zone beneath the 216-B-12 Crib in Borehole C3246 to a depth of 91.5 m (302 ft) bgs for radionuclides, although many of these maximum concentrations are less than 1 or 2 pCi/g. Maximum radionuclide concentrations were located at or above the 12.1 m (40 ft) bgs level of the borehole. For the 216-B-12 Crib, vertical profile plots of contaminants are shown in Figure 2-8.

The following are maximum concentrations for primary waste stream radionuclides detected in shallow soils at concentrations greater than 1 pCi/g:

- K-40 — 14.2 pCi/g at 4.4 m (14.5 ft) bgs
- Th-230 — 1.19 pCi/g at 4.4 m (14.5 ft) bgs
- Tritium — 8.28 pCi/g at 4.4 m (14.5 ft) bgs.

Also detected in site soils was Sn-126 at 0.724 pCi/g at 4.4 m (14.5 ft) bgs.

The following are maximum concentrations for the primary waste stream radionuclides detected in deep soils at concentrations greater than 1 pCi/g:

- Ac-228 — 1.02 pCi/g at 28.8 m (94.5 ft) bgs
- Am-241 — 2.00 pCi/g at 10.8 m (35.5 ft) bgs
- Bi-214 — 1.05 pCi/g at 28.8 m (94.5 ft) bgs

• Carbon-14	3.30 pCi/g at 19.1 m (62.5 ft) bgs
• Cs-137	61,900 pCi/g at 10.8 m (35.5 ft) bgs
• Eu-155	34.9 pCi/g at 10.8 m (35.5 ft) bgs
• Pb-214	1.08 pCi/g at 28.8 m (94.5 ft) bgs
• Pu-239/240	3.90 pCi/g at 10.8 m (35.5 ft) bgs
• K-40	15.8 pCi/g at 60.2 m (197.5 ft) bgs
• Ra-226	1.05 pCi/g at 28.8 m (94.5 ft) bgs
• Ra-228	1.02 pCi/g at 28.8 m (94.5 ft) bgs
• Th-228	7.54 pCi/g at 10.8 m (35.5 ft) bgs
• Th-230	1.19 pCi/g at 4.4 m (14.5 ft) bgs
• Th-234	2.01 pCi/g at 28.8 m (94.5 ft) bgs
• Total radioactive strontium	12,700 pCi/g at 10.8 m (35.5 ft) bgs
• Tritium	8.28 pCi/g at 4.4 m (14.5 ft) bgs
• U-233/234	4.90 pCi/g at 12.2 m (40 ft) bgs
• U-238	12.1 pCi/g at 12.2 m (40 ft) bgs.

The high Cs-137 and Sr-90 concentrations, and the presence of high total uranium, U-238, and U-233/234 concentrations, corroborate site waste receipt history.

The following are maximum concentrations for the primary nonradioactive contaminants detected in shallow soils:

• Arsenic	7.30 mg/kg at 4.4 m (14.5 ft) bgs
• Boron	1.30 mg/kg at 4.4 m (14.5 ft) bgs
• Bis(2-ethylhexyl)phthalate	0.018 mg/kg at 4.4 m (14.5 ft) bgs.

Pesticides and herbicides used to kill vegetation on the surface of the crib were tested for at 0.15 m (0.5 ft) bgs and were not detected.

The following are maximum concentrations for the nonradioactive contaminants detected in deep soils:

• Nitrate as nitrogen	165 mg/kg at 10.8 m (35.5 ft) bgs
• Nitrate/nitrite as nitrogen	126 mg/kg at 15.3 m (50 ft) bgs
• Total uranium	28.0 mg/kg at 10.8 m (35.5 ft) bgs.

As expected from this waste stream, TBP was found, but the maximum concentrations of 2.0 mg/kg at 12.2 m (40 ft) bgs and 0.6 mg/kg at 29.5 m (97.5 ft bgs) were below screening levels.

Geophysical logging performed in Borehole C3246 using the SGLS, the HRLS, and the NMLS showed Cs-137, U-238, and Eu-154 as the only manmade radionuclides present in this borehole (CP-18666, Appendix F). Although borehole logging results are consistently higher than the laboratory data, the relative levels of sample results at different depths are consistent and generally confirm the vertical distribution of the radionuclide predicted by logging. The maximum Cs-137 concentration found during logging was 121,000 pCi, seen at 10.6 m (35 ft) bgs, compared to 61,900 pCi/g at the same depth by sampling. Processed uranium (U-238) was identified by logging at 35.8 m (118 ft) bgs at a concentration of 13 pCi/g; sample results obtained at 28.6 to 59.8 m (94.5 to 197.5 ft) bgs were 0.69 to 1.7 pCi/g. Europium-154 was detected during logging at 9.4 m (31 ft) bgs, with a concentration of 9 pCi/g, but was not detected in laboratory samples, although Eu-155 (0.282 pCi/g) at 28.6 m (94.5 ft) bgs was found in one laboratory sample. No other geophysical or laboratory data have been collected from this site since 1977. NMLS showed low uniform wetness to the water table and no major areas of wetness, which correlates well with sample results.

The conceptual contaminant distribution model (DOE/RL-2000-60, Figure 3-12) correlates well with the characterization results. With few exceptions, radionuclides either were not detected or were detected at approximately 2 pCi/g or less deeper than 12.1 m (40 ft). Most of the radionuclides were found in the predicted high-contamination range (4.5 to 19.7 m [15 to 65 ft] bgs), as were many of the metals associated with contamination. Those that were found in elevated concentrations farther down the borehole still were in the predicted medium-contamination range (to 30.3 m [100 ft] bgs) except chromium, which was high (30 p/m) at the 91.5 m (302 ft) level. Contaminant distribution data indicate that a possible geologic structure might be located beneath the crib, causing the contaminant distribution of total uranium and of all measured isotopes to be anomalous. Uranium is elevated at 10.7 to 15.2 m (35 to 50 ft bgs), drops at 19.1 m (62.5 ft) bgs, and, contrary to the conceptual model that expects medium contamination at the 28.2 m (92.5 ft), rises again at 28.2 m (92.5 ft bgs), and then drops off again between 60.2 to 75.4 m (197.5 to 247.5 ft) bgs. However, this does not significantly conflict with the contaminant distribution model. Soil data, effluent discharge volume, and groundwater monitoring information confirm the conceptual model that the 216-B-12 Crib likely impacted groundwater.

2.4.2.2.4 Potential for Groundwater Impact

The effluent volume (520,000 m^3) discharged at the 16-B-12 Crib site is 28 times greater than the soil-pore volume (18,300 m^3). These data indicate a high likelihood of impact to the groundwater at this site. The status of groundwater contamination at the 216-B-12 Crib is described in PNNL-13788. The report indicates that the I-129 and nitrate as nitrogen plumes extend northwesterly from the B Plant and might exist beneath the 216-B-12 Crib, but does not specifically imply that this site is the source (DOE/RL-2000-60). PNNL-14187 does not report exceedances of any groundwater parameters in wells associated with this waste site.

2.4.2.3 216-S-7 Crib

This section describes the 216-S-7 Crib, crib characterization activities, and the nature and extent of contamination found at the site.

2.4.2.3.1 Description

The 216-S-7 Crib (Figure 2-9) is located in the 200 West Area, about 230 m (750 ft) northwest of the 202-S Canyon Building and 290 m (95 ft) east of the SX Tank Farm. The waste site consists of two roofed wooden boxes, each of which is 4.9 by 4.9 m (16 by 16 ft) square by 1.6 m (5.2 ft) tall, placed in an excavation that was 6.7 m (22 ft) deep with bottom dimensions of 15.2 by 30.4 m (50 by 100 ft). Elevation at the original ground surface is 205.5 m (674.2 ft) above mean sea level. The wooden cribs are centered 15.2 m (50 ft) apart in an excavation. The wooden boxes received liquid waste through a 7.6 cm (3-in.) diameter stainless steel inlet pipe placed 4.6 m (15 ft) below grade. The inlet pipe split at the center of the crib and fed the two wooden boxes in parallel. The pipe was covered with a gravel and sand cover. Covering this is a vapor barrier, consisting of two layers of heavy construction paper extending over the entire gravel bed and lapped up the side of the excavation 0.6 m (2 ft). The excavated soil probably was used as backfill over the gravel and paper barrier. Surface dimensions of the excavation are 28.7 by 43.9 m (94 by 144 ft), based on a 45-degree slope into the excavation. For a configuration diagram of the 216-S-7 Crib, refer to Figure D-1 of the Work Plan (DOE/RL-2000-60).

The 216-S-7 Crib was constructed in 1955 to receive the waste treatment stream from the REDOX process and was active from January 1956 to July 1965. The primary sources for the waste were the D-1 and D-2 cell tanks in the 202-S Building (REDOX).

The 216-S-7 Crib received 390,000,000 L (103,000,000 gal) of process waste. The discharged waste was acidic (as low as pH=2), at least at the start of 216-S-7 Crib operations. An estimated 3 percent by volume of the waste from this tank was settleable solids. The waste discharged to the soil column at the 216-S-7 Crib included 2,560 kg of uranium, 440 g of plutonium, 703 Ci of Cs-137, and 1,390 Ci of Sr-90 (decayed through 1989). The initial inventory also included 25 Ci of Co-60 and 1,500 Ci of Ru-106. Chemical inventory data included 110,000 kg of nitrate, 40,000 kg of aluminum nitrate, 250,000 kg of nitric acid, and 7,000 kg of sodium.

2.4.2.3.2 Characterization Activities

New Borehole C4557 was drilled and sampled to support the 216-S-7 Crib RI. The borehole is located in the center of the crib and was drilled from the ground surface to the water table at depths of approximately 68.6 m (225 ft). Also, two nearby wells were logged.

Drill cuttings and soil samples collected from the borehole were screened in the field for volatile organic constituents, ammonia, TBP, beta-gamma activity, and alpha activity.

Thirty-five samples were obtained from the borehole for chemical and radiological analysis and determination of physical properties. Of these, seven were QC samples (splits, duplicates, blanks) and four were for physical properties. Samples were analyzed for parameters identified in Appendix D, Table D2-1. Sample collection was guided by the sample schedule in Appendix D of the Work Plan (DOE/RL-2000-60). Data from the characterization activities are presented in the borehole summary report (D&D-25034). Analytical results are presented in Appendix A of this FS and are discussed further in this section.

2.4.2.3.3 Nature and Extent of Contamination

This section describes the nature and extent of contamination in the 216-S-7 Crib area. The crib received uranium-rich solutions from process condensates from the REDOX Plant, which was active between January 1956 and July 1965. When actively receiving waste, the crib was 6.7 m (22 ft) deep. Contamination was detected in the vadose zone beneath the 216-S-7 Crib in Borehole C4557 to a depth of 68.8 m (225.5 ft) bgs. The water table was reached and drilling was stopped at 226 ft bgs. The maximum contaminant levels (MCL) are found from 7.3 to 7.8 m (24 to 26.5 ft). A vertical profile plot of the maximum detected contaminant concentrations for the 216-S-7 Crib is shown in Figure 2-9.

Tritium reported at 184 pCi/g at 4.4 to 5.2 m (14.5 to 17 ft) bgs was the only radionuclide detected in shallow soils at greater than 1 pCi/g.

The maximum concentrations of radionuclides detected in deep soils at concentrations greater than 1 pCi/g are as follows:

- Am-241 — 1,900 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs
- Cs-137 — 20,000 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs
- Np-237 — 6.80 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs
- Ni-63 — 13.7 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs
- Pu-238 — 190 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs
- Pu-239/240 — 11,000 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs
- K-40 — 16.2 pCi/g at 13.4 to 14.2 m (44 to 46.5 ft) bgs
- Sr-90 — 53,000 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs
- Tc-99 — 14.7 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs
- Th-228 — 4.78 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs
- Tritium — 1,410 pCi/g at 47.3 to 48.0 m (155 to 157.5 ft) bgs
- U-233/234 — 230 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs
- U-235 — 25.0 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs
- U-238 — 200 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs.

The maximum concentrations of nonradioactive contaminants detected in shallow soils are as follows:

- Mercury — 1.7 mg/kg at 4.4 to 5.2 m (14.4 to 17 ft) bgs
- Silver — 3.9 mg/kg at 4.4 to 5.2 m (14.4 to 17 ft) bgs
- Hexavalent chromium — 7.2 mg/kg at 4.4 to 5.2 m (14.4 to 17 ft) bgs.

The maximum concentrations for nonradioactive contaminants in deep soils are as follows:

- Arsenic — 7.09 mg/kg at 47.3 to 48.0 m (155 to 157.5 ft) bgs
- Nitrate — 53.0 mg/kg at 38.4 to 39.2m (126 to 128.5 ft) bgs
- Nitrate/nitrite — 45.0 mg/kg at 68 to 68.8m (223 to 225.5 ft) bgs
- Uranium — 463 mg/kg at 7.3 to 8.1 m (24 to 26.5 ft) bgs.

Pesticides and herbicides used to kill vegetation on the trench surface were tested for at 0 to 1 m (0 to 3 ft) bgs and were detected at very low concentrations (maximum of 1.4 μg/kg), less than screening values.

SGLS detected Cs-137 from the ground surface to 39 m (128 ft) in Borehole C4557 with the maximum concentration at approximately 2 million pCi/g at 7.6 m (25 ft) bgs in depth and the major concentration zone being between 4.6 and 10.7 m (15 and 35 ft). Also, existing boreholes in the vicinity of the crib (299-W22-12 [A7837], 299-W22-13 [A7838], 299-W22-14 [A7839], 299-W22-32 [A7851], and 299-W22-33 [A7852]) were logged in SGLS before Borehole C4557 was drilled. Typically, Cs-137, Co-60, U-238, and Eu-154 were the manmade radionuclides detected by logging in adjacent boreholes. These radionuclides were detected at considerably lower concentrations (detection level to 450 pCi from 10.7 to 11.9 m [35 to 39 ft]) in Boreholes A7837, A7838, and A7839 located outside the crib, indicating limited lateral spread of contamination beyond the crib boundary. However, Boreholes A7851 and A7852 located in the crib just to the southeast and the southwest of Borehole C4557 (located in the center of the crib), respectively, detected Cs-137 at 3,000,000 pCi/g (A7851) and 300,000 pCi/g (A7852) at levels more closely correlating with Borehole C4557 results. Laboratory samples from Borehole C4557 indicate much lower peak Cs-137 concentrations of 20,000 pCi/g at 7.3 to 8.1 m (24 to 26.5 ft) bgs, generally dropping to ≤760 pCi/g at the 10.4 to 11.1 m (34 to 36.5 ft) level and continuing to drop markedly down the borehole. However, on a relative basis, these results match the laboratory sample results measured at 8.5 m (28 ft) and 8.4 m (27.5 ft), respectively. Data from all six SGLS logs and the Borehole C4557 laboratory data clearly show a marked increase in Cs-137 at the crib bottom (about 7.6 m [25 ft]) followed by a marked decrease. Data from the boreholes within the crib boundaries (C4557, 299-W22-32, and 299-W22-33) also show a second, lower Cs-137, concentration peak at about the 15.3 m (50 ft) level, corresponding to a layer of silty sandy gravel in nearby Borehole C4557 (underbed of Hanford Unit 1).

Although some discharges to the 216-S-7 Crib are believed to have been hexone-rich concentrator wastes, 216-S-7 Crib sampling identified few organics in the soil column. Uranium, plutonium, and fission products such as Cs-137 and Sr-90 are present in large quantities near the crib bed. Concentrations of radionuclides in the borehole at the 20.1 m (66 ft) level and below are ≤1.6 pCi/g with the exceptions of the highly mobile contaminants tritium and Tc-99, which potentially impacted groundwater. The distribution of radionuclides in the soil column is similar to the distribution in other 200-PW-2 and 200-PW-4 OU sites; concentrations are greatly elevated at the crib bottom and drop off markedly down the borehole with the exception of the highly mobile contaminants.

2.4.2.3.4 Potential for Groundwater Impact

Currently there are no active monitoring wells near the 216-S-7 Crib. However, based on available monitoring data, this crib likely is not currently impacting groundwater. The closest active downgradient wells are approximately 600 m away and include well 299-W22-79 (near the 216-U-12 Crib). Well 299-W22-79 exceeds carbon tetrachloride, tritium, and I-129 standards, and well 299-W22-9 exceeds tritium and I-129 standards. Of older wells existing adjacent to the crib, only well 299-W22-12 provides groundwater quality data, the most recent being from 1993. These data showed that the primary 200 West Area contaminants (nitrate, carbon tetrachloride, chromium, Tc-99, uranium, tritium, Sr-90, and gross beta) were below drinking water standards in 1993 and far below past (1950s through 1970s) levels for nitrate, gross beta, and tritium, which greatly exceeded standards. Chromium, nitrate, Tc-99, Sr-90, and tritium plumes exist upgradient to the west of the crib (PNNL-13788). However, PNNL-15070, *Hanford Site Groundwater Monitoring for Fiscal Year 2004*, indicates that these plumes generally do not underlie the 216-S-7 Crib at levels above drinking water standards, with the possible exception of the carbon tetrachloride plume. However, the 216-S-7 Crib was not a source of carbon tetrachloride.

2.4.2.4 216-A-10 Crib

This section describes the 216-A-10 Crib, site characterization activities, and the nature and extent of contamination found at the site.

2.4.2.4.1 Description

The 216-A-10 Crib (Figure 2-4) is located in the 200 East Area approximately 82 m (270 ft) south of the southwest corner of the 202-A Building (PUREX Plant). The rock-filled crib has a wedge-shaped cross section and is 84 by 14 m (275 by 45 ft) at the sisalkraft layer. The sisalkraft layer is about 9.2 m (30 ft) below grade and 4.6 m (15 ft) from the bottom of the crib. Elevation at the surface was 218 m (714 ft) (HW-43121, *Tabulation of Radioactive Liquid Waste Disposal Facilities*). The original 203 mm (8-in.) diameter vitrified clay distribution pipe was placed horizontally 9.2 m (30 ft) below grade at the crib centerline. In 1962, the original vitrified clay pipe was replaced with a 203 mm (8-in.) diameter stainless steel effluent pipeline, because the acidic waste destroyed the integrity of the original vitrified clay pipe. The replacement pipe was placed 9 m (27 ft) east of the crib centerline. In 1967, some portions of the stainless steel pipe also were replaced. For a configuration diagram of the 216-A-10 Crib, refer to Figure 2-24 of the Work Plan (DOE/RL-2000-60).

The crib was designed as a percolation unit for the disposal of liquid waste from the PUREX Plant and initially was a spare crib for the 216-A-5 Crib and received only water. The design capacity for the 216-A-10 Crib was 272,500 L (72,000 gal) per day. From 1956 to 1959, the crib received 2.34×10^8 L (6.18×10^7 gal) of water. The 216-A-10 Crib replaced the 216-A-5 Crib in 1961, which was the year contaminated liquid waste began being discharged into the crib (WIDS). Liquid waste included an acidic waste stream (D002) from the process distillate discharge from the PUREX Plant (RHO-CD-673).

The crib was inactive from 1978 to 1981. From 1981 to 1986, the crib received acidic process condensate from the 202-A Building, which resulted in the site being permitted as a RCRA TSD unit (Section 2.1.3). The crib operated until 1987. After operational use ceased, the crib was backfilled.

The total volume of liquid effluent discharged to the crib was approximately 3.2×10^9 L (8.5×10^8 gal) (DOE/RL-96-81). The crib received tritium, Sr-90 (82.5 Ci), I-129, Am-241 (0.7 Ci), Cs-137 (80.5 Ci), Pm-147, Pu-238, Pu-239, and Pu-241 (350 g total plutonium), and 241 kg (530 lb) of uranium (DOE/RL-88-19, *Information on Hanford Site Cribs and Septic Systems*, and DOE/RL-96-81).

2.4.2.4.2 Characterization Activities

Five large-diameter push holes and a borehole were installed for 216-A-10 Crib characterization (CP-18666). Geophysical logging data were used to determine where Borehole C3247 would be drilled and sampled in the area of highest contamination in this crib.

- C4107 was installed on April 15 and 16, 2003, to a depth of 27.8 m (91 ft) bgs.
- C4108 was installed on April 15, 2003, to a depth of 27.8 m (91 ft) bgs.
- C4110 was completed on April 8, 2003, at a depth of 18.3 m (60 ft) bgs.
- C4111 was installed on April 9, 2003, to a depth of 27.1 m (89 ft) bgs.
- C4112 was installed on April 8, 2003, to a depth of 24.4 m (80 ft) bgs.

Push holes were decommissioned in accordance with WAC 173-160.

Borehole C3247 was drilled based on geophysical logging data locating the most contaminated portion of the crib. The borehole was drilled through the 216-A-10 Crib from the ground surface to the water table beginning on May 15, 2003, and concluding on October 3, 2003, to a drilled depth of 98.8 m (324 ft) bgs.

Drill cuttings and soil samples collected from the borehole were screened in the field for volatile organic constituents, ammonia, TBP, beta-gamma activity, and alpha activity.

A total of 23 samples were sent for analysis, of which 2 were QC samples (equipment blanks) and 21 were of soil obtained from the borehole from 0.2 to 96.6 m (0.5 to 317 ft) bgs for chemical and radiological analysis and determination of physical properties. Sample collection was guided by the sample schedule in the Work Plan (DOE/RL-2000-60). Soil sample parameters are summarized in Table 2-7 of the RI Report (DOE/RL-2004-25). Geophysical data from the characterization activities are presented in the borehole summary report (CP-18666). Analytical results are presented in Appendix A of the RI Report and are discussed further in the following section.

2.4.2.4.3 Nature and Extent of Contamination

This section describes the nature and extent of contamination at the 216-A-10 Crib. When actively receiving effluent, the crib was about 14 m (45 ft) deep. The effluent discharged to the 216-A-10 Crib was acidic process condensate from the PUREX Plant containing uranium and nitrate (DOE/RL-2000-60). Contamination was detected in the vadose zone beneath the 216-A-10 Crib in Borehole C3247 to a depth of 96.1 m (317 ft) bgs for radionuclides. Maximum concentrations mainly are present in the 15.8 to 18.9 m (52- to 62.5-ft) depth interval of the soil column. A vertical profile plot of maximum detected contaminant concentrations for the 216-A-10 Crib is shown in Figure 2-10.

The maximum radionuclide concentration greater than 1 pCi/g in shallow soils was the naturally occurring K-40 at 18.7 pCi/g at 3.8 m (12.5 ft) bgs. Also detected at concentrations lower than 1 pCi/g was Np-237 detected at 0.043 pCi/g at 3.8 m (12.5 ft).

The following are the maximum concentrations of primary waste stream radioactive contaminants detected in deep soils at concentrations greater than 1 pCi/g:

- Am-241 — 1,320 pCi/g at 15.9 m (52 ft) bgs
- C-14 — 7.50 pCi/g at 19.1 m (62.5 ft) bgs
- Cs-137 — 2,950 pCi/g at 19.1 m (62.5 ft) bgs
- I-129 — 38.8 pCi/g at 19.1 m (62.5 ft) bgs
- Np-237 — 0.132 pCi/g at 19.1 m (62.5 ft) bgs
- Ni-63 — 2.13 pCi/g at 38.9 m (127.5 ft) bgs
- Pu-238 — 316 pCi/g at 15.9 m (52 ft) bgs
- Pu-239/240 — 7,110 pCi/g at 15.9 m (52 ft) bgs
- K-40 — 27.0 pCi/g at 15.9 m (52 ft) bgs
- Ra-228 — 1.27 pCi/g at 19.1 m (62.5 ft) bgs
- Tc-99 — 1.03 pCi/g at 19.1 m (62.5 ft) bgs
- Th-228 — 2.11 pCi/g at 19.1 m (62.5 ft) bgs
- Th-230 — 1.10 pCi/g at 19.1 m (62.5 ft) bgs

• Sr-90	44.7 pCi/g at 38.9 m (127.5 ft) bgs
• Tritium	835 pCi/g at 96.7 m (317 ft) bgs
• U-233/234	1.39 pCi/g at 19.1 m (62.5 ft) bgs
• U-238	1.22 pCi/g at 19.1 m (62.5 ft) bgs.

Maximum tritium contamination was detected near the soil/groundwater interface.

The following are maximum concentrations of nonradiological contaminants detected in shallow soils:

• Boron	0.890 mg/kg at 3.8 m (12.5 ft) bgs
• Beta-1,2,3,4,5,6-hexachlorocyclohexane (B-BHC)	0.07 mg/kg at 0.15 m (0.5 ft) bgs.

The following are maximum concentrations of nonradiological contaminants detected in deep soils:

• 1-Chloropropane	0.38 mg/kg at 15.9 m (52 ft) bgs
• 2-Butoxyethanol	0.025 mg/kg at 19.1 m (62.5 ft) bgs
• Methylene chloride	0.029 mg/kg at 19.1 m (62.5 ft) bgs
• Pentachlorophenol	0.020 mg/kg at 19.1 m (62.5 ft) bgs
• TPH – kerosene	10,000 mg/kg at 16.5 m (54 ft) bgs
• TBP	2,000 mg/kg at 19.1 m (62.5 ft) bgs
• Nitrate/nitrite (as nitrogen)	25.8 mg/kg at 15.9 m (52.0 ft) bgs.

Of all the 200-PW-2/200-PW-4 OU sites, sampling at this crib reported the widest variety of organics detected having maximum concentrations near the 19.1 m (62.5-ft) depth.

Geophysical logging of Borehole C3247 identifies Cs-137 as the primary manmade radionuclide detected. Cesium-137 was detected from 13.7 m (48 ft) bgs, which is the bottom of the crib, to 25.6 m (84 ft) bgs in concentrations ranging from 0.3 to 2800 pCi/g. The maximum concentration was measured at a depth of 18.8 m (62 ft) bgs and was detected at or near the MDL (0.3 pCi/g) throughout the vadose zone. The moisture logs show a wetter area at 18.8 m (62 ft) bgs, corresponding to the peak cesium concentration. The Cs-137 and the low levels of U-238 found during logging show that logging and laboratory sample data in the same region are in good agreement and indicate natural levels of uranium throughout the entire soil column.

In general, the contaminant distribution model (DOE/RL-2000-60, Figure 3-15) is well supported by the data, indicating that high contamination is in the 9.1 to 27.3 m (30- to 90-ft) bgs range; medium contamination is to be found in the 27.3 to 39.4 m (90- to 130-ft) bgs range; and tritium is a groundwater concern. The volume of effluent discharged, current groundwater monitoring, and laboratory data also confirm the likelihood that the 216-A-10 Crib impacted groundwater.

2.4.2.4.4 Potential for Groundwater Impact

The effluent volume (3,210,096 m^3) discharged at this site is 114 times greater than the soil pore volume (28,072 m^3), indicating a high likelihood of impact to the groundwater from this site. The status of the groundwater contamination in the vicinity of the 216-A-10 Crib is comparable to that of the 216-A-36B Crib. The cribs are close to each other and had the same general wastewater source. Groundwater contamination in the area of these cribs is described in PNNL-13788 and is partially attributed to these two waste sites. The report indicates that tritium, nitrate as nitrogen, I-129, Sr-90, and gross beta exceed the groundwater protection standards/guidelines in the vicinity of the crib. Well 299-E17-19 at the 216-A-10 Crib was the only well in the 200 East Area showing an increase in manganese concentration during FY 2002 (41.7 and 31.1 μg/L), neither of which exceeds the drinking water standards (50.0 μg/L). The source of the increased levels of manganese is unknown but is presumed to be from the associated PUREX cribs. However, as with the PUREX cribs and other Hanford Site wells, the source also might be corrosion of the well screens or casings (PNNL-14187).

2.4.2.5 216-A-36B Crib

This section describes the 216-A-36B Crib, site characterization activities, and the nature and extent of contamination found at the site.

2.4.2.5.1 Description

The 216-A-36B Crib (Figure 2-4) is located in the 200 East Area about 366 m (1,200 ft) south of the 202-A Building (PUREX Plant). The surface elevation is about 218 m (715 ft), and the subsurface elevation of the crib is about 210 m (690 ft). The gravel-filled crib has bottom dimensions of 152 m (500 ft) and a width of 3.4 m (11 ft). The bottom of the crib is 7.3 m (24 ft) below grade (WHC-EP-0100, *Properties and Environmental Impact of Ammonia Scrubber Discharge Waste to the 216-A-36B Crib*). A 15 cm (6-in.) diameter perforated pipe was placed horizontally 7 m (23 ft) below grade. For a configuration diagram of the 216-A-36B Crib (showing both the "A" and "B" segments), refer to Figure 2-25 of the Work Plan (DOE/RL-2000-60).

The 216-A-36B Crib is the southern 152 m (500 ft) of a longer crib, originally known as the 216-A-36 Crib. The original crib received liquid effluent from September 1965 to March 1966. In 1966, the 216-A-36 Crib was reconfigured into two segments: 216-A-36A and 216-A-36B. Grout was injected into the gravel layer of the crib to form a barrier between the two segments. The 216-A-36B Crib was extended southward from the 216-A-36A Crib by inserting a smaller diameter pipeline inside the original pipeline, effectively moving the discharge point farther south into the 216-A-36B Crib and bypassing the 216-A-36A Crib. Discharge to the 216-A-36B Crib resumed in March 1966. Operations continued until October 1972, when the crib temporarily was removed from service. In May 1970, about 14,000 Ci were discharged to the crib from a leaking valve in the scrubber drain to the catch tank. The crib was placed back in service in November 1982 for the restart of the PUREX Plant and remained active until the spring of 1987.

During operational use, the 216-A-36B Crib received ASD waste, a state-only toxic dangerous waste (WT02) from the 202-A Building (RHO-CD-673). The ASD waste contained Am-241 (0.2 Ci), Co-60, Pu-239 (258 g), Sr-90 (1,310 Ci), tritium, Sn-113, I-129, Cs-137 (1,200 Ci), Pm-147, and U-238 (262 kg). Chemical ASD contaminants included ammonium fluoride, ammonium nitrate, and sodium dichromate. This resulted in the crib's designation as a RCRA TSD unit in the fall of 1987. A RCRA interim-status indicator parameter evaluation program has been in operation at the crib since May 1988. Use of the crib was discontinued in the spring of 1987, and the crib was backfilled (BHI-00121, *216-A-36B Crib Supplemental Information to the Hanford Facility Contingency Plan (DOE/RL-93-75)*). No stabilization actions have taken place at the waste site.

2.4.2.5.2 Characterization Activities

Boreholes C3248 and C4160 were drilled for characterization of the 216-A-36B Crib. Drilling commenced in Borehole C3248 on July 1, 2003, and met refusal at a depth of 8 m (26 ft) bgs, resulting in abandoning the attempt and decommissioning the borehole. Soil samples were taken to a depth of 7.3 m (24 ft) bgs before borehole decommissioning. Borehole C4160 was drilled from the ground surface to the water table at a depth of approximately 85 m (278 ft). Drilling of Borehole C4160 began July 2, 2003, and was completed September 9, 2003.

Geophysical logging (CP-18666, Appendix F) was performed between August 5 and September 2, 2003, for Borehole C4160 using the SGLS, HRLS, and NMLS.

Drill cuttings and soil samples collected from the borehole were screened in the field for indications of contamination. Samples were screened for volatile organic constituents, ammonia, TBP, beta-gamma activity, and alpha activity.

Thirty-two samples representing Boreholes C3248 and C4160 were sent for chemical and radiological analysis and determination of physical properties. Two were QC samples (equipment blanks) and the remainder (30) were soil samples obtained from the boreholes from 0.2 to 97.1 m (0.5 to 318.5 ft) bgs. Four of the soil samples were from Borehole C3248, and the remainder were from Borehole C4160. Sample collection was guided by the sample schedule in the Work Plan (DOE/RL-2000-60). Soil sample parameters are summarized in Table 2-4 of the RI Report (DOE/RL-2004-25). Data from geophysical logging activities are presented in the borehole summary report (CP-18666). Analytical results are presented in Appendices A and B of the RI Report and are discussed further in the following section.

2.4.2.5.3 Nature and Extent of Contamination

This section describes the nature and extent of contamination in the 216-A-36B Crib. Effluent discharged to the 216-A-36B Crib was ammonia scrubber waste from the PUREX Plant (DOE/RL-2000-60). When actively receiving effluent, the crib was about 7.6 m (25 ft) deep. Contamination was detected in the vadose zone beneath the 216-A-36B Crib in Borehole C4160 to a depth of 96.5 m (318.5 ft) bgs. Maximum radionuclide contaminant concentrations are present in the crib to a depth of 87.1 m (287.5 ft) bgs. A vertical profile plot of maximum detected contaminant concentrations for the 216-A-36B Crib is shown in Figure 2-11.

No radionuclide concentrations exceeded 1 pCi/g in shallow soils.

The following are maximum concentrations of primary waste stream radionuclides that were detected in deep soils at concentrations greater than 1 pCi/g:

- Am-241 — 40,000 pCi/g at 7.6 m (25 ft) bgs
- Bi-214 — 1.27 pCi/g at 16.3 m (53.5 ft) bgs

• C-14	116 pCi/g at 7.6 m (25 ft) bgs
• Cs-137	2,650,000 pCi/g at 7.6 m (25 ft) bgs
• Co-60	623 pCi/g at 7.6 m (25 ft) bgs
• Eu-154	1,800 pCi/g at 7.6 m (25 ft) bgs
• Pb-212	1.37 pCi/g at 16.3 m (53.5 ft) bgs
• Pb-214	1.23 pCi/g at 16.3 m (53.5 ft) bgs
• Ni-63	181,000 pCi/g at 7.6 m (25 ft) bgs
• Pu-239/240	98,000 pCi/g at 7.6 m (25 ft) bgs
• K-40	19.4 pCi/g at 16.3 m (53.5 ft) bgs
• Ra-226	1.27 pCi/g at 16.3 m (53.5 ft) bgs
• Ra-228	1.15 pCi/g at 16.3 m (53.5 ft) bgs
• Total radioactive strontium	208,000 pCi/g at 7.6 m (25 ft) bgs
• Tc-99	41.9 pCi/g at 7.6 m (25 ft) bgs
• Th-230	11.4 pCi/g at 9.2 m (30 ft) bgs
• Th-232	4.84 pCi/g at 7.6 m (25 ft) bgs
• Th-234	1.58 pCi/g at 89.1 m (292 ft) bgs
• Tritium	121 pCi/g at 87.7 m (287.5 ft) bgs
• U-233/234	81.2 pCi/g at 9.2 m (30 ft) bgs
• U-235	3.29 pCi/g at 7.6 m (25 ft) bgs
• U-236	4.54 pCi/g at 7.6 m (25 ft) bgs
• U-238	70.9 pCi/g at 7.6 m (25 ft) bgs.

Radioactive contaminants at the 216-A-36B Crib are markedly elevated at the 7.6 m (25-ft) bgs depth (i.e., base of the crib); the concentration decreases again at 12.1 m (40 ft) bgs. From 15.2 to 18.2 m (50 to 60 ft) bgs, the concentrations rise again. This pattern is true of Am-241, C-14, Co-60, Cs-137, Ni-63, Pu-239/240, Tc-99, Sr-90, and all uranium isotopes plus total uranium. This pattern is consistent with the conceptual contaminant distribution model in the Work Plan (DOE/RL-2000-60, Figure 3-16).

The high levels of Pu-239/240 and Am-241 in waste sample B17487 indicate the possibility that some of the soil from this crib might be designated as transuranic waste if removed.

Soil samples were collected in 1988 and reported in the Work Plan (DOE/RL-2000-60) and the 200-UW-1 FFS (DOE/RL-2003-23, *Focused Feasibility Study for the 200-UW-1 Operable Unit*) from Borehole 299-E17-55 (located in the crib). Radionuclides analyzed for were Cs-137, Co-60, Am-241, and U-235. The maximum concentrations of these radionuclides were at 9.2 m (30 ft) and closely correlate with current analytical sample data:

• Am-241	48,100 pCi/g at 9.2 m (30 ft) bgs
• Cs-137	3,280,000 pCi/g at 9.2 m (30 ft) bgs
• Co-60	1,025 pCi/g at 9.2 m (30 ft) bgs
• U-235	1,225 pCi/g at 9.2 m (30 ft) bgs.

The maximum concentrations for the nonradioactive contaminants detected in shallow soils are as follows:

- Silver 3.12 mg/kg at 3.8 m (12.5 ft) bgs
- Chromium (total) 8.85 mg/kg at 3.8 m (12.5 ft) bgs.

Pesticides and herbicides used to kill vegetation on the surface of the crib were tested for at 0.15 m (0.5 ft) bgs and were not detected.

The maximum concentrations of the nonradioactive contaminants detected in deep soils are as follows:

- Ammonia (as nitrogen) 58.2 mg/kg at 16.3 m (53.5 ft) bgs
- Chromium (total) 23.5 mg/kg at 60.2 m (197.5 ft) bgs
- Bismuth 91.4 mg/kg at 9.2 m (30 ft) bgs
- Nitrate (as nitrogen) 289 mg/kg at 16.3 m (53.5 ft) bgs
- Nitrate/nitrite (as nitrogen) 287 mg/kg at 16.3 m (53.5 ft) bgs
- Nitrite (as nitrogen) 18.8 mg/kg at 7.6 m (25 ft) bgs
- Total uranium 36.8 mg/kg at 9.2 m (30 ft) bgs
- Isophorone 0.50 mg/kg at 60.2 m (197.5 ft) bgs.

Ammonia (as nitrogen) was reported at 40 to 60 mg/kg at 16.2 m (53.5 ft) bgs as expected at sites receiving ammonia scrubber waste. Fluoride (from ammonium fluoride) did not exceed background for this site.

Soil samples collected in 1988 also were analyzed for a limited number of nonradioactive constituents from Borehole 299-E17-55 located inside the crib and from five boreholes (299-E17-14, 299-E17-15, 299-E17-16, 299-E17-17, and 299-E17-18) located adjacent to the crib. Sample results showed nitrate concentrations (as nitrogen) ranging between 0.021 and 9.40 mg/kg and maximum ammonia concentrations (as nitrogen) were 23.5 mg/kg, consistent for sites receiving ammonia scrubber waste.

Higher (approximately 50 mg/kg) nickel detects at 7.3 to 7.6 m (24 to 25 ft) bgs, which at this depth do not exceed groundwater protection screening levels, are surrounded by below-background detects of from 4 to 19 mg/kg. The high detects likely are related to the large amounts of Ni-63 in this region of the borehole. Besides nickel and uranium, no other metal shows the distinctive distribution pattern of contamination at 7.6 m (25 ft) bgs.

Geophysical logging (CP-18666, Appendix F) was performed for Borehole C4160 using the SGLS, HRLS, and NMLS. Cesium-137 and Co-60 were the only manmade radionuclides found in the borehole, and laboratory sample results correlate well for both constituents. SGLS data show a maximum concentration of 2,000,000 pCi/g at 8.2 m (27 ft) bgs, decreasing at greater depths as with the analytical data. The Co-60 was detected between 11.6 and 18.3 m (38 and 60 ft) bgs and sporadically to 35.4 m (116 ft) bgs. Also, SGLS logging of Borehole 299-E17-9, located within the adjoining 216-A-36A Crib, identified similar contamination distribution patterns in the 216-A-36A Crib.

Characterization data from scintillation logs collected from 1965 to 1977 from wells 299-E17-5, 299-E17-11, and 299-E17-51 show a vertical profile of gamma activity suggesting that contamination in the 216-A-36A Crib might extend to 73 m (240 ft) (DOE/RL-2000-60). Moisture logging as confirmed by laboratory sample data from Borehole C4160 shows areas of increased wetness at approximately 87.6 m (289 ft) bgs, 9.2 m (30 ft) above the water table, correlating with a higher Th-232 concentration and suggesting a less porous, clay-like material at this depth.

Geophysical logging results and previous (1988) soil sampling generally correlate well with analytical data confirming maximum concentration at 7.6 m (25 ft) bgs, decreasing at greater depths, and are consistent with the conceptual contaminant distribution model for the 216-A-36B Crib (see Figure 3-16 of the Work Plan [DOE/RL-2006-60]). The volume of effluent discharge and current groundwater monitoring data confirm the contaminant distribution model indicating that the 216-A-36B Crib impacted groundwater.

2.4.2.5.4 Potential for Groundwater Impact

The effluent volume (318,080 m^3) discharged at this site is almost 20 times the soil pore volume (16,327 m^3), indicating a high likelihood that this site impacted groundwater. Groundwater contamination in the vicinity of the 216-A-36B Crib is attributed to the crib as described in PNNL-13788. The report indicates that tritium, nitrate as nitrogen, I-129, Sr-90, and gross beta exceed the groundwater protection standards/guidelines in the vicinity of the crib.

High nitrate concentrations continue to be found near liquid waste-disposal facilities that received effluent from PUREX Plant operations, although overall nitrate concentrations generally are decreasing with time. The maximum nitrate concentration detected near the PUREX Plant in FY 2002 was 52.6 mg/L in well 299-E17-9, which is adjacent to the 216-A-36B Crib (PNNL-14187).

The maximum Sr-90 concentration detected in FY 2002 was 21 pCi/L in a well (299-E17-14) near the 216-A-36B Crib and generally has been rising in this well since 1997 (PNNL-14187).

During FY 2002, the water level in well 299-E17-9 near the 216-A-36B Crib dropped to a level too low for sampling. Substitute well 299-E17-16, located southeast of well 299-E17-9, does not intercept the groundwater contamination plumes in a location where concentrations are as high as the well 299-E17-9 location (PNNL-14187).

2.4.2.6 207-A South Retention Basin

This section describes the 207-A South Retention Basin, basin characterization activities, and the nature and extent of contamination found at the site.

2.4.2.6.1 Description

The 207-A-South Retention Basin (Figure 2-5) is one of two RCRA TSD units in the 200-PW-4 OU and is located in the 200 East Area directly east of the 242-A Evaporator. The 207-A South Retention Basin, also known as Process Condensate Basins 1, 2, and 3 (i.e., PC-1, PC-2, and PC-3), began operations in March 1977. The 207-A South Retention Basin consists of three concrete cells, each with a 264,979 L (70,000-gal) design capacity, for a total capacity of 794,937 L (210,000 gal). The bottom dimension of each cell is 16.8 m (55 ft) long, 3 m (10 ft) wide at the bottom, and 2.1 m (7 ft) deep. All three cells were coated to prevent constituents from penetrating the concrete. For a configuration diagram of the 207-A South Retention Basin, refer to Figure 2-26 of the Work Plan (DOE/RL-2000-60).

The 207-A South Retention Basin was used for the interim storage of the 242-A Evaporator process condensate to allow for sampling and analysis before the condensate was discharged to the 216-A-37-1 Crib for disposal to the soil column. Discharge of 242-A Evaporator process condensate to the 207-A South Retention Basin was terminated on April 12, 1989, when the 242-A Evaporator process condensate was determined to contain dangerous waste regulated under WAC 173-303. The waste was considered a dangerous waste, because the waste was derived from a waste containing spent halogenated and nonhalogenated solvents (Waste Codes F001, F002, F003, F004, and F005) and because of the toxicity of ammonia (WT02, state-only, toxic, dangerous waste). The basin was emptied and cleaned out in September 1989 and no longer is in use.

2.4.2.6.2 Characterization Activities

To collect soil boring and concrete samples, three push holes were made: C4113 in the west cell, C4114 in the middle cell, and C4115 in the east cell. C4114 (middle cell) and C4115 (east cell) were drilled using a combination of Guzzler[1] and hand-auger methods. At each sample interval, a hand auger was used to collect soil, and the Guzzler was used to advance the hole to the next interval, with the final interval at 3.8 to 4.1 m (12.5 to 13.5 ft) bgs. Geophysical logging data were not collected for the 207-A South Retention Basin, because this type of logging is not effective in the 4.2 m (14-ft) shallow push hole at this site. The conceptual contaminant distribution model for this site (DOE/RL-2000-60) indicates that contamination is unlikely to be present at about 4.5 m (15 ft) bgs, because the coated concrete effectively protected the soil from contamination.

Samples were collected from the concrete basin and elastomeric lining, borings of the soil beneath the lining to a depth of 4.2 m (14 ft) bgs, and composite samples of the soil (blowing) and the water (precipitation) from the basin used for waste-designation purposes, not site characterization. A total of 44 samples were sent for analysis, 4 of which were QC (equipment blanks). Soil and concrete samples were screened in the field for volatile organic constituents, ammonia, TBP, beta-gamma activity, and alpha activity.

Composite samples of residual soil and water runoff were taken from the east, middle, and west cells in the 207-A South Retention Basin and analyzed for a small suite of analytes: metals, gross alpha, gross beta, pH, a limited number of radionuclides, and total organic carbon. Risk-based screening for human health and ecological and residual radioactivity was not performed on the composites. Analytical results are in the RI Report (DOE/RL-2004-25, Appendix B).

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[1]Guzzler is a trademark of Guzzler Manufacturing, Inc., Streator, Illinois.

Nine concrete samples, three from each basin, were taken and submitted for analysis. The concrete samples were analyzed for parameters identified in the RI Report, Table 2-6. Organics analyzed for were related to the composition of the elastomer. These were not detected in the soil beneath the basin (RI Report).

A total of 29 soil samples were obtained from the boreholes in the 3 cells (east, middle, and west cells) from 0.3 to 4.1 m (1.0 to 13.5 ft) bgs for chemical and radiological analysis and determination of physical properties. Sample collection was guided by the sample schedule in the Work Plan (DOE/RL-2000-60). Soil sample parameters are summarized in Table 2-6 of the RI Report (DOE/RL-2004-25). Residual concentrations of pesticides and herbicides were tested at 0.3 to 0.6 m (1 to 2 ft) bgs. Data from characterization activities are presented in the borehole summary report (CP-18666). Analytical results are presented in Appendix A of the RI Report and are discussed further in the following section.

2.4.2.6.3 Nature and Extent of Contamination

This section describes the nature and extent of contamination in the 207-A South Retention Basin, which stored process condensate from the 242-A Evaporator containing mixed waste from spent halogenated and nonhalogenated solvents, and ammonia (DOE/RL-2000-60). For the 207-A South Retention Basin, a vertical profile plot of contaminants is shown in Figure 2-12.

Soil samples detected relatively little radionuclide contamination in the vadose zone beneath the 207-A South Retention Basin, consistent with the conceptual contaminant distribution model (DOE/RL 2000-60, Figure 3-17). Maximum contaminant concentrations are nearly all present in the top 1.8 m (6 ft) of the borehole, and concentrations are low at MDA.

Maximum concentrations of radiological and chemical contaminants are present in Borehole C4115 (east cell), except for Sr-90 having a maximum concentration at Borehole C4114 (middle cell) from 0.3 to 2.1 m (1 to 7 ft) bgs.

The following are maximum concentrations of primary waste stream radionuclides detected in shallow soils at concentrations greater than 1 pCi/g:

- Ac-228 — 1.10 pCi/g at 1.8 to 2.1 m (6 to 7 ft) bgs
- Cs-137 — 1.07 pCi/g at 0.3 to 0.6 m (1 to 2 ft) bgs
- Pb-212 — 1.18 pCi/g at 1.8 to 2.1 m (6 to 7 ft) bgs
- Ra-228 — 1.10 pCi/g at 1.8 to 2.1 m (6 to 7 ft) bgs
- Th-230 — 1.26 pCi/g at 0.3 to 0.6 m (1 to 2 ft) bgs
- Th-234 — 3.16 pCi/g at 0.6 to 1 m (2 to 3 ft) bgs
- Total radioactive strontium — 1.40 pCi/g at 0.3 to 0.6 m (1 to 2 ft) bgs
- Tritium — 16.6 pCi/g at 1.8 to 2.1 m (6 to 7 ft) bgs.

Also detected in site soils was Nb-94 at 0.032 pCi/g at 0.7 m (2.3 ft) bgs and Ra-226 at 0.859 pCi/g at 1.8 to 2.1 m (6 to 7 ft) bgs.

The following are maximum concentrations of nonradiological contaminants detected in shallow soils:

- Arsenic 9.98 mg/kg at 1.8 to 2.1 m (6 to 7 ft) bgs
- Butyl benzyl phthalate 110 µg/kg at 0.3 to 0.6 m (1 to 2 ft) bgs
- Nitrate/nitrite as nitrogen 20.9 mg/kg at 0.6 to 1 m (2 to 3 ft) bgs
- Silver 5.01 mg/kg at 1.8 to 2.1 m (6 to 7 ft) bgs
- 2,4-dichlorophenoxyacetic acid 7.1 µg/kg (Borehole C4115) at 0.3 to 0.6 m (1 to 2 ft) bgs
- 2-(2,4,5-trichlorophenoxy) propionic acid 3.3 µg/kg (Borehole C4114) at 0.3 to 0.6 m (1 to 2 ft) bgs.

Concrete sample results showed organics related to the composition of the elastomer and TBP in small amounts. However, none exceeded screening levels. The RI Report (DOE/RL-2004-25, Appendix B) contains the concrete analytical data. Sample parameters related to the elastomer basin lining (e.g., xylenes, all benzene derivatives, cresols, naphthalene and its derivatives, isopherone, other ketones) and fuel-related residuals (e.g., diesel, gasoline, motor oil, and octadecane) were not detected in the soil beneath the basin.

Separate composite samples of residual soil and water runoff were taken from the east, middle, and west cells in the 207-A South Retention Basin for waste-disposal purposes. Gross beta was found at 15 pCi/L in the water; gross alpha was found at 2 pCi/L. Total organic carbon was measured at 18.9 mg/L. Risk-based screening for human health and ecological impacts and residual radioactivity was not performed on the composites.

Analytical data confirm the conceptual contaminant distribution model for the 207-A South Retention Basin (DOE/RL-2000-60, Figure 3-17), indicating that contamination is unlikely to be present at more than about 4.5 m (15 ft) bgs, because the coated concrete effectively protected the soil from contamination.

2.4.2.6.4 Potential for Groundwater Impact

The basin was not a disposal unit. The basin was designed to hold liquids for disposal at the 216-A-37-1 Crib (DOE/RL-2000-60). Groundwater monitoring (PNNL-14187) is consistent with the conceptual contamination model and does not report exceedances of any groundwater parameters in wells near this waste site.

2.4.2.7 216-A-37-1 Crib

This section describes the 216-A-37-1 Crib, site characterization activities, and the nature and extent of contamination found at the site.

2.4.2.7.1 Description

The 216-A-37-1 Crib (Figure 2-5) is one of two RCRA TSD units in the 200-PW-4 OU. This site is located outside the 200 East Area perimeter fence about 610 m (2,000 ft) east of the 202-A Building. The gravel-filled crib has bottom dimensions of 213 m (700 ft) long and 3 m (10 ft) wide. A 25.4 m (10-in.) diameter galvanized steel distribution pipe was placed 2.1 m

(7 ft) below grade along the centerline of the crib. The pipe was covered with a gravel and sand cover before backfill was used to fill the crib to the surface elevation. A valve station is at the south end of the crib, and a vent is located at the north end. The valve station is inside the crib perimeter fence and has surface radiation warning signs and a light chain barricade. For a configuration diagram of the 216-A-37-1 Crib, refer to Chapter 2.0, Figure 2-27, of the Work Plan (DOE/RL-2000-60).

The 216-A-37-1 Crib began operation in March 1977 and was used to percolate the 242-A Evaporator process condensate to the soil column. The process design capacity of 327,000 L (86,400 gal) per day was based on the daily output of the 242-A Evaporator process condensate discharged to the crib. Discharge of the evaporator process condensate to the crib was terminated on April 12, 1989, when evaporator process condensate was determined potentially to be a mixed waste regulated under WAC 173-303. The crib is out of service and will be closed under interim status.

The site received 377,000,000 L (99,590,000 gal) of 242-A Evaporator process condensate, thought to contain Am-241, Cs-137, tritium, I-129, Pm-147, Pu-239, Ru-106, Sn-113, and Sr-90.

Wells 299-E25-19 and 299-E25-20 monitor this site and indicate an increasing and decreasing tritium activity, respectively. The nitrate concentration remains at two to five times the drinking water standards. A surface radiation survey, performed in 1991, did not detect contamination.

2.4.2.7.2 Characterization Activities

Drilling of Borehole C4106 commenced May 29, 2003, and was completed June 24, 2003. The borehole was drilled to a total depth of 84.8 m (278 ft) bgs, and the water table was found at 84.1 m (277.5 ft) bgs.

Geophysical logging was performed for this borehole using the SGLS and the NMLS between April 30 and May 12, 2003. Data and additional details from the 216-A-37-1 Crib characterization activities are presented in the borehole summary report (CP-18666, Appendix F) and in the RI Report (DOE/RL-2004-25).

Drill cuttings and soil samples collected from the borehole were screened in the field for volatile organic constituents, ammonia, TBP, beta-gamma activity, and alpha activity and to assist with determining discrete sample locations or depths, to support worker health and safety, and for sample shipping information.

Thirty samples were analyzed. Two were QC samples (equipment blanks), and the remainder (28) were obtained from borehole material from 0.2 to 83.1 m (0.5 to 272.5 ft) bgs for chemical and radiological analysis and determination of physical properties. Sample collection was guided by the sample schedule in the Work Plan (DOE/RL-2000-60). Soil sample parameters are summarized in Table 2-2 of the RI Report (DOE/RL-2004-25). Data from the characterization activities are presented in the borehole summary report (CP-18666). Analytical results are presented in Appendix A of the RI Report and discussed further in Section 2.5.

2.4.2.7.3 Nature and Extent of Contamination

This section describes the nature and extent of contamination in the 216-A-37-1 Crib. The 216-A-37-1 Crib received process condensate waste from the 242-A Evaporator, containing mixed waste from spent halogenated and nonhalogenated solvents and ammonia. When actively receiving effluent, the crib was about 2.4 to 4.3 m (8 to 14 ft) deep. For the 216-A-37-1 Crib, a vertical profile plot of maximum detected contaminant concentrations is shown in Figure 2-13.

Radionuclide contamination was detected in the vadose zone beneath the 216-A-37-1 Crib in Borehole C4106 to a depth of 83.1 m (272.5 ft) bgs. Maximum radionuclide concentrations are present from 3.8 to 14.4 m (12.5 to 47.5 ft) bgs.

The following are maximum concentrations for the primary waste stream radionuclides detected in shallow soils at concentrations greater than 1 pCi/g:

- Total radioactive strontium 1.70 pCi/g at 3.8 m (12.5 ft) bgs
- Tritium 134 pCi/g at 3.8 m (12.5 ft) bgs.

Cesium-137 also was detected in shallow soils at 0.113 pCi/g at 3.8 m (12.5 ft) bgs.

The following are maximum concentrations for primary waste stream radionuclides detected in deep soils at concentrations greater than 1 pCi/g:

- Ni-63 14.4 pCi/g at 11.4 m (35.5 ft) bgs
- K-40 9.15 pCi/g at 83.1 m (272.5 ft) bgs
- Total radioactive strontium 1.70 pCi/g at 3.8 m (12.5 ft) bgs
- Tritium 267 pCi/g at 14.5 m (47.5 ft) bgs.

The following are maximum concentrations for the nonradioactive contaminants detected in shallow soils:

- Barium 0.165 mg/kg at 3.8 m (12.5 ft) bgs
- Boron 0.510 mg/kg at 3.8 m (12.5 ft) bgs
- Acetone 0.013 mg/kg at 3.8 m (12.5 ft) bgs
- Bis(2-ethylhexyl)phthalate 2.1 mg/kg at 3.8 m (12.5 ft) bgs
- TBP 0.045 mg/kg at 3.8 m (12.5 ft) bgs.

Pesticides and herbicides used to kill vegetation on the surface of the crib were tested for at 0.15 m (0.5 ft) bgs and were not detected. The maximum ammonia (as nitrogen) concentration was 266 mg/kg at 3.8 m (12.5 ft) bgs, which does not exceed screening levels for shallow soils.

The following are maximum concentrations of the nonradioactive contaminants detected in deep soils:

- Aluminum 15,000 mg/kg at 22.1 m (72.5 ft) bgs
- Barium 0.193 mg/kg at 29.7 m (97.5 ft) bgs
- Cobalt 15.9 mg/kg at 22.1 m (72.5 ft) bgs
- Manganese 652 mg/kg at 22.1 m (72.5 ft) bgs

- Nitrate as nitrogen 385 mg/kg at 3.8 m (12.5 ft) bgs
- Nitrate/nitrite as nitrogen 489 mg/kg at 3.8 m (12.5 ft) bgs
- Thallium 1.54 mg/kg at 29.7 m (97.5 ft) bgs.

Geophysical logging was performed for Borehole C4106 using the SGLS and the NMLS. Cesium-137 was the only manmade radionuclide detected and was observed at the surface and again between 2.7 and 11.0 m (9 and 36 ft) bgs, at concentrations ranging from 0.2 to 30 pCi/g, with the maximum concentration measured at 3 m (10 ft) bgs (CP-18666, Appendix F). Geophysical logging also was performed in 2003 in wells 299-E25-17 (A6301), 299-E25-19 (A4765), and 299-E25-20 (A4767), and Cs-137 was the only manmade radionuclide detected in these locations also. Cesium-137 was detected sporadically and only at concentrations near the MDL (0.2 pCi/g), indicating low potential for lateral spread of contamination. Neutron moisture logging showed low moisture levels from 21.4 to 32.6 m (70 to 107 ft) bgs, consistent with analytical data reporting concentrations of Cs-137 near MDL at these depths.

Logging data compared relatively well with laboratory sample data. Sampling showed low levels for Cs-137 from Borehole C4106 with only two results above the MDA: one located at 3.8 m (12.5 ft) bgs at 0.113 pCi/g (MDA of 0.014) and the second located at 5.3 m (17.5 ft) bgs at 0.018 pCi/g (MDA of 0.012).

The conceptual contaminant distribution model for this site (DOE/RL 2000-60, Figure 3-18) indicates that high contamination might be expected from 3.3 to about 9.2 m (11 to 30 ft) and medium contamination might be expected from 9.1 to about 12.1 m (30 to 40 ft) bgs. The characterization data correlate well with this model. Laboratory data, the volume of effluent discharged, and groundwater monitoring data confirm the conceptual contaminant distribution model (DOE/RL-2000-60, Figure 3-18), identifying the likelihood that the 216-A-37-1 Crib impacted groundwater.

2.4.2.7.4 Potential for Groundwater Impact

The effluent volume discharged (377,011 m^3) at this site is almost 24 times the soil column pore volume (15,879 m^3) beneath the crib. These data indicate that this site could have impacted groundwater. The status of groundwater contamination at the crib is described in PNNL-13788. The report indicates that there are two plumes (I-129 and tritium) near the crib (DOE/RL-2000-60). PNNL-14187 does not report exceedances of any groundwater parameters in wells associated with this waste site.

2.5 EVALUATION OF ANALOGOUS WASTE SITES

This section identifies the rationale used for alignment of representative and analogous 200-PW-2 and 200-PW-4 OU waste sites and presents the analogous site groupings.

The 200-PW-2 and 200-PW-4 OUs represent 2 of the 23 process-based Waste Site Grouping OUs in the 200 Areas. The Implementation Plan (DOE/RL-98-28) initially selected four sites of the 200-PW-2 OU (216-A-19 Trench, 216-B-12 Crib, 216-U-8 Crib and 216-U-12 Crib [RCRA TSD unit]) and two sites of the 200-PW-4 OU (216-A-37-1 Crib and 207-A South Retention

Basin [both RCRA TSD units]) for characterization. These sites were selected as being representative or otherwise presenting bounding conditions for the remaining, uncharacterized sites. The 216-U-8 Crib and 216-U-12 Crib, which initially were 200-PW-2 OU sites, subsequently were reassigned to the 200-UW-1 OU and were replaced with the 216-A-10 and 216-A-36B Cribs, both of which are RCRA TSD units. The list of 200-PW-4 OU representative waste sites has not changed. The findings from representative waste site investigations are extended to apply to remaining sites in the waste group (analogous sites), taking into account site similarities including waste stream, discharge history, geology, and available characterization data. This approach reduces the amount of characterization and evaluation required to support remedial action decision-making and facilitates earlier remedy selection and cleanup. Confirmatory sampling of the analogous sites after remedy selection may be required and will be built into the remedial design planning to demonstrate that analogous conditions exist.

2.5.1 Rationale for Assignment of Representative and Analogous Waste Sites

The rationale used to align potential analogous waste sites to the representative waste sites compares important characteristics of representative and potential analogous sites, including the following:

- Waste stream received
- Volume of effluent received in relation to the available pore volume for the waste site
- Types and amounts of contaminants received; contaminant inventory
- Waste site size
- Waste site configuration and construction (e.g., crib, trench, UPR)
- Expected distribution of contaminants/nature and extent of contamination
- Neighboring waste sites, structures, or utilities
- Geologic setting
- Potential for hydrologic and contaminant impacts to groundwater.

Figure 2-14 shows the process for evaluating the analogous sites against the representative waste sites from the risk assessment through confirmatory sample design. For each analogous site, the following criteria and site characteristics were used to identify the representative waste site as a similar or as a bounding condition.

1. *Configuration* criteria compare the representative and analogous waste site construction, size, and depth.

2. *Waste stream origin* identifies the source facility and compares representative and analogous waste site overall volume of effluent received.

3. *Contaminant inventory* compares the type and quantity of contaminants received and potentially remaining at the waste site.

4. *Geology* compares the location of the representative and analogous waste sites with regard to Hanford Site area location (200 East or 200 West Area) and proximity.

5. *Extent of contamination* compares the representative waste site depth of discharge with the analogous site anticipated depth of discharge, given effluent volume as a hydraulic driver, duration of operations, contaminant mobility, and volume of effluent relative to soil-pore volume.

6. *Impact to groundwater* compares potential groundwater impact of the representative to the analogous waste site with regard to volume of effluent received, effluent discharged relative to soil-pore-volume ratio, overall contaminant inventory, and/or current groundwater monitoring or modeling information.

Table 2-2 identifies the analogous sites aligned with each representative waste site and information supporting the alignment rationale.

2.5.2 Analogous Site Groupings

This section summarizes the rationale for alignment of representative and analogous waste sites as detailed in Table 2-2. The 216-A-37-1 Crib is listed on Table 2-2 as a standalone site (i.e., represents no analogous site) and was characterized for purposes of RCRA TSD unit closure (Section 2.4).

2.5.2.1 216-A-19 Trench and Analogous Waste Sites

The 216-A-19 Trench is a representative waste site for the following analogous sites:

- 216-A-18 Trench
- 216-A-20 Trench
- 216-S-8 Trench
- 216-A-1 Crib
- 216-A-3 Crib
- 216-A-34 Ditch
- 216-A-22 French Drain
- 216-A-28 Crib
- UPR-200-E-17
- UPR-200-E-145

216-A-18 Trench, 216-A-20 Trench, and 216-S-8 Trench. The three analogous trenches (216-A-18, 216-A-20, and 216-S-8) are all unlined trenches, although their sizes vary (i.e., 216-A-18 Trench is larger and the 216-S-8 Trench is larger and deeper). They received the same or similar waste streams over a short operating period (i.e., during PUREX and REDOX startup activities), having uranium as the primary contaminant and some fission products. These sites received similar or smaller quantities of the primarily and more mobile contaminants uranium and nitrates and similar quantities of Cs-137 and Sr-90 than the representative waste site. The 216-A-18 and 216-A-20 Trenches are located in the 200 East Area, as is the representative waste site and, although the 216-S-8 Trench is located in the 200 West Area, their geologies should be sufficiently similar for an analogous determination. As unlined trenches, the depth of waste discharge for all is expected to be similar or bounded by the 216-A-19 Trench, which generally received greater effluent overall or greater effluent relative to size and pore volume and contains greater or equal inventories of the primary radionuclide uranium, and nitrate. These sites had little potential to have impacted groundwater.

216-A-1 Crib and 216-A-3 Crib. The analogous cribs, 216-A-1 Crib and 216-A-3 Crib, also are unlined disposal sites of the same approximate size and depth, but are specific retention cribs, not trenches. The contaminant inventory of primary waste stream radionuclides generally is less or only slightly greater than the representative waste site (e.g., uranium was less, plutonium was slightly higher, less or no nitrates). These sites also are located in the vicinity of PUREX in the 200 East Area, and their geology is similar. The contamination distribution should be similar and should correlate with the conceptual contaminant distribution model, because both received similar contaminants at low volumes relative to soil-pore volume, and the major zone of contamination will be near the trench bottom. These sites also have little likelihood to have impacted groundwater, because the 216-A-1 Crib effluent discharge volume is well below pore volume and the 216-A-3 Crib, although exceeding soil-pore-volume ratio at this site, had a lower contaminant inventory of mobile contaminants (i.e., more mobile nitrates were not discharged to this site in significant quantities).

216-A-34 Ditch. The analogous 216-A-34 Ditch also is a long, narrow unlined excavation that is shallower (1.8 m vs. 4.6 m [6 ft vs. 15 ft]) than the representative waste site. Both sites received PUREX waste streams. This site received the lower activity contact condenser waste and had no reportable contaminant inventory, whereas the 216-A-19 Trench received PUREX startup waste containing a significant inventory of radionuclide contaminants. Both are colocated in the 200 East Area and have the same geology. The extent of contamination is bounded by the 216-A-19 Trench, because this site is shallower and likely received less effluent, having a significantly lower activity level. This site has no reasonable potential to have contaminated groundwater.

216-A-22 French Drain and 216-A-28 Crib. The analogous 216-A-22 French Drain and 216-A-28 Crib also are unlined excavations that are smaller than the representative waste site and are shallower or essentially the same depth as the 216-A-19 Trench. Both sites also received liquid waste from PUREX operations containing primarily uranium, but the effluent volume and contaminant inventory are smaller in comparison to that received by normal process waste-disposal sites such as the 216-A-19 Trench. Uranium and nitrate inventories were identified for the 216-A-28 Crib. However, no contaminant inventory was developed for the 216-A-22 French Drain. These sites are located near PUREX in the 200 East Area and have similar geology. Both sites received far less effluent relative to pore volume and, with no reported inventory of other radionuclides other than uranium, these drains have no reasonable potential to have impacted groundwater.

UPR-200-E-17 and UPR-200-E-145. Analogous waste sites UPR-200-E-17 and UPR-200-E-145 are surface spills that can be equated to discharges to bare soil although accidental, limited in volume, and not purposeful disposal. These are smaller and shallower areas contaminated by spills of liquid waste from PUREX operations that contained uranium and no significant quantities of other radionuclides. No volume of effluent or contaminant inventory has been assigned to these releases. It is unlikely that contaminant distribution at these sites is nearly as extensive as the 216-A-19 Trench. Both UPR sites are located in the same portion of the 200 East Area, and their geology is the same. As UPRs and not engineered disposal sites, these sites received essentially only uranium oxide and much less effluent than the 216-A19 Trench and are bounded regarding the extent of contamination. These sites have no reasonable potential to have contaminated groundwater.

2.5.2.2 216-B-12 Crib and Analogous Waste Sites

The 216-B-12 Crib is a representative waste site for the following analogous sites:

- 216-B-60 Crib
- 216-C-3 Crib
- 216-C-5 Crib
- 216-C-7 Crib
- 216-C-10 Crib
- 270-E-1 (Neutralization Tank)
- 209-E-WS-3 (Valve Pit and Hold-Up Tank)
- UPR-200-E-64

216-B-60 Crib, 216-C-3 Crib, 216-C-5 Crib, 216-C-7 Crib, and 216-C-10 Crib. The analogous 216-B-60, 216-C-3, 216-C-5, 216-C-7, and 216-C-10 Cribs are all drain-field-type cribs, except the 216-B-60 Crib, which is round steel caissons. Although constructed differently than the 216-B-12 Crib box construction, all discharged to soil. All are generally smaller and/or shallower. These sites received PUREX waste streams containing the same primary radionuclides at significantly lower inventories and making the representative waste site a bounding condition. All sites received 201-C Building process condensate from C Plant operations involving REDOX and PUREX startup waste, except that the 216-B-60 Crib was used for a single cell drain residual cleanout campaign and all received significantly less effluent. These sites all are located in the west portion of the 200 East Area, and their geology is similar. These sites have smaller effluent volume and a smaller effluent to pore volume ratio. Contrary to the representative waste site that likely impacted groundwater, these sites had little potential to have impacted groundwater.

270-E-1 Neutralization Tank and 209-E-WS-3 Valve Pit and Hold-Up Tank. The analogous 270-E-1 and 209-E-WS-3 sites are both metal neutralization and waste storage tanks (with 209-E-WS-3 also having an associated concrete valve pit), as opposed to being unlined disposal sites. Both tanks acted as a conduit to their respective disposal sites, the 216-B-12 Crib and the 216-C-7 Crib, respectively. As waste conduits with no known history of leaks, the effluent volume received is inconsequential, and the sites have no developed soil column contaminant inventory. These tanks potentially contain residues and residual waste that could not drain from the tank during normal operations. Because such residual waste and waste released from the tank, if any, would be shallower, of much smaller quantity, and would contain similar constituents, the 216-B-12 Crib is bounding for these tanks (and tank removal areas) for extent of contamination. Both sites are in the 200 East Area, and their geology is the same and generally not a consideration. Without a known history of spills or reported contaminant inventory, neither has any reasonable potential to have impacted groundwater.

UPR-200-E-64. The analogous UPR-200-E-64 waste site is a near-surface speck contamination (not a disposal structure) that, although it is larger in surface area, is shallower (now 0.6 m [2 ft] deep since the site was stabilized) than the representative waste site. This site did not receive effluent but instead received the same waste constituents in the form of contaminated residues tracked to the surface by ants and then spread by wind, accounting for the current site size. As near-surface (0.6 to 1 m [2 to 3 ft] deep) speck contamination, the contaminant inventory is minimal, shallow, and bound by the 216-B-12 Crib. This site also is located in the 200 East Area, making their geology similar. This speck contamination area has no potential to have impacted groundwater.

2.5.2.3 216-A-36B Crib and Analogous Waste Sites

The 216-A-36B Crib is a representative waste site for the 216-A-36A Crib and UPR-200-E-39.

216-A-36A Crib. The analogous 216-A-36A Crib physically adjoins the 216-A-36B Crib and is similar in construction, waste stream received, contaminant inventory, effluent volume received, and potential to have impacted groundwater. The CERCLA action will address the 216-A-36A and 216-A-36B Cribs as a single site. This site also is anticipated to have similarly high levels of Pu-239/240 and Am-241, suggesting the possibility that some of the soil from this crib also has a potential to designate as transuranic waste upon removal. As essentially twin sites, both sites have a similarly high likelihood of having impacted groundwater, based on high effluent volume, high effluent volume relative to soil-pore volume, and the existence of moderately to highly mobile contaminants in the waste stream (uranium, Sr-90, and nitrates).

UPR-200-E-39. Analogous site UPR-200-E-39 also is a discharge to soil but was a single accidental discharge primarily to blacktop that was then hosed down to adjacent gravel. It constituted a much smaller area (63 m^2 [676 ft^2]) of contamination than the representative waste site and is shallower, because the quantity of contaminants spilled to the soil relative to the disposal site was insignificant. A conservative assumption is that contamination penetrated the soil column to a depth of 1 m (3 ft) (given that contaminant transport only would be driven by natural precipitation). The waste stream also is the same waste discharged to the 216-A-36B Crib but, as a one-time accidental release from sample equipment, it would be much smaller in volume and diluted by the response action (hose-down of the asphalt pad). Both sites are in the 200 East Area, and the geology at these locations is similar. The extent of contamination is bounded by the representative waste site crib, and this site has no reasonable potential to affect groundwater.

2.5.2.4 216-A-10 Crib and Analogous Waste Sites

The 216-A-10 Crib is a representative waste site for the following analogous sites.

- 216-C-1 Crib
- 216-A-5 Crib
- 216-A-45 Crib
- 200-E-58 (Neutralization Tank)

216-C-1 Crib, 216-A-5 Crib, and 216-A-45 Crib. The analogous 216-C-1, 216-A-5, and 216-A-45 Cribs are all gravel-bottomed, drain-field-type cribs that are generally smaller and are shallower or of similar depth (216-A-45 Crib). All of these sites received the same PUREX 202-A Building process condensate, consisting of acidic process waste containing uranium and fission products, except that all sites received significantly less effluent and essentially equivalent or smaller inventories of the same primary radionuclides and nitrate. These sites are all located in the 200 East Area and have similar geology. Effluent quantities exceeded site pore volume at all sites, with the 216-A-5 and 216-C-1 Cribs significantly overwhelming their respective soil-pore volumes and containing significant quantities of mobile contaminants, which suggests a high potential for these sites to have impacted groundwater. The 216-A-45 Crib received significantly less effluent volume that only slightly exceeded soil-pore capacity and had a low inventory of the more mobile contaminants uranium and nitrate, suggesting a lower potential to have impacted groundwater.

200-E-58 Neutralization Tank. The analogous 200-E-58 Neutralization Tank is a buried metal waste tank that acted as a conduit for waste going to the 216-A-10 Crib and was not an unlined subsurface liquid waste-disposal site. At approximately 4.9 m (16 ft) deep, this site is 6 m (20 ft) shallower than the representative waste site crib and is much smaller. The tank received the same 202-A Building (PUREX Plant) waste that went to the 216-A-10 Crib. The tank was only a waste conduit with no known history of spills, and so it has no identified contaminant inventory, the tank site waste inventory being limited to waste that could not drain from the tank under normal operating conditions and waste residues on internal tank surfaces. Both sites are located in the 200 East Area, and the geology of the two locations is the same. There is no known history of spills but, if any, they would be smaller and shallower than the representative disposal site and would be so limited in nature that no reasonable potential exists for groundwater contamination from this tank.

2.5.2.5 207-A South Retention Basin

The 207-A South Retention Basin is a representative waste site for the 200-W-22 stabilization area (also known as 203-S/205-S Stabilized area).

200-W-22. The analogous 200-W-22 waste site also is an underground radioactive material area, having contaminated below-grade concrete structures with associated buried pipelines, although this site contains substantially more buried materials. The buried site materials are anticipated to be contaminated with residues of constituents from the REDOX UNH processing facilities, primarily uranium and low levels of incidental fission products. The representative basins contain waste from the 242-A Evaporator, which processed DST waste containing UNH process contaminants. As storage and processing facilities, neither site has a developed contaminant inventory. This site is located in the 200 West Area, and the 207-A South Retention Basin is located in the 200 East Area. However, because contamination from structures at both sites is expected to be shallow (upper 3 m [10 ft]), and the geology for the 200 East and 200 West Areas is essentially the same in the upper 3 m (10 ft), the geology for these sites is similar. Because substantial migration of waste residues on buried structures is not anticipated, neither site has any reasonable potential to have impacted groundwater.

2.5.2.6 216-S-7 Crib and Analogous Waste Sites

The 216-S-7 Crib is a representative waste site for the following analogous sites:

- 216-S-1&2 Cribs
- 216-S-22 Crib
- 216-S-23 Crib
- UPR-200-W-36
- 216-S-4 French Drain
- 216-T-20 Trench

216-S-1&2 Cribs, 216-S-22 Crib, and 216-S-23 Crib. The analogous 216-S-1&2, 216-S-22, and 216-S-23 Cribs are all retention cribs that are smaller and either shallower (216-S-22 Crib) or only somewhat deeper (216-S-1&2 and 216-S-23 Cribs) than the representative waste site. All sites received REDOX process condensate waste (216-S-1&2 and 216-S-23 Cribs received 202-S cell drainage), and the 216-S-22 Crib received 293-S Building waste but in significantly less volume. All sites received REDOX waste streams having the same primary radionuclides and chemicals (nitrates and sodium). All of these sites received significantly lower volume of effluent, have smaller soil contaminant inventories (except for 216-S-1&2 Cribs, which contain more plutonium and Cs-137, but less uranium, Sr-90, and nitrates), and contain less of the more mobile contaminants (uranium, Sr-90, and nitrates). All either exceeded pore volume to a lesser degree (216-S-1&2 Cribs and 126-S-23 Crib) or did not exceed site pore volume (216-S-22 Crib). These sites all are essentially colocated in the 200 West Area, making their geology similar. The 216-S-1&2 Cribs likely impacted groundwater, given that the effluent discharge to this site exceeded its pore volume significantly and directly discharged to groundwater (UPR-200-W-36). The 216-S-23 Crib had a more limited potential to have impacted groundwater, given the relatively low volume of effluent received, the low effluent to pore volume ratio, the predominance of low mobility contaminants in the waste stream, and the low quantity or absence of high-mobility contaminants in the waste stream (e.g., uranium and nitrates). The 216-S-22 Crib likely did not impact groundwater, given the very low volume of effluent received, the low effluent discharged relative to pore volume ratio, and the low contaminant inventory.

UPR-200-W-36. The analogous UPR-200-W-36 site is a failed groundwater monitoring well casing located within and at the east end of the 216-S-1&2 Cribs that sent crib waste directly to groundwater. The contamination is expected to be limited to the failed well casing and affected groundwater. The site has no developed contaminant inventory. This site received the same waste stream as the 216-S-1&2 Cribs, which also is bounded by the 216-S-7 Crib. Although the volume of effluent discharged is unknown, it is known that the effluent went directly to groundwater and, therefore, this site impacted groundwater.

216-S-4 French Drain. The analogous 216-S-4 French Drain is a site for liquid waste disposal to the soil column that is 6 m (20 ft) deep, but this site is much smaller than the representative waste site. This site also received REDOX-related waste, so waste stream constituents potentially are the same, but the volume of waste received at this site is so low that a contaminant inventory was not established. Both sites also are located in the 200 West Area, and their geology is similar. Although this site is the same depth, and the effluent volume exceeded its pore volume, the site received far less effluent overall and has a smaller effluent to pore volume ratio, suggesting that this site likely did not impact groundwater.

216-T-20 Trench. The analogous 216-T-20 Trench also is an unlined disposal site but is much smaller and shallower and was a single-use pit. Although 216-T-20 Trench waste was from the T Plant, and the 216-S-7 Crib waste was from the S Plant (REDOX), both plants at this time were using the same bismuth/phosphate plutonium separation process, so the waste is expected to be similar. As a single-use pit, the site received a significantly smaller quantity of effluent. Both sites received nitrates and the same primary radionuclides (except plutonium), but this site received these constituents in much smaller quantities. This site is likely to have received plutonium but in such small quantities that a contaminant inventory was not established. Both sites are located in the 200 West Area, and their geology is similar. The extent of contaminant distribution is bounded by the representative waste site and, because of the much smaller size and depth (4 ft vs. 20 ft deep), the small relative quantity of waste received, and the low effluent volume, this site had no potential to impact groundwater.

2.6 SUMMARY OF RISK ASSESSMENT

The baseline human-health risk assessment (HHRA) evaluated potential adverse health effects from nonradiological and radiological contaminants in representative waste site soils. The representative waste sites include the 216-A-19 Trench, 216-B-12 Crib, 216-S-7 Crib, 216-A-10 Crib (TSD) and 216-A-36B Crib (TSD) of the 200-PW-2 OU and the 216-A-37-1 Crib (TSD) and 207-A South Retention Basin (TSD) of the 200-PW-4 OU. The HHRA identified risk to human receptors, ecological receptors, and groundwater. An evaluation of potential risk to intruders also was evaluated. A Native American scenario was not considered, because the land use inside the 200-PW-2 and 200-PW-4 OUs industrial (exclusive) zone does not include a subsistence scenario.

The HHRA identified COPCs that could pose unacceptable risk and/or dose consequences and that therefore require consideration by the FS. The OU COPCs for the RI characterization sampling activity were identified in the Work Plan (DOE/RL-2000-60, Table 3-7 for the 200-PW-2 OU and Table 3-8 for the 200-PW-4 OU). The stated scope of this risk assessment process, as indicated in the RI Report, was to identify from this list of constituents only those COPCs that the FS process will further refine down to a list of COCs. Analytical data used in the assessment include shallow and deep-zone soil geophysical logging and sample results. Analytical data were screened to identify COPCs in accordance with EPA, DOE, and Ecology guidance. The COPCs that exceeded the risk-based screening levels, unless information is available justifying their elimination, are considered COCs requiring a remedial decision. The risk assessment results support detailed and comparative analysis of remedial alternatives (Chapters 6.0 and 7.0) and remedial alternative recommendations (Chapter 8.0) for the COCs.

The following is a summary of these assessments and their use in the FS.

Risk Scenario or Element	FS Application*	Discussion Section	Comments
Human-health assessment (industrial land-use scenario)	Supports setting cleanup levels	2.6.2	Conceptual exposure model formulated for shallow-zone soils, 0 to 4.6 m (0 to 15 ft)
Ecological assessment	Identifies risk to terrestrial wildlife receptors and associated mitigating actions to support remedial decision making	2.6.3	Screening-level ecological risk assessment performed. Compares contaminants in shallow-zone soils, 0 to 4.6 m (0 to 15 ft) with concentration protective of terrestrial populations
Groundwater protection assessment	Identifies risks to groundwater from soil contaminants and soil cleanup levels protective of groundwater to support remedial decision making	2.6.4	Screening-level and detailed analysis performed (if indicated by screening-level analysis) for deep-zone soils (zero to water table)
Intruder scenario	Identifies risk to an inadvertent intruder, given failure of institutional controls to support decision making	2.6.5	Risk to a future (150 years from present) potential intruder are calculated

*Klein, K. A., D. R. Einan, and M. A. Wilson, 2002, "Consensus Advice #132: Exposure Scenarios Task Force on the 200 Area," and HAB 2002, *Report of the Exposure Scenarios Task Force.*

The risk-screening processes, criteria, and initial risk assessment screening results are detailed in the RI Report (DOE/RL-2004-25) and summarized in Appendices D and A (216-S-7 Crib) of this FS. Further evaluation of contaminants carried forward to the FS from the RI Report (Table 4-39 and Table 6-1) as COPCs is contained in Sections 2.6 and 2.7 and Appendix E of this FS. The final list of COCs is presented in Table 3-1.

For purposes of risk evaluation, a contaminant exposure scenario requires a complete exposure pathway. For the pathway to be complete, a contaminant source; mechanism for contaminant release and transport; exposure point (location where receptor would come in contact with contaminant); exposure route (receptor exposure method); and a receptor (exposed population) are required. In the absence of any one of these components, an exposure pathway is considered incomplete and, by definition, no risk or hazard exists. The conceptual exposure model for the waste sites is presented in Figure 2-15.

As a portion of the exposure pathway, the risk assessment process considered points of compliance (POC) for human and ecological receptors as the location within the site where a particular receptor could be exposed to contaminants. For the human health and ecological risk assessment, the POC is shallow-zone soils (0 to 4.6 m [0 to 15 ft] bgs) (WAC 173-340-740(6)(d), "Unrestricted Land Use Soil Cleanup Standards," "Point of Compliance") from which sample data are collected and evaluated. This is considered a reasonable depth of soil that would be excavated and disturbed as a result of development activities and is deeper than the maximum depth of intrusion by biota. For the groundwater protection and intruder assessment, the POC is deep-zone soils, defined as soils from throughout the site (i.e., surface to groundwater table) (WAC 173-340-740(6)(e)).

2.6.1 Tri-Parties Framework

The Tri-Parties (DOE, EPA, and Ecology) developed a framework for risk assessments in the 200 Areas Central Plateau. This process included a series of workshops with representatives from the Tri-Parties, Hanford Advisory Board (HAB), Tribal Nations, the State of Oregon, and other interested stakeholders. The workshops focused on the different programs involved in activities in the 200 Areas Central Plateau and the need for a consistent application of risk assessment assumptions and goals. The results of the risk framework are documented in HAB 132, "Exposure Scenarios Task Force on the 200 Area"; in the Tri-Parties response to the HAB advice (Klein et al. 2002, "Consensus Advice #132: Exposure Scenarios Task Force on the 200 Area"); and in the *Report of the Exposure Scenarios Task Force* (HAB 2002). The following items provide the risk framework description from the Tri-Parties' response to the HAB, which serves as a basis for RI risk assessment activities.

- The Core Zone (200 Areas including the B Pond [main pond] and S Ponds) will have an industrial (exclusive) land use for the foreseeable future.

- The Core Zone will be remediated and closed, allowing for "other uses" consistent with an industrial scenario (environmental industries) that will maintain active human presence in this area, which in turn will enhance the ability to maintain the institutional knowledge of wastes left in place for future generations. Exposure scenarios used for this zone should include a reasonable maximum exposure to a worker/day user, to possible Native American users, and to intruders.

- The DOE will follow the required regulatory processes for groundwater remediation (including public participation) to establish the points of compliance and RAOs. It is anticipated that groundwater contamination under the Core Zone will preclude beneficial use for the foreseeable future, which is at least the period of waste management and institutional controls (150 years). It is assumed that the tritium and I-129 plumes beyond the Core Zone boundary will exceed the drinking water standards for the period of the next 150 to 300 years (less for the tritium plume). It is expected that other groundwater contaminants will remain below, or will be restored to, drinking water levels outside this zone.

- No drilling for water use or otherwise will be allowed in the Core Zone. An intruder scenario will be calculated for assessing the risk to human health and the environment.

- Waste sites outside the Core Zone, but within the Central Plateau (200N, Gable Mountain Pond, B/C Crib Controlled Area), will be remediated and closed based on an evaluation of multiple land-use scenarios to optimize land use, institutional control cost, and long-term stewardship.

- An industrial land-use scenario will set cleanup levels on the Central Plateau. Other scenarios (e.g., residential, recreational) may be used for comparison purposes to support decision making, especially for:
  - The post-institutional controls period (>150 years)
  - Sites near the Core Zone perimeter, to analyze opportunities to "shrink the site"
  - Early (precedent-setting) closure/remediation decisions
- This framework does not address the tank retrieval decision.

2.6.2 Human-Health Risk Assessment

This section summarizes the HHRA (direct-contact) results for chemical and radiological constituents at each representative waste site. Based on the current understanding of land-use conditions in the vicinity of these sites, the most plausible exposure pathway for characterizing human-health risks is the industrial land-use scenario. The industrial land-use scenario is the baseline for evaluation in this FS as agreed by the Tri-Parties. Because of the risk framework assumption of an industrial-use scenario (Section 2.6.1, item 1), only the shallow-zone soil, from 0 to 4.6 m (0 to 15 ft) bgs was considered in the assessment for direct exposure of chemical and radiological constituents. Chemical and radiological contaminants require separate methods for risk assessment.

The general methodology for the nonradiological risk assessment is to compare the soil concentrations to risk-based concentrations (RBC). Nonradiological constituents consider exposure through the direct-contact pathway (incidental soil ingestion and dermal contact) inhalation of dust and vapors in ambient air and do not assume use of groundwater for drinking water purposes. Nonradiological soil concentrations are compared to RBCs that are equivalent to a maximum excess lifetime cancer risk (ELCR) of 10^{-5} for carcinogens and/or hazard quotient (HQ) of 1.0 for noncarcinogens. RBCs exist for direct exposure to soil and for exposure to suspended soil particles in the air. Exposure assumptions and methodology used for developing the WAC 173-340 Method C RBCs for direct contact with soil and for inhalation of dust and vapors under the industrial land-use scenarios are provided in WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties" and WAC 173-340-750, "Cleanup Standards to Protect Air Quality," respectively. Risk assessment screening used RBCs calculated by Ecology based on the WAC 173-340 methodology and reported in Ecology 94-145, *Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation; CLARC, Version 3.1* (CLARC). For some constituents with available toxicity information but not listed in CLARC, RBCs were calculated based on methodology provided in WAC 173-340-745.

Radiological concentrations are modeled with a computer code to determine radiation dose and ELCR based on industrial land use. The risk assessment for radiological constituents was performed using the RESidual RADioactivity code (RESRAD) Version 6.21 analysis (ANL 2002, *RESRAD for Windows*). This modeling obtained risk and dose estimates from direct-contact exposure to radiological constituents present in the shallow zone. RESRAD inputs include OU-specific data collected during the RI; state and Hanford Site-specific data from other sources; EPA risk assessment guidance (EPA/540/R-92/003, *Risk Assessment Guidance for Superfund: Volume I -- Human Health Evaluation Manual (Part B. Development of Risk-Based*

Preliminary Remediation Goals), Interim, Publication 9285.7-01B; and RESRAD defaults. The industrial-use scenario assumes exposure from external gamma radiation, inhalation, and soil-ingestion pathways. The dose and risk limit suggested by EPA for guiding radiological cleanup is 15 mrem/yr, which generally equates to an estimated ELCR of 1 x 10^{-4}. For comparative purposes, the risk and dose estimates are based on exposure times of 50 years (length of time the DOE will have an on-site presence) and 150 years (estimated time that institutional controls will remain effective).

Groundwater at the waste sites is not used for drinking water purposes in the industrial land-use scenario. However, RAOs (Chapter 3.0) require no further degradation of groundwater. Consequently, the potential for contaminants to migrate from soil to groundwater was evaluated. Soil contamination impacts to groundwater are calculated assuming groundwater ingestion and equate to achievement of the Federal drinking water standards (MCLs). The groundwater protection assessment is documented separately in Section 2.6.4.

Exposure estimates for current and future industrial workers to nonradionuclides and to radionuclides at the representative waste sites are based on assumptions and input parameters documented in Appendix D, Table D-3 of this FS for nonradionuclides and Tables D-6 and D-7 (216-S-7 Crib) for radionuclides.

2.6.2.1 Human-Health Assessment Results for Nonradionclides

For comparison to WAC 173-340-745 Method C direct-contact soil risk-based cleanup levels, the maximum COPC concentrations from shallow-zone soils were used. For all seven waste sites, the maximum concentrations of all constituents in shallow soil are below their respective industrial site soil RBCs. Detailed screening results are provided in Appendix D, Table D-4.

For comparison against ambient-air risk-based standards, inhalation of dust, or organic vapors, the maximum concentrations in shallow-zone soils were compared to WAC 173-340-750 Method C ambient-air cleanup levels for the industrial exposure scenario. The maximum soil concentrations for each contaminant were converted to an air concentration based on a particulate emission factor or a volatilization factor, depending on the contaminant. The ambient-air concentrations then were compared to their respective RBCs. No contaminant maximum soil concentrations in the seven representative waste sites and TSD units from the 200-PW-2 and 200-PW-4 OUs exceeded ambient-air RBCs. Detailed screening results are provided in Appendix D, Table D-5.

2.6.2.2 Human-Health Assessment Results for Radionuclides

Evaluation of radiological constituents in shallow-zone soil (for the industrial worker direct-contact exposure pathway) was conducted based on site cover conditions represented in the "cover" and "no-cover" scenarios. The cover scenario is considered representative of current site conditions, because it accounts for the risk and dose shielding effect of existing relatively clean cover over the waste site (i.e., original deep backfill material or clean stabilization material added later to prevent intrusion and/or mitigate contaminant migration). The no-cover evaluation method is considered representative of worst case conditions; it assumes that no clean cover is present over the top of the representative waste site (i.e., the exposure-point concentration is representative of the entire shallow zone). It also is considered the most stringent condition.

Exceptions to these evaluations occurred for the 216-A-36B, 216-A-10, 216-B-12, and 216-S-7 Cribs. No direct-exposure scenario (either cover or no cover) was run for the 216-A-36B Crib, because the depth of clean fill was great (7.6 to 9.2 m [25 to 30 ft]) and removal of the cover by erosion or accidental excavation is implausible precluding the human-health exposure pathway. The cover scenario was not run for the 216-A-10, 216-B-12, and 216-S-7 Cribs, because even though the fill depth was great (6.4 to 9.2 m [21 to 30 ft]), the fill material itself was slightly contaminated, so the contaminated fill material was conservatively evaluated as if no clean cover existed.

The dose and risk, with or without a clean cover (the most stringent scenario), do not exceed the 15 mrem/yr above background standard for direct exposure for any of the representative waste sites and TSD units. Detailed dose and risk results predicted by RESRAD modeling are provided in Appendix D, Tables D-8 and D-9. Detailed RESRAD results are provided in Appendix D, Tables D-8 (dose/no cover), D-9 (risk/no cover), D-10 (dose/cover), and D-11 (risk/cover).

2.6.3 Screening-Level Ecological Risk Assessment

The ecological risk assessment consists of a screening-level ecological risk assessment (SLERA) to identify chemical and radionuclide contaminants of ecological concern. This process equates to steps 1 and 2 of EPA's ecological risk assessment process [EPA/540/R-97/006, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (Interim Final)*]. The SLERA is followed by a more detailed FS evaluation to determine whether remedial actions are necessary (Sections 2.6.6 and 2.6.8). Within the industrial use framework, the SLERA compares the shallow-zone concentrations in the representative waste sites and TSD units with soil concentrations thought to be protective of terrestrial wildlife populations.

For nonradiological contaminants, the protective soil concentrations are ecological indicator soil concentrations from WAC 173-340-900, "Tables," Table 749-3 and methods described in WAC 173-340-7490, "Terrestrial Ecological Evaluation Procedures." Also considered were ecological soil screening levels developed by EPA (EPA 2003, *Guidance for Developing Ecological Soil Screening Levels*, OSWER Directive 9285.7-55).

For radiological contaminants, the protective soil concentrations are biota concentration guides (BCG) taken from DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*, and DOE/EH-0676, *RESRAD BIOTA: A Tool for Implementing a Graded Approach to Biota Dose Evaluation.*

Appendix D, Tables D-12 (nonradionuclides) and D-13 (radionuclides), identify screening results for the seven representative waste sites. Initial screening results identified concentrations of at least one contaminant at all representative waste sites as exceeding screening levels thought to be protective of terrestrial populations or no screening level existed, thus requiring further FS evaluation or remedial action. As indicated below, after further FS evaluation (Section 2.6.6), these chemical and radiological contaminants were removed as potential ecological COCs, except as noted.

- **207-A South Retention Basin.** Arsenic and silver initially exceeded their ecological soil indicator concentrations. No ecological soil indicator concentrations exist for 2,4-dichlorophenoxyacetic acid, 2-(2,4,5-trichlorphenoxy) propionic acid, and butylbenzyl phthalate. No radiological constituents exceeded the screening level, but no BCG exists for Nb-94 and Th-230. After further evaluation (Section 2.6.6), these contaminants were removed as ecological COCs.

- **216-A-10 Crib.** Boron exceeded its ecological soil indicator concentration used by the risk assessment. No ecological indicator soil concentration exists for beta-1,2,3,4,5,6-hexachlorocyclohexane. No radiological constituents exceeded the screening levels, but no BCG exists for Np-237 and K-40. After further FS evaluation (Section 2.6.6), these contaminants were removed as ecological COCs.

- **216-A-19 Trench.** Boron, uranium, and vanadium exceeded their ecological soil indicator concentrations. No ecological soil indicator concentrations exist for TBP and bis(2-ethylhexyl)phthalate (also called di-octyl phthalate). No radiological contaminant exceeded the screening levels, but no BCG exists for Ni-63. After further FS evaluation (Section 2.6.6), all the contaminants except uranium were removed as ecological COCs.

- **216-A-36B Crib.** Silver exceeded its ecological soil indicator concentration. However, no radiological constituents exceeded the ecological screening levels. After further FS evaluation (Section 2.6.6), this contaminant was removed as an ecological COC.

- **216-A-37-1 Crib.** Barium and boron exceeded their ecological soil indicator concentrations. No indicator concentrations exist for acetone, bis(2-ethylhexyl)phthalate, and TBP. No radiological constituents exceeded the ecological screening levels. After further FS evaluation (Section 2.6.6), these contaminants were removed as ecological COCs.

- **216-B-12 Crib.** Arsenic and boron exceeded their ecological soil indicator concentrations. No ecological indicator concentrations exist for bis(2-ethylhexyl)phthalate. However, no radiological constituents exceeded the screening levels. No BCG exists for Th-230 and Sn-126. After further evaluation (Section 2.6.6), these contaminants were removed as ecological COCs.

- **216-S-7 Crib.** Table D-12 identified silver as exceeding its plant value ecological indicator soil concentration. However, silver did not exceed its ecological soil indicator value for terrestrial wildlife as the applicable screening value. No ecological soil indicator concentration exists for hexavalent chrome. No radiological constituents exceeded the ecological screening levels. After further evaluation (Sections 2.6.6), these contaminants were removed as ecological COCs.

2.6.4 Protection of Groundwater Assessment and Results

The industrial-use framework of the risk assessment (Section 2.6.1, items 1 and 4) precludes use of groundwater in the 200 Areas for drinking purposes. However, RAOs (Chapter 3.0) require no further degradation of groundwater. The potential for contaminants to migrate from soil to groundwater was evaluated for impact to groundwater through ingestion of groundwater calculated for comparison to drinking water standards (MCLs).

The exposure assumptions and methodology used for deriving soil concentrations for groundwater protection are provided in WAC 173-340-747. Maximum soil concentrations of nonradiological constituents for protection of groundwater in the industrial land-use scenario were screened against the WAC 173-340-747 RBCs provided in the CLARC tables (Ecology 94-145). Nonradiological impacts to groundwater are provided as concentrations for comparison to the MCLs of EPA's drinking water standards in 40 CFR 141, "National Primary Drinking Water Regulations."

Radiological impacts to groundwater are provided as dose rates from drinking water for comparison to the EPA drinking water standards of 4 mrem/yr and 1 x 10^{-6} ELCR (40 CFR 141). For radionuclides, RESRAD modeling was used to calculate groundwater impacts. The RESRAD model also was used to obtain risk and dose estimates associated with the groundwater pathway, based on contaminants in soils throughout the site. The results obtained from the RESRAD model for the groundwater protection model are limited to screening purposes only, consistent with DOE and EPA guidance. For some waste sites, RESRAD modeling was extended beyond 1,000 years to 1,500 years if dose and risk beyond target values were predicted to occur beyond this time period. The FS conservatively retains for further consideration the risk and dose levels modeled beyond the 1,000-year modeling period for discussion regarding remedial decision making.

An analysis using more detailed process modeling of flow and transport using the Subsurface Transport Over Multiple Phases (STOMP) code developed by the Pacific Northwest National Laboratory (PNNL) (PNNL-12030, *STOMP, Subsurface Transport Over Multiple Phases, Version 2.0, Theory Guide*) was not deemed necessary for investigation of 200-PW-2 and 200-PW-4 OU waste sites. Modeling conducted previously at other 200 Areas sites for nonradioactive constituents (e.g., 200-TW-1 and 200-TW-2 OUs [DOE/RL-2002-42, *Remedial Investigation Report for the 200-TW-1 and 200-TW-2 Operable Units (Includes the 200-PW-5 Operable Unit)*] and the 200-CW-5 OU [DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-CS-1 Steam Condensate Group Operable Units*]) consistently has indicated breakthrough to the water table for constituents with soil-water partition coefficients (K_d) of zero to one. PNNL has documented that constituents with K_ds of 40 L/kg or greater are effectively immobile in the vadose zone and groundwater (PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*). For some constituents that exceeded groundwater thresholds in the screening phase, additional modeling only would have served to restate previous findings.

2.6.4.1 Nonradiological Groundwater Protection Screening Results

Deep-zone soil maximum concentrations of the following constituents initially were identified as exceeding their respective WAC 173-340-747 groundwater protection values (Appendix D, Table D-14). These exceedances were further evaluated (Section 2.6.6) and, except as noted, were removed as groundwater COCs.

- **207-A South Retention Basin.** Arsenic and nitrate/nitrite initially were reported by the risk assessment as having exceeded their respective groundwater protection soil RBCs. However, after further FS evaluation (Section 2.6.6), these contaminants were removed as potential groundwater COCs.
- **216-A-10 Crib.** Nitrate/nitrite, beta-1,2,3,4,5,6-hexachlorocyclohexane, methylene chloride, pentachlorophenol, and TBP were reported by the risk assessment as having exceeded their groundwater protection RBCs. No established groundwater RBC exists for TPH-kerosene and "oil and grease." However, after further FS evaluation (Section 2.6.6), only nitrate/nitrite, nitrate, and uranium remain as groundwater COCs.
- **216-A-19 Trench.** Nitrate/nitrite, arsenic, manganese, nitrate, uranium, and TBP initially were reported as exceeding their soil groundwater protection RBCs. However, after further FS evaluation (Section 2.6.6), only nitrate/nitrite, nitrate, and uranium remain as groundwater COCs.
- **216-A-36B Crib.** The maximum concentration of nitrate/nitrite, nitrate, nitrite, uranium, and isophorone initially were reported as exceeding their respective soil RBCs. No RBC exists for "oil and grease." After further FS evaluation (Section 2.6.6), only nitrate/nitrite, nitrate, nitrite, and uranium remain as groundwater COCs.
- **216-A-37-1 Crib.** Nitrate/nitrite, aluminum, manganese, and nitrate initially were reported as exceeding their respective groundwater protection soil RBCs. After further FS evaluation (Section 2.6.6), only nitrate/nitrite and nitrate remain as groundwater COCs.
- **216-B-12 Crib.** Nitrate/nitrite, arsenic, nitrate, and uranium exceeded their respective groundwater protection soil RBCs. After further FS evaluation (Section 2.6.6), only nitrate/nitrite, nitrate, and uranium (metal) remain as groundwater COCs.
- **216-S-7 Crib.** Nitrate/nitrite, arsenic, nitrate, and uranium initially were reported as exceeding their respective groundwater protection soil RBCs. After further FS evaluation (Section 2.6.6), only nitrate/nitrite, nitrate, and uranium (metal) remain as groundwater COCs.

2.6.4.2 Radiological Screening

RESRAD modeling results for groundwater impacts from soil contaminants are identified in Appendix D, Tables D-15 and D-16. Contamination levels at the following sites produced groundwater contamination that exceeded the 4 mrem/yr drinking water standard, as follows.

- **216-A-10 Crib.** The dose attributed to I-129 (beta gamma emitter with no MCL concentration) at the 216-A-10 Crib peaks at 2,100 mrem/yr as modeled 1,193 years in the future.

- **216-A-36B Crib.** The dose attributed to Tc-99 (beta gamma emitter with no MCL concentration) at the 216-A-36B Crib peaks at 15.3 mrem/yr as modeled 1,025 years in the future.

- **216-S-7 Crib.** For the 216-S-7 Crib, a maximum dose of tritium peaks at 4.6 mrem/yr at year 30 (to approximately year 35), and a maximum dose of Tc-99 peaks at 2.1 mrem/yr at year 1250.

As indicated above, only tritium at the 216-S-7 Crib exceeded the 4 mrem/yr and the 1×10^{-6} ELCR criterion for drinking water within the 1,000-year analytical period.

2.6.5 Intruder Risk Assessment and Results

Potential risks to a hypothetical, inadvertent intruder from exposure to radioactive contaminants were evaluated at the representative waste sites for informational purposes (Klein et al. 2002). Intruder information provides additional information for analysis of alternatives with regard to long-term effectiveness, particularly Alternatives 1, 2, 4, and 5, which leave waste in place and include institutional controls. This intruder evaluation and the evaluated scenarios are consistent with other intruder evaluations conducted within the Central Plateau for the 200-UW-1 OU (DOE/RL-2003-23) and the 200-CW-5 OU (DOE/RL-2004-24, *Feasibility Study for the 200-CW-5 (U Pond/Z Ditches Cooling Water Waste group), 200-CW-2 (S Pond and Ditches Cooling Water Waste Group), 200-CW-4 (T Pond and Ditches Cooling Water Waste Group), and 200-SC-1 (Steam Condensate Waste Group) Operable Units*).

The intruder scenario is based on the possibilty that after 150 years, an individual unwittingly (through human error or loss of knowledge concerning the location of contaminants) engages in an activity at a 200-PW-2 or 200-PW-4 OU waste site resulting in contact with wastes left in place. This scenario assumes loss of institutional controls at disposal sites containing radioactive waste at year 2150 when a 100-year period of institutional controls (beginning at year 2050) is presumed to end. The intruder risk also was evaluated at a 500-year control period.

Intruder assessment modeling is used to predict at which representative waste site a target ELCR of 1×10^{-4} to 1×10^{-6} and a target dose of 15 mrem/yr above background could be exceeded if no remedial action is taken. Three intruder scenarios were evaluated: a construction trench worker, a well driller, and a rural resident. Of the three scenarios proposed for evaluation, the construction trench worker scenario is most consistent with the Central Plateau land-use assumptions. The rural resident scenario is considered the worst case scenario, primarily because of the longer exposure time, because the scenario assumes that a receptor is residing within the waste site and has planted a garden using the drill cuttings taken from a well drilled through the waste site. The resident receives dose from direct exposure to the radiation field in the garden, inhales resuspended dust, ingests soil, and consumes garden produce grown in the contaminated soil. Consumption of groundwater is not included in this evaluation, because groundwater in this area currently is under remediation and is not available for use.

The results of the intruder analysis at the seven representative waste sites, for each of the three intruder scenarios identifying exceedances of the 15 mrem/yr target value, are identified in Appendix D, Attachment B, and are summarized below and in Table 2-4 (for the rural resident).

- **Construction trench worker.** No representative waste site exceeded 15 mrem/yr target dose for the construction trench worker scenario under the more stringent no-cover scenario.
- **Well driller:**
  - 216-A-36B Crib exceeded the 15 mrem/yr target dose at 150 years for Cs-137 and at 500 years for Pu-239 and Am-241.
- **Rural resident:**
  - 216-A-36B Crib exceeded the 15 mrem/yr target dose at 150 years for Cs-137 and at 500 years for Pu-239 and Am-241
  - 216-B-12 Crib exceeded the 15 mrem/yr target dose at 150 years for Cs-137
  - 216-S-7 Crib exceeded the 15 mrem/yr target dose at 150 years for Cs-137 and Sr-90 and at 500 years for Pu-239
  - 216-A-10 Crib exceeded the 15 mrem/yr target dose at 150 years for Cs-137 and Pu-239 and at 500 years for Pu-239.

Uncertainties exist regarding the well driller and rural resident intruder risk scenarios. The likelihood of the total institutional control failure necessary to allow these exposure scenarios is low. A loss of knowledge regarding location of waste contaminants is not anticipated, because ongoing human presence purposely is being encouraged in the 200 Areas to ensure retention of waste knowledge. Such scenarios assume not only loss of waste site memory but a breakdown of laws and regulations pertaining to covenants and restrictions within legal ownership documents (deeds) identifying the presence of waste on the property. Rural resident activities contrary to such restrictions are improbable, given the extreme expense and logistical difficulties associated with the precursor activity of drilling a very deep (280 to 300 ft) well to groundwater. Drilling requires appropriate permits that would not be approved at these locations. The probability of locating and then drilling within one of the waste sites that exceed intruder target values is small, because the area of these waste sites is very small when compared to the entire area of the Central Plateau industrial (exclusive) zone. Given the above, the probability of the well driller and rural resident intruder scenarios is low.

2.6.6 Further Evaluation of Contaminants of Potential Concern Carried Forward by the Risk Assessment

The radiological and nonradiological contaminants carried forward by the RI Report (DOE/RL-2004-25, Tables 4-39 and 6-1) as risk assessment COCs underwent further evaluation as described in this section and detailed in Appendix E.

Nonradiological contaminants identified in the risk assessment (Appendix D) as exceeding screening levels (or having no screening levels) were carried forward as COPCs for further evaluation during the FS process. Based on the evaluation presented in Appendix E, the nonradiological constituents listed in Table 2-5 can be removed from further consideration as COCs at the identified 200-PW-2 and 200-PW-4 OU waste site(s) under the identified risk scenario.

Radiological contaminants identified in the risk assessment (Appendix D) shown by sampling or modeling to have exceeded risk levels were carried forward from the RI Report (DOE/RL-2004-25, Tables 4-39 and 6-1) as waste site-specific COCs for further evaluation during the FS process. Based on the evaluation presented in Appendix E, the constituents listed in Table 2-6 can be removed from further consideration as COCs under the identified risk scenario at the identified 200-PW-2 and 200-PW-4 OU waste site(s).

2.6.7 Evaluation of Potential Human Health and Ecological Risk at Shallow Analogous Waste Sites

This section summarizes methodology and results for evaluation of potential human health and ecological risk at analogous 200-PW-2 and 200-PW-4 OU waste sites where the representative waste site human health and ecological risk assessment may not apply.

2.6.7.1 Background and Scope

This evaluation occurred for analogous waste sites that are shallow (i.e., less than 4.6 m [15 ft] deep at the site bottom or waste entry point) and therefore have a potential for human health and ecological risk but that have deeper (4.6 m [15 ft] or greater) representative waste sites having no identified human health and ecological risk. Detailed evaluation results are presented in Appendix G. Backfill material of the 216-A-10, 216-B-12, and 216-S-7 Cribs was slightly contaminated, but this contamination was not sufficient to provide human health or ecological risk (Sections 2.6.2 and 2.6.3) and so is not relevant to this evaluation.

The following representative waste sites and their shallower analogous sites were evaluated for human health or ecological risk:

- 216-B-12 Crib (9.2 m [30 ft] deep) and shallower analogous sites 216-C-3 Crib, 216-C-5 Crib, 216-C-7 Crib, and 216-C-10 Crib
- 216-A-10 Crib (14 m [45 ft] deep) and shallower analogous site 216-C-1 Crib
- 216-S-7 Crib (21 ft deep) and shallower analogous sites 216-T-20 Trench and 216-S-22 Crib.

Although the analogous UPR-E-17, UPR-E-39, UPR-E-64, and UPR-E-145 sites are shallower than their representative waste sites, the 200-PW-2 and 200-PW-4 OU UPRs were not evaluated for human health and ecological risk using this method. These UPRs are shallow-surface contaminations and not engineered disposal sites. They are highly bound by their respective representative waste sites regarding contaminant inventory, because these UPRs generally have no developed contaminant inventory for comparative evaluation. The ecological significance of these unevaluated UPRs is further discussed in Section 2.6.8. Because these UPRs are not fully characterized, the exact nature and extent of contamination and of human health and ecological risk is indeterminate without further and potentially extensive characterization. Consequently, removal is the recommended remedial alternative for all of these UPRs (Chapter 8.0).

Of the seven representative waste sites, only the 216-A-19 Trench (4.6 m [15 ft] deep) had ecological risk from uranium identified within the shallow-zone soils. The 216-A-19 Trench and its analogous sites include the 216-A-1 Crib, 216-A-3 Crib, 216-A-18 Trench, 216-A-22 French Drain, 216-A-28 Crib, and 216-A-34 Ditch and are shallower or approximately the same depth. For the 216-A-19 Trench analogous site evaluation, uranium concentrations in shallow soil will be directly applied to all analogous sites having developed uranium inventories. Because no uranium contaminant inventory was developed for the 216-A-34 Ditch, this site was not evaluated using this method. Table 2-7 summarized the evaluation results for the analogous sites.

2.6.7.2 Shallow-Site Evaluation Methodology

In general, this method superimposes contaminant concentrations reported in deeper representative waste site soils onto the zone of uncharacterized shallower analogous site soil. This evaluation requires the existence of representative waste site analytical sample data, developed representative waste site contaminant inventory, and developed analogous site waste inventory for comparison. The general steps for the evaluation process were as follows.

- Using waste site depths (Table 2-2), the number of feet of uncharacterized analogous waste site soils requiring evaluation and an equivalent number of feet of characterized representative waste site soils (from the site bottom) were identified. The number of analogous site feet requiring evaluation is calculated as 4.6 m (15 ft) (human health and ecological POC) minus the depth of clean backfill (generally the analogous site bottom). This number represents the minimum number of feet of representative waste site surrogate soil downward from the engineered representative waste site bottom (generally the most contaminated soils) that will be evaluated against human health and ecological risk screening criteria.

- Using representative waste site soil data (Section 2.4.2) for contaminants having developed contaminant inventory (Table 2-2), human health and ecological PRG exceedances in the representative waste site surrogate soils were identified. These soil concentrations were compared to PRGs (Table 3-1) or other screening levels identified in Appendix G. The PRG exceedance(s) were quantified by order of magnitude (OM). This OM value became the benchmark criterion for comparison of analogous and representative waste site contaminant inventory to determine the potential for analogous site human health or ecological risk.

- Representative waste site and analogous site contaminant inventories (Table 2-2) were compared using the representative waste site OM benchmark criterion. Potential human health or ecological risk was suggested at analogous sites where the analogous site contaminant inventory exceeded the representative waste site contaminant inventory by the OM benchmark.

2.6.7.3 Evaluation Results

This section summarizes the results of the shallow-site evaluation for human health and ecological risk at the representative waste site identified above and in Appendix G.

2.6.7.3.1 Representative Waste Site 216-B-12 Crib

The 216-B-12 Crib and its shallower analogous waste sites include the 216-C-3 Crib, 216-C-5 Crib, 216-C-7 Crib, and 216-C-10 Crib. In the 216-B-12 Crib soil range of 3.4 m (11 ft), only the maximum concentration of Sr-90 (12,700 pCi/g) exceeded human-health and ecological (terrestrial wildlife) PRGs. The Sr-90 (12,700 pCi/g) exceeded its human-health PRG (2250 pCi/g) by just over ½ OM and its terrestrial wildlife PRG (22.5 pCi) by approximately 2½ OM.

Analogous 216-C-3 Crib. The 216-C-3 Crib inventory of Sr-90 (8.04 Ci) is 1 OM smaller than the representative waste site Sr-90 contaminant inventory of 80.0 Ci.

- **Human Health.** This site did not exceed the Sr-90 human health ½ OM value, suggesting the absence of human-health risk at this analogous site.
- **Ecological.** The analogous site contaminant inventory is not at least 2½ OM smaller than the representative waste site contaminant inventory of Sr-90, suggesting potential ecological risk at this analogous site.

Analogous 216-C-5 Crib. The analogous waste site 216-C-5 Crib inventory of Sr-90 (4.2 Ci) is approximately 1½ OM smaller than the representative waste site Sr-90 contaminant inventory of 80.0 Ci.

- **Human Health.** This site did not exceed the minimum human health ½ OM value, suggesting the absence of human-health risk at this analogous site.
- **Ecological.** This site contaminant inventory is not at least 2½ OM smaller than the representative waste site contaminant inventory, suggesting a potential for ecological risk from Sr-90 at this analogous site.

216-C-7 Crib. The analogous waste site 216-C-7 Crib inventory of Sr-90 (05 Ci) is more than 3 OM smaller than the representative waste site Sr-90 contaminant inventory of 80.0 Ci.

- **Human Health and Ecological.** This site did not exceed the human health ½ OM value or the ecological (terrestrial wildlife) 2½ OM value, suggesting the absence of potential human health or ecological risk at this site.

Analogous 216-C-10 Crib. The analogous site 216-C-10 Crib inventory of Sr-90 (3.5 Ci) is more than 1 OM smaller than the representative waste site Sr-90 contaminant inventory of 80.0 Ci.

- **Human Health.** This site did not exceed the human health ½ OM value, suggesting the absence of potential human-health risk.
- **Ecological.** The analogous site contaminant inventory is not at least 2½ OM smaller than the representative waste site contaminant inventory, suggesting potential ecological risk at this site from Sr-90.

2.6.7.3.2 Representative Waste Site 216-A-10 Crib

The 216-A-10 Crib is representative of the 216-C-1 Crib. In the surrogate range of 2.1 m (7 ft), Pu-239/240 (7110 pCi/g) exceeded its human-health PRG (425 pCi/g) by 1½ OM and exceeded its ecological (terrestrial wildlife) PRG (6110 pCi/g) by less than 1 OM. Cesium-137 (1080 pCi/g) exceeded its human-health PRG (23.4 pCi/g) by slightly less than 2 OM and its ecological PRG (115 pCi/g) by 1 OM. Americium-241 (1320 pCi/g) exceeded its human-health PRG (335 pCi/g) by less than 1 OM. The shallow-site evaluation compared contaminant inventories for Pu-239/240, Cs-137, and Am-241, because all exceeded human health and/or ecological PRGs.

Analogous 216-C-1 Crib. The analogous site contaminant inventory for total plutonium (8.0 Ci) is at least 1½ OM smaller than the representative waste site contaminant inventory of 350 Ci. This site had no developed Am-241 contaminant inventory and therefore no discernable human health or ecological risk from Am-241. The analogous site contaminant inventory for Cs-137 (0.04 Ci) was 3 OM smaller than the representative waste site contaminant inventory of 80.5 Ci.

- **Human Health and Ecological.** This site did not exceed the plutonium human health 1½ OM value or the minimum plutonium ecological (terrestrial wildlife) of less than 1 OM, suggesting the absence of human health or ecological risk at this site. This site had no developed Am-241 contaminant inventory and therefore no discernable human health or ecological risk from Am-241. This site did not exceed the Cs-137 human health 2 OM range and the Cs-137 ecological (terrestrial wildlife) range of 1 OM, suggesting the absence of potential human health or ecological risk at this site.

2.6.7.3.3 Representative Waste Site 216-S-7 Crib

The 216-S-7 Crib has two shallower analogous sites, the 216-T-20 Trench and the 216-S-22 Crib. In the 216-S-7 Crib, in the 3.4 m (11-ft) surrogate soil range, Am-241, Cs-137, Pu-239/240, and Sr-90 would exceed human health and/or ecological screening values as follows. Americium-241 (1900 pCi) would exceed its human-health PRG (335 pCi/g) by ½ OM. Cesium-137 (20,000 pCi/g) would exceed its human-health PRG (23.4 pCi/g) by almost 3 OM and its ecological PRG (115 pCi/g) by 2½ OM. Plutonium-239/240 (11,000 pCi) would exceed its human-health PRG (425 pCi/g) by OM+ and its ecological PRG (6110 pCi/g) by ½ OM. Strontium-90 (53,000 pCi) would exceed its human-health PRG (2530 pCi/g) by 1+OM and its terrestrial wildlife PRG (22.5 pCi/g) by 2+OM. Because Pu-239/240, Cs-137, Sr-90, and Am-241 all exceeded human health and/or ecological PRGs, the shallow analogous sites will be evaluated for all of these constituents.

Analogous 216-T-20 Trench. The 216-T-20 Trench had no developed contaminant inventory for Am-241 and Pu-239/240. The 216-T-20 Trench contaminant inventory for Cs-137 (0.44 Ci) was at least 3 OM smaller than the representative waste site contaminant inventory of 703 Ci. The 216-T-20 Trench contaminant inventory for Sr-90 (0.39 pCi/g) was at least 3 OM smaller than the representative waste site contaminant inventory for Sr-90 of 1,390 Ci.

- **Human Health and Ecological.** This site has no developed contaminant inventory for Am-241 and Pu-239/240 and so has no discernable human health or ecological risk from these constituents. This site did not exceed the Cs-137 human health and ecological OM values of just less than 3- OM and 2½ OM, respectively, suggesting the absence of potential human health or ecological risk from Cs-137. This site did not exceed the Sr-90 human health and ecological OM values of 1+ OM and 2+ OM respectively, suggesting the absence of potential human health or ecological risk from Sr-90 at this site.

Analogous 216-S-22 Crib. The 216-S-22 Crib has no developed contaminant inventory for Am-241 and so has no discernable human health or ecological risk from Am-241. The 216-S-22 Crib contaminant inventory for Cs-137 (0.48 Ci) was at least 3 OM less than the representative waste site Cs-137 contaminant inventory of 703 Ci. The 216-S-22 Crib contaminant inventory for Sr-90 (0.46 Ci) was at least 3 OM smaller than the representative waste site Sr-90 contaminant inventory of 1390 Ci. The 216-S-22 Crib contaminant inventory for total plutonium (0.10 Ci) was at least 3 OM less than the representative waste site total plutonium contaminant inventory of 440 Ci.

- **Human Health and Ecological.** This site did not exceed the Cs-137 human health and ecological OM values of less than 3 OM and 2½ OM, respectively, suggesting the absence of potential human health or ecological risk from Cs-137. This site did not exceed the Sr-90 human health and ecological OM values of 1+ OM and 2+ OM, respectively, suggesting the absence of human health or ecological risk from Sr-90. This site did not exceed the total plutonium human health and ecological OM values of 1+ OM and ½ OM, respectively, suggesting the absence of human health or ecological risk from plutonium.

2.6.7.3.4 Representative Waste Site 216-A-19 Trench

All 216-A-19 Trench analogous sites were evaluated for human health and ecological risk, because maximum contaminant concentrations were found in the shallow-soil sample, and ecological risk was identified in trench shallow soils. Therefore, the first step of the evaluation, identification of a surrogate range of representative waste site soil, was not necessary because shallow-soil concentrations could be directly applied to the shallow soils of the analogous sites. The first trench sample, taken at 4.4 m (14.5 ft) bgs, contained the maximum concentrations for all constituents except Sr-90 (5.3 m [17.5 ft]), manganese (5.3 m [17.5 ft]), uranium (6.9 m [22.5 ft]), and nitrates (8.4 m [27.5 ft]), all of which already were included in the evaluation. None of the maximum concentrations in shallow soils exceeded their respective human-health screening levels. However, the maximum uranium concentration of 129 pCi/g in shallow soils (4.4 m [14.5 ft] bgs) exceeded the terrestrial wildlife PRG for uranium (5.9 mg/kg) by 1 OM x 2, indicating ecological risk at the representative 216-A-19 Trench, and a potential for ecological risk at its analogous sites from uranium was evaluated.

Analogous 216-A-1 Crib, 216-A-3 Crib, 216-A-18 Trench, 216-A-20 Trench, 216-A-22 French Drain, and 216-S-8 Trench. All of these sites are at least 4.6 m (15 ft) bgs and so they are below the 4.6 m (15-ft) human health and ecological POC. Also, their uranium inventories are smaller than, or essentially at, the representative waste site inventory, and so they did not exceed the OM value.

- **Human Health.** These sites are deep and uranium inventory did not exceed a human-health screening value, so no human health risk is anticipated to exist at the evaluated analogous waste sites.
- **Ecological.** These sites are deep and uranium inventory did not exceed the ecological OM evaluation criteria, suggesting that ecological risk is unlikely at these sites.

Analogous 216-A-28 Crib. The 216-A-28 Crib and the 216-A-34 Ditch are shallower than the representative 216-A-19 Trench. The 216-A-28 Crib uranium inventory (627 kg) was more than 2 OM smaller than the representative waste site uranium inventory of 3.87×10^{-4}.

- **Human Health and Ecological.** The 216-A-28 Crib did not exceed the 1 OM value, suggesting the absence of ecological risk from uranium.

2.6.8 Evaluation of Ecological Significance

Of the seven representative waste sites, the SLERA (Section 2.6.3 and Appendix D, Tables D-12 and D-13) initially identified concentrations of one or more chemicals and/or radionuclides that exceeded ecological screening values, thus requiring further evaluation. Potential ecological exposure risk at some shallow analogous waste sites also was identified in a separate evaluation (Section 2.6.7 and Appendix G). This section summarizes the results of the evaluation of ecological significance of SLERA constituents and ecological significance of contamination at the shallow analogous sites to wildlife receptors of particular concern.

2.6.8.1 Ecological Significance of Representative Waste Site SLERA Results

Of the seven representative waste sites that underwent ecological risk assessment, only uranium (metal) at the 216-A-19 Trench was identified as exceeding an ecological indicator soil concentration or a BCG. The FS evaluation (Section 2.6.6 and Appendix E) effectively has eliminated all other potential SLERA COPCs from further consideration as ecological COCs.

216-A-19 Trench. This site was a small (i.e., 7.6 by 7.6 m [25 by 25 ft] at the bottom and 4.6 m [15 ft]) deep, unlined trench having a small surface area of 58 m^2 (625 ft^2). After operations, the trench was backfilled with clean soil, and the surface was stabilized in 1990 with additional fill material. The overlying soil cover prevents exposure to site-related contaminants by most wildlife species. However, burrowing mammals such as the badger, coyote, northern pocket gopher, deer mouse, and Great Basin pocket mouse, and burrowing owl, if present, could be exposed to site-related contaminants. Consequently, some uncertainty exists regarding the potential risk to burrowing animals that might occur on this site. However, the small size of the site and the depth of relatively clean cover soil serve to minimize the exposure pathway. Use of this flat, open area by burrowing animals probably would be minimal. The disturbed nature and sparse vegetation at this site provides poor quality habitat offering little cover and forage, suggesting that it is not supportive of ecological populations. It would be highly unlikely that any individual animal would use *only* this site for foraging and/or shelter, suggesting that exposure to contaminants from this site likely would be minor relative to the entire area used by an animal. In summary, the depth of clean cover and small areal extent reduce the extent to which wildlife species would use this site and would be exposed to site-related contaminants, rendering the potential site-related ecological risk negligible.

2.6.8.2 Significance of Ecological Risk for Analogous Waste Sites

The evaluation process for shallow analogous waste sites (Section 2.6.7) identified three analogous sites for the 216-B-12 Crib (216-C-3 Crib, 216-C-5 Crib, and the 216-C-10 Crib) that potentially could present ecological risk. Ecological impact of the shallow UPRs and the 216-A-34 Ditch, which were not evaluated in Section 2.6.7, also are discussed below.

216-C-3 Crib, 216-C-5 Crib, and the 216-C-10 Crib. Because these cribs are collocated; are of similar configuration, size, and depth; received similar contaminants; and have similar inventory, they will be discussed together with regard to significance of ecological risk. These sites are all small, gravel-covered, rectangular-shaped drain-field-type cribs that are short and narrow, having small surface areas: 216-C-3 is 15.2 by 3.0 m and 3.0 m deep (46.4 m^2) (50 by 10 ft and 10 ft deep [500 ft^2]); 216-C-5 is 6.1 by 3.0 m (18.6 m^2) (20 by 10 ft [200 ft^2]); and 216-C-10 is 9.7 by 1.5 m (14.9 m^2) (32 by 5 ft [160 ft^2]). These cribs are covered by clean soil at an average depth of 8 ft (2.4 m). The overlying soil cover prevents exposure to site-related contaminants by most wildlife species. However, burrowing mammals such as the badger, coyote, northern pocket gopher, deer mouse, and Great Basin pocket mouse, and the burrowing owl, if present, could be exposed to site-related contaminants, and so some uncertainty exists regarding the potential risk to burrowing animals that might occur on these sites. However, the small size of these sites and the 2.4 m (8-ft) soil cover serve to minimize the exposure pathway. Use of these flat, open, gravel-covered cribs by burrowing animals probably would be minimal. The disturbed nature and sparse vegetation at these sites provide poor quality habitat offering no cover and little forage, suggesting that they are not supportive of ecological populations. It would be highly unlikely that any individual animal would use *only* one of these cribs for foraging and/or shelter, suggesting that exposure to contaminants at these sites probably would be minor relative to the entire area used by an animal. In summary, the 2.4 m (8-ft) soil cover, small areal extent, and linear nature of the sites reduce the extent to which wildlife species would be exposed to site-related contaminants, making the potential site-related ecological risk negligible.

216-A-34 Ditch. The 216-A-34 Ditch is 1.8 m (6 ft) deep and was a waste conduit (not a disposal site) for transfer of 241-A-431 Tank Farm Ventilation Building low-activity contact condenser cooling water to the 216-A-18 and 216-A-20 Trenches. This site had no developed uranium inventory for comparison to the 216-A-19 Trench representative waste site and so could not be evaluated for potential ecological risk using the methodology described in Section 2.6.7. Because no uranium contaminant inventory was developed for the 216-A-34 Ditch, this site was not evaluated using this method.

UPRs. Because the following 200-PW-2 and 200-PW-4 UPRs are not fully characterized, the exact nature and extent of contamination, and therefore the potential ecological risk from these sites, are indeterminate without extensive characterization.

- **UPR-200-E-145.** UPR-200-E-145 is a shallow, small area release of unknown quantity (i.e., no developed contaminant inventory) that occurred before 1957. The release primarily was uranium oxide from clay piping buried about 1 m (3 ft) deep that was used to transfer low-activity uranium bearing 241-A-431 Tank Farm Ventilation Building contact condenser cooling water from the 216-A-8 Proportional Sample Pit to the 216-A-34 Ditch. This site was discovered during an excavation in 1993, the excavation was backfilled, and it is anticipated to provide limited ecological risk.

- **UPR 200-E-17.** UPR 200-E-17 was a spill of unknown quantity (no developed contaminant inventory) to the surface of the 216-A-22 French Drain, making the risk from this spill indeterminate. Because the site was covered with soil in 1959, an otherwise indeterminate ecological risk was further minimized. Further, because this site is located against the north wall of the 203-A Building, its location limits wildlife access and provides low-quality habitat and little potential forage for wildlife receptors, suggesting that risk to ecological receptors is unlikely.

- **UPR-200-E-39.** UPR-200-E-39 was a spill of unknown quantity (no developed contaminant inventory) that occurred in 1968 on the ground and blacktop outside the 216-A-36B Crib Sampler Shack, which is located in the 200 East Area inside the PUREX fence, south of the 202-A Building. This site (including the asphalt) is approximately 7.9 by 7.9 m (26 by 26 ft). The waste was PUREX ASD waste containing uranium and fission products. The volume released is unknown, but based on the limited nature of the spill response (i.e., blacktop hose-off), the volume is anticipated to be relatively small. As a low-volume surface release, the contamination in the gravel area conservatively is presumed to be approximately 1 m (3 ft) deep. The location of this release to asphalt surfaces and surrounding edges limits wildlife access, habitat, and forage for wildlife receptor use, suggesting that risk to ecological receptors at this site is unlikely.

- **UPR-200-E-64.** The UPR-200-E-64 site consists of migrating (ant spread) radioactive speck contamination that was identified in 1984. This location is a posted radiological surface contamination area that has increased in size from wind and, as of 1995, was approximately 8,100 m^2 (2 a). The contamination consists primarily of Cs-137 and Sr-90. The volume of contamination released and the depth of contamination are unknown but are conservatively placed at 1 m (3 ft). Because site contamination is only trace levels and because the site was stabilized with at least 0.6 m (2 ft) of clean backfill, ecological risk from this site is very limited.

2.6.8.3 Potential Risk to Ecological Receptors of Concern

Contamination at the 200-PW-2 and 200-PW-4 OU waste sites does not pose potential risk to Federally listed species or Washington State "species of concern." The bald eagle (*Haliaeetus leucocephalus*), Federally listed as threatened, is the only species listed under the Federal *Endangered Species Act of 1973* that has been observed at the Hanford Site. Previous reports have included the Aleutian Canada goose (*Branta canadensis leucopareia*) as a Federally threatened species known to occur at the Hanford Site; however, this species has largely recovered and was delisted in March 2001. It is no longer a Federally listed species (USFWS 2004, *Threatened and Endangered Species System, Delisted Species Information*). The bald eagle and the Aleutian Canada goose inhabit the Columbia River corridor and rarely are seen in the Central Plateau.

Four other bird species classified by the Washington Department of Fish and Wildlife as "species of concern" also have been reported to occur at the Hanford Site (WDFW 2004, *Species of Concern in Washington State).* These species consist of the ferruginous hawk (*Buteo regalis*), state-listed as threatened, and the burrowing owl (*Athene cunicularia*), loggerhead shrike (*Lanius ludovicianus*), and sage sparrow (*Amphispiza belli*). The burrowing owl, loggerhead shrike, and sage sparrow are each listed as "state candidate" species (WDFW 2004). However, because the cover of clean soil at the five sites limits exposure to site-related contaminants by the ferruginous hawk, loggerhead shrike, and sage sparrow, site-related potential risk to these three state-listed species is negligible. Site-related potential risk to the burrowing owl is greater but also is considered minimal because the burrows for these owls can exceed 1.8 m (6 ft) in length but generally are not deep. No other plants, invertebrates, amphibians, reptiles, or mammals that are Federally listed or listed by the State of Washington as threatened or endangered species are known to exist in the Central Plateau.

2.6.8.4 Conclusion: No Further Ecological Evaluation Necessary

For commercial or industrial property, only the ecological risk to terrestrial wildlife requires evaluation. Potential risk to soil invertebrates and plants does not require evaluation. Because the 200-PW-2 and 200-PW-4 OU waste sites are in an industrial (exclusive) area (WAC-173-340-200, "Definitions"), the ecological exposure risk evaluations have been limited to terrestrial wildlife.

Of the seven representative waste sites, only the 216-A-19 Trench has a potential terrestrial wildlife ecological risk, with none of its analogous sites providing ecological risk. Of the analogous waste sites for the other six representative waste sites, only the 216-C-3 Crib, 216-C-5 Crib, and 216-C-10 Crib (all analogous to the 216-B-12 Crib), have an identified potential for ecological risk without remedial action.

The sites with a potential for ecological risk represent only a small areal extent relative to the size of wildlife forage areas and therefore provide little opportunity for use by terrestrial receptors. These sites are covered by clean soil to an average depth of 8 ft (2.4 m), suggesting that the potential ecological risk posed by these cribs is negligible. The uncertainty associated with risks to burrowing animals at this site is small and would be further reduced if the selected remedial alternative were capping or source removal. Selection of a surface barrier (cap) alternative assumes removal of burrowing animals present at the sites before remediation, and the additional cap thickness and engineered intrusion-deterrence features would deter potential future populations of burrowing animals. Selection of a no-action remedial alternative for these sites could necessitate additional ecological investigation and assessment of risk to burrowing animals. However, because the recommended alternative for all of the 200-PW-2 and

200-PW-4 OU sites having ecological risk currently is source removal (Chapter 8.0), no additional ecological investigation or assessment is required.

2.6.9 Representative Waste Sites Risk Assessment Synopsis

Risk assessment results are used to develop and evaluate appropriate alternatives for the representative waste sites and their associated analogous waste site(s). The human-health, ecological, groundwater protection, and intruder risk assessments performed for the 200-PW-2 and 200-PW-4 OU representative waste sites and TSDs were summarized in the RI Report (DOE/RL-2004-25), Table 4-39, with expanded detail provided in the RI Report, Tables 6-1 and 6-2. The COPCs above risk-screening levels or modeling risk and dose target values were identified for each waste site and carried forward as COPCs into the FS for further evaluation. Some COPCs were retained at a given site because there was no basis to exclude them (i.e., they had no site background and no listing in the pertinent regulations). These COPCs have undergone further FS evaluation (Sections 2.6.6 and 2.6.7 and Appendices E and G). Vadose zone fate and transport modeling beyond RESRAD (e.g., STOMP modeling) was deemed unnecessary for these waste sites.

Table 2-8 identifies potential representative waste site human-health, ecological (terrestrial wildlife), groundwater, and intruder risks at representative waste sites from the COCs retained by this FS for remedial decision making. Risk information and conclusions arrived at through the RI risk assessment framework do not necessarily limit the scope of recommended remedial actions.

216-A-19 Trench

- **Human health:** Protected with respect to radiological and chemical contaminants because no constituents remaining after FS evaluation (Section 2.6.6) exceed human-health screening values in shallow soil because of deep, relatively clean cover that exceeds the human-health POC.
- **Groundwater:** Not protected from nitrates and uranium (metal) in vadose zone soils without remedial action.
- **Ecological:** Not protected from uranium (metal) in shallow soil without remedial action.
- **Intruders:** Protected from radiological dose greater than the 15 mrem/yr target value for the 150- and 500-year control periods.

216-B-12 Crib

- **Human health:** Protected with respect to chemical and radiological contaminants in shallow soil, because no constituents remaining after FS evaluation (Section 2.6.6) exceed human-health screening values in shallow soil because of deep, relatively clean cover that exceeds the human-health POC.

- **Groundwater:** Not protected for nitrates and uranium in vadose zone soils without remedial action.

- **Ecological:** Protected (at the 216-B-12 Crib), because no constituents remaining after FS evaluation (Section 2.6.6) exceed ecological screening values in shallow soil because of deep, relatively clean cover that exceeds the ecological POC. Potentially not protected at analogous 216-C-3, 216-C-5, and 216-C-10 Cribs sites without remedial action (Section 2.6.7).

- **Intruders:** Rural resident intruders not protected at the 150-year modeling period for Cs-137.

216-A-36B Crib

- **Human health:** Protected with respect to chemical and radiological contamination in shallow soils, because no constituents remaining after FS evaluation (Section 2.6.6) exceed human-health screening values in shallow soil because of the 7.6 m (25-ft) depth of clean cover that exceeds the human-health POC.

- **Groundwater:** Not protected from uranium and nitrates in vadose zone soil. Protected for radionuclides within the 1,000-year RESRAD modeling simulation period. Potentially not protected beyond the 1,000-year modeling period from Tc-99 predicted by RESRAD modeling to reach groundwater above RBCs at year 1025 (risk diminishes significantly by year 1100).

- **Ecological:** Protected, because no constituents remaining after FS evaluation (Section 2.6.6) exceed ecological screening values in shallow soils because of the 7.6 m (25-ft) depth of clean fill that exceeds the ecological POC.

- **Intruders.** Well driller and rural resident intruders not protected at 150 years for Cs-137 and at 500 years for Pu-239 and Am-241, predicted by modeling to exceed the 15 mrem/yr target dose.

216-A-10 Crib

- **Human health.** Protected with respect to radiological contaminants in shallow soil, because no constituents remaining after FS evaluation (Section 2.6.6) exceed human-health screening values in shallow soil because of the 14 m (45-ft) depth of relatively clean cover that exceeds the human-health POC.
- **Groundwater.** Protected for chemical and radionuclides within the 1,000-year modeling simulation period. Not protected beyond 1,000 years from I-129, which is predicted by RESRAD modeling to reach groundwater above 4 mrem/yr dose levels at year 1193 without remedial action.
- **Ecological:** Protected, because no constituents remaining after FS evaluation (Section 2.6.6) exceed human-health screening values in shallow soil because of the 14 m (45-ft) depth of relatively clean cover that exceeds the ecological POC.
- **Intruders:** Rural resident intruders not protected from Cs-137 and Pu-239 at 150 years and from Pu-239 at 500 years, predicted by modeling to exceed the 15 mrem/yr target dose.

207-A South Retention Basin

- **Human health:** Protected with respect to radiological contaminants, because no constituents remaining after FS evaluation (Section 2.6.6) exceed human-health screening values in shallow soil.
- **Groundwater:** Protected with respect to chemical and radiological contaminants in vadose zone soil.
- **Ecological:** Protected in shallow soil from chemical and radiological contamination after screening against RBCs and evaluation (Section 2.6.6), and because the concrete structure precludes the ecological exposure pathway.
- **Intruder:** Protected at the 150- and 500-year modeling periods.

216-A-37-1 Crib

- **Human health:** Protected with respect to chemical and radiological contaminants, because no constituents remaining after FS evaluation (Section 2.6.6) exceed human-health screening values in shallow soil.
- **Groundwater:** Not protected for nitrate and nitrate/nitrite contamination in vadose soil.

- **Ecological:** Protected with respect to chemical and radiological contaminants, because no constituents remaining after FS evaluation (Section 2.6.6) exceed ecological screening values in shallow soil.

- **Intruder:** Protected from radiological dose greater than 15 mrem/yr above background target value for the 150- and 500-year control periods.

216-S-7 Crib

- **Human health.** Protected with respect to chemical and radiological contaminants, because no constituents remaining after FS evaluation (Section 2.6.6) exceed human-health screening values in shallow soil because of the 4.6 to 7.3 m (15- to 24-ft) depth of relatively clean cover that exceeds the human-health POC.

- **Groundwater.** Not protected for uranium (metal) and nitrates in vadose zone soil above RBCs protective of groundwater and for tritium predicted by modeling to reach the groundwater above MCLs or risk-based standards without remedial action.

- **Ecological.** Protected with respect to chemical and radiological contaminants after FS evaluation (Section 2.6.6) that removed hexavalent chrome and silver as COCs, leaving no constituents remaining that exceed human-health screening values in shallow soil because of the 4.6 to 7.3 m (15- to 24-ft) depth of relatively clean cover that exceeds the ecological POC.

- **Intruders.** Not protected without remedial action from radiological dose greater than 15 mrem/yr above background target value at 150 years for Cs-137 and Sr-90 and at 500 years for Pu-239.

Figure 2-1. Stratigraphic Column for the 200 Areas.

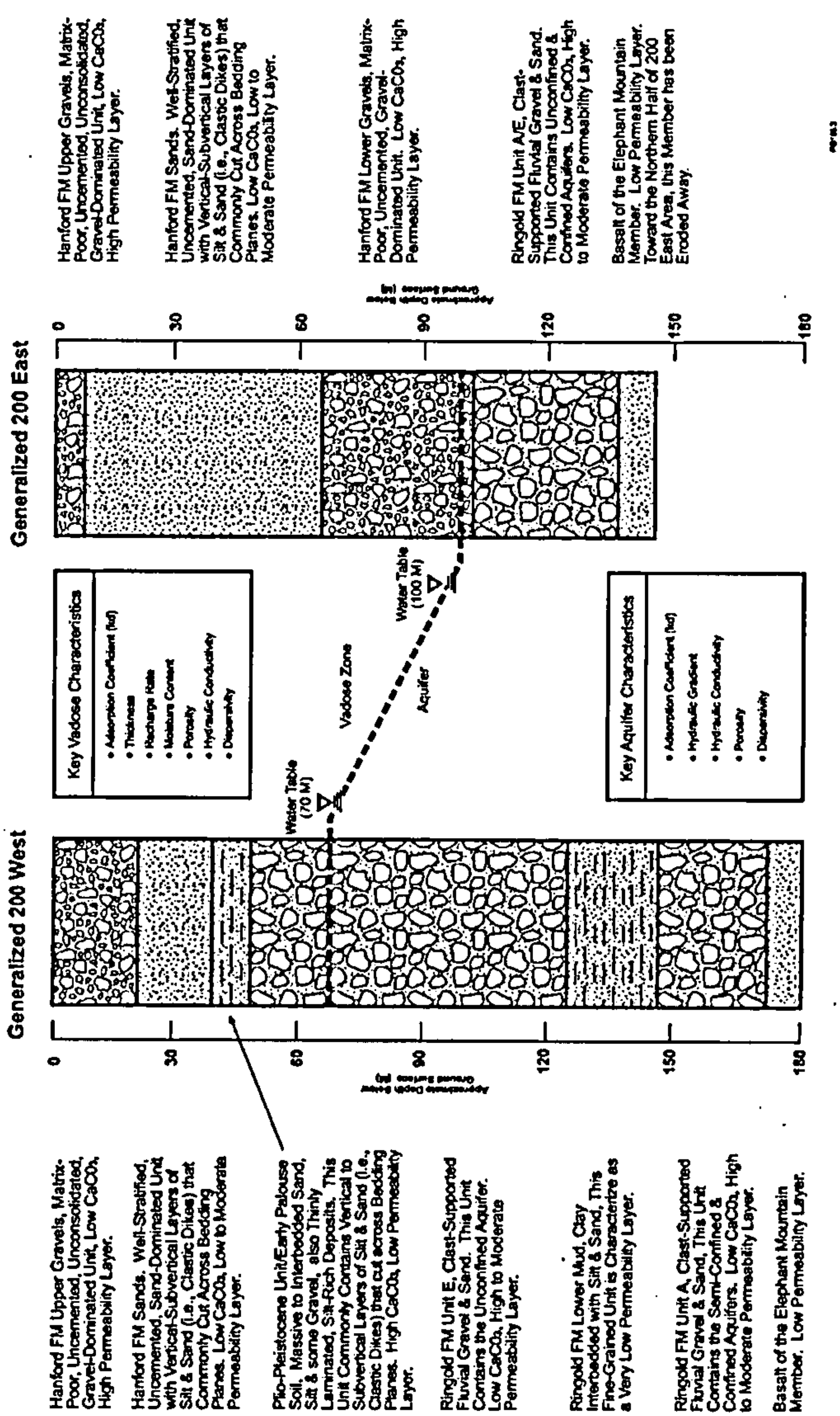
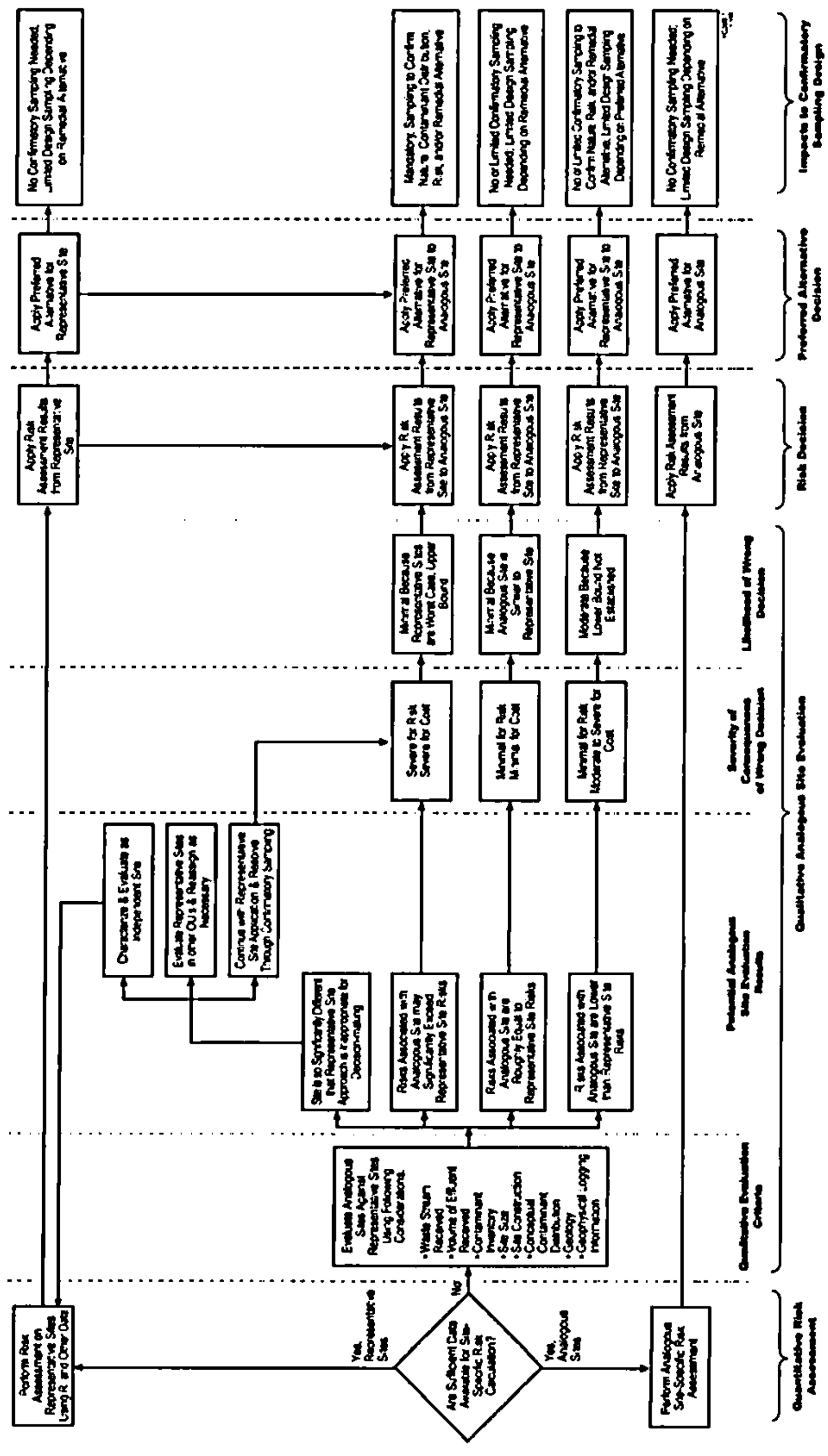


Figure 2-14. Analogous Site Alternative Selection.



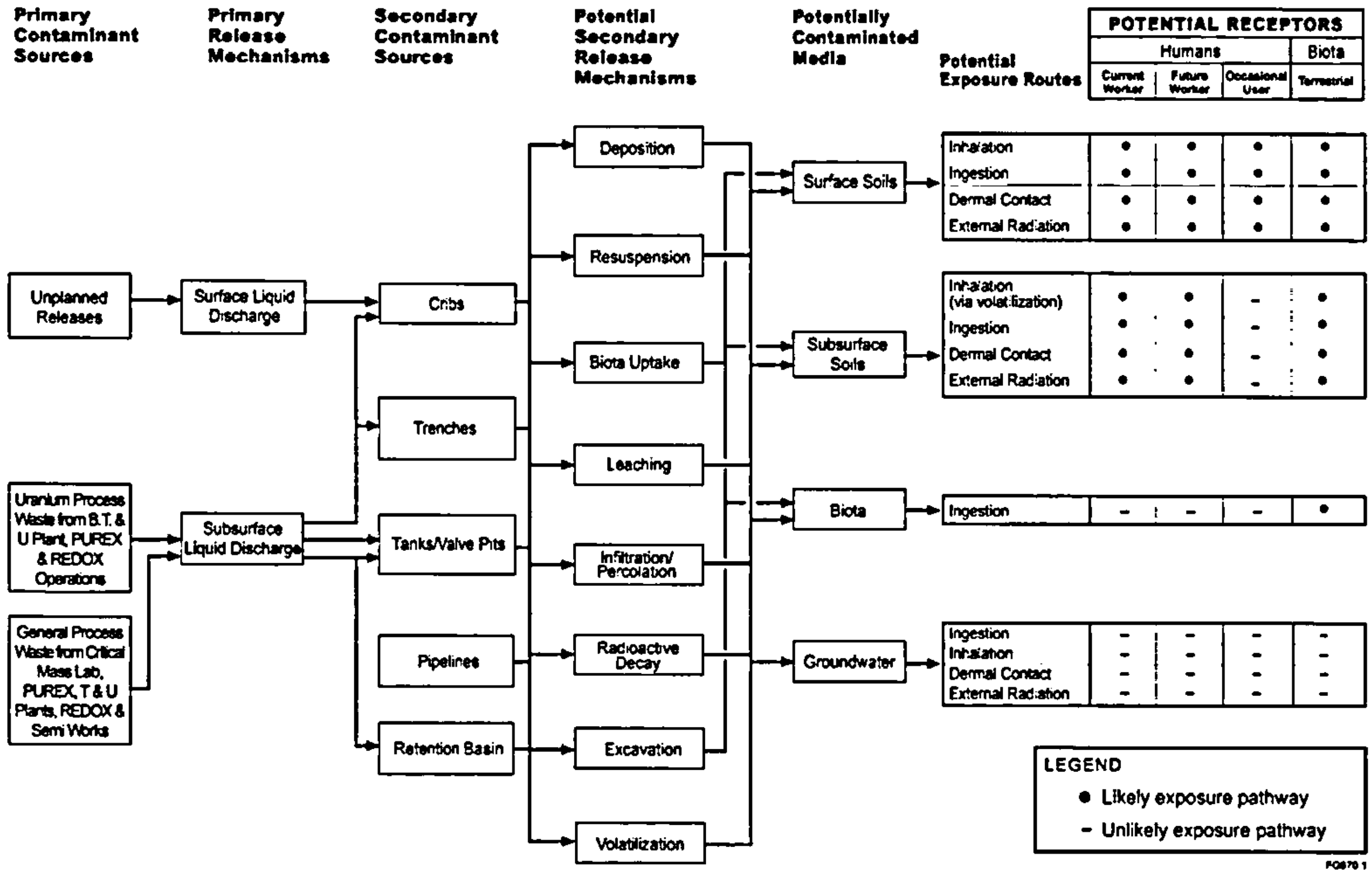


Figure 2-15. Conceptual Exposure Model.

Table 2-1. Lithofacies of the Cold Creek Unit.

Lithofacies	Environment of Deposition	Previous Site Nomenclature
Fine-grained, laminated to massive. Consists of a brown- to yellow very well sorted cohesive, compact, and massive- to laminated- and stratified-fine-grained sand and silt. It is moderately to strongly calcareous with relatively high natural background gamma activity.	Fluvial-overbank and eolian	Palouse soil, early "Palouse" soil, Hanford formation/ Plio-Pleistocene unit silt.
Fine- to coarse-grained, calcium carbonate cemented. Consists of basaltic to quartzite gravels, sands, silts, and clay that are cemented with one or more layers of secondary, pedogenic calcium carbonate.	Calcic paleosol	Highly weathered subunit of the Plio-Pleistocene unit/ caliche, calcrete.
Coarse-grained, multilithic. Consists of rounded, quartzose to gneissic clast-supported pebble- to cobble-size gravel with a quartzo-feldspathic sand matrix.	Mainstream alluvium	Distantly derived subunit of the Plio-Pleistocene unit/ pre-Missoula flood gravel.
Coarse-grained, angular, basaltic. Consists of angular, clast- to matrix-supported basaltic gravel in a poorly sorted mixture of sand and silt with no stratification. Calcic paleosols may be present.	Colluvium	New facies designation for the Pasco Basin.
Coarse-grained, round basaltic lithofacies.	Sidestream alluvium	Locally derived subunit of the Plio-Pleistocene unit.

NOTE: Based on DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for Post-Ringold Formation Sediments Within the Central Pasco Basin.*

Table 2-2. 200-PW-2/200-PW-4 Operable Unit Representative Sites and Associated Analogous Waste Sites. (25 Pages)

Waste Site*	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory									Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
REPRESENTATIVE SITE														
216-A-19 Trench (216-A-19 Test Hole, 216-A-19 Grave, 216-A-19 Sump, 216-A-19 Crib)	The 216-A-19 Trench was constructed in 1955 for disposal of PUREX startup waste. It is an unlined trench located east of the 200 East Area perimeter fence about 800 m (2,625 ft) northwest of the 202-A (PUREX Plant) Building. Waste from PUREX entered the trench from above-ground piping. During operations the trench was 4.6 m (15 ft) deep and was approximately 7.6 m x 7.6 m (25 ft x 25 ft) at the bottom. The excavation has side slopes of 1:2 (V/H). The 216-A-19 Trench was deactivated by removing the above-ground piping and backfilling the excavation and later was covered with several feet of fill. The site was surface stabilized again in 1990 with additional fill material.	The trench operated from 1955 to 1956 and received 1,100,000 L (291,000 gal) of PUREX startup waste containing nonirradiated uranium and fission products (Co-60, Sr-90, Cs-137, Pu-239/240, and U-238). Contact condenser cooling water from the 241-A-431 Tank Farm Ventilation Building containing uranium and nitric acid may have reached the trench from the 216-A-34 Ditch. Nitrate salts also were disposed of at the site.	3.87 E+04 (4.34E+04)	1.00 E-01 (0)	 (0)	4.44 E-02 (0)	4.20 E-02 (0)	20,000 (1.09E+04)	—	—	—	1,100	1,232 Effluent volume to pore volume ratio: 0.89	Contaminants were detected beneath the 216-A-19 Trench to a depth of 75.6 m (248 ft). Maximum concentrations for all radiological and most chemical contaminants were found near the trench bottom from 4.4 to 5.3 m (14.5 to 17.5 ft) bgs. When actively receiving waste, this trench was 4.6 m (15 ft) deep. The trench has been backfilled and further stabilized with several feet of fill. Maximum concentrations of primary waste stream radionuclides detected in trench soil: • Nickel-63 17.6 pCi/g at 4.4 m (14.5 ft) bgs • Thorium-234 56.8 pCi/g at 4.4 m (14.5 ft) bgs • Uranium-233/234 6.0 pCi/g at 4.4 m (14.5 ft) bgs • Uranium-238 51 pCi/g at 4.4 m (14.5 ft) bgs • Radioactive strontium (total) 20.0 pCi/g at 5.3 m (17.5 ft) bgs. Maximum concentrations of primary waste stream nonradiological contaminants detected in trench soil: • Arsenic 7.0 mg/kg at 4.4 m (14.5 ft) bgs • Bismuth 36,400 mg/kg at 29.7 m (97.5 ft) bgs • Bis(2-ethylhexyl)phthalate 0.660 mg/kg at 4.4 m (14.5 ft) bgs • Boron 38.9 mg/kg at 4.4 m (14.5 ft) bgs • Manganese 538 mg/kg at 5.3 m (17.5 ft) bgs • Nitrate (as N) 9,860 mg/kg at 8.4 m (27.5 ft) bgs • Nitrate/nitrite (as N) 1,120 mg/kg at 9.9 m (32.5 ft) bgs • Tributyl phosphate 280,000 mg/kg at 4.4 m (14.5 ft) bgs • Uranium, total 130 mg/kg at 6.9 m (22.5 ft) bgs • Vanadium 96.1 mg/kg at 4.4 m (14.5 ft) bgs. Logging of nearby borehole (299-E25-10) 59 ft north of the trench did not detect Cs-137, indicating minimal lateral spread of contamination. The distribution shown by sample data and logging data showing maximum concentrations of Cs-137 (40 pCi/g) and U-238 (560 pCi/g) in the top 0.3 m to 3.4 m (1 ft to 11 ft) bgs) agree that the most contaminated area will be from about 5.5 m to 10.7 m (18 to 35 ft) bgs, medium amounts of contamination to 15.2 m (50 ft) bgs, and low contamination below 15.2 m (50 ft) bgs. Although deeper contamination could pose a potential threat to groundwater, soil-sampling data, the volume of effluent discharged, and groundwater-monitoring data confirm the contaminant distribution model (DOE/RL-2000-60, Rev. 1, Figure 3-11) showing that the 216-A-19 Trench likely did not impact groundwater. Moisture logs confirm this by showing no major areas of wetness for transport of mobile constituents to groundwater. Current groundwater risk screening identifies nitrates and uranium in soils above groundwater protection PRGs.

Table 2-2. 200-PW-2/200-PW-4 Operable Unit Representative Sites and Associated Analogous Waste Sites. (25 Pages)

Waste Site*	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory									Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
ANALOGOUS WASTE SITES TO BE EVALUATED BY THE 216-A-19 TRENCH MODEL														
216-A-1 Crib (216-A-1 Cavern, 216-A-1 Trench)	The 216-A-1 Crib operated during 1955 for disposal of depleted uranium waste from cold startup tests at PUREX. The crib is located inside the 200 East Area perimeter fence extension; east of 241-A Tank Farm, next to the 216-A-7 Crib. This crib is a drain-field-type crib approximately 9.1 m x 9.1 m (30 ft x 30 ft) at the bottom and is 4.57 m (15 ft) deep. The side slope from the surface to approximately 2.1 m (7 ft) deep is 1:1.5 and from approximately 2.1 m (7 ft) to site bottom is 1:2. The crib was fed by a 15 cm (6 in.) perforated pipe running horizontally at 2.7 m (9 ft) below grade with two 9.1 m (30 ft) lengths of 15 cm (6 in.) perforated pipes placed perpendicularly to the first length of pipe, forming an H pattern. There is a 15 cm (6 in.) vertical riser, from the bottom of the crib to 7.6 cm (3 in.) above original grade, in the center of the crib. The crib has two layers of sisal fiber paper separating the gravel fill from the backfill. There is approximately 1.8 m (6 ft) of coarse rock in the excavation bottom. The site was backfilled with about 0.6 m (2 ft) of material in 1992.	The 216-A-1 Crib operated during November and December of 1955, during cold startup testing at PUREX; during that time it received 98,400 L (26,000 gal) of depleted uranium waste. Some Cs-137, Co-60, and SR-90 also are present. When the specific retention capacity was reached, the site was deactivated by removal of the overground piping and backfilling.	1.53 E+02 Less than rep site. (1.38E+02)	1.00 E-01 Equal to rep site. (0)	(0)	4.44 E-02 Equal to rep site. (0)	4.22 E-02 Greater than rep site. (0)	80 Less than rep site. (1.07E+03)	(0)	(—)	(0)	98	1,980 Effluent volume to pore volume ratio: 0.05	As described below, the 216-A-1 Crib is analogous to or bounded by its representative site the 216-A-19 Trench with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Configuration:* Both sites are unlined disposal sites that are both the same surface and depth, although this site is a specific retention crib and the representative site is a trench. 2. *Waste stream origin/volume:* Both sites received the same cold startup waste from PUREX, although this site received less effluent. 3. *Contaminant inventory:* This site contains the same or smaller inventory of the primary radionuclide contaminants, making the representative site a bounding condition. 4. *Geology:* Both sites are located in the 200 East Area (near PUREX), and their geology is similar. 5. *Extent of contamination:* The representative 216-A-19 Trench site will be a bounding condition with regard to overall extent of contamination, because it received significantly more waste over a longer period of operations. However, the contamination distribution is expected to be similar for both sites, because both received similar contaminants at low volumes relative to soil pore volume. For this site, as for the representative site, the major zone of contamination will be near the trench bottom (about 15 ft). 6. *Groundwater impact:* For both sites, the effluent discharge volume is well below pore volume, correlating well with the conceptual contaminant distribution predicting no groundwater impact from this site.
216-A-3 Crib (216-A-3 Cavern)	The 216-A-3 Crib began operations in 1956 for disposal of PUREX waste. The crib is located in the 200 East Area. It is a drain-field-type crib that is approximately 6.1 m x 6.1 m (20 ft x 20 ft) at the bottom and is 4.88 m (16 ft) deep. The side slope surface to approximately 2.1 m (7 ft) deep is 1:1.5 and from approximately 2.1 m (7 ft) to the site bottom is 1:2. The crib is composed of a 10 cm (4 in.) perforated pipe running horizontally at 2.4 m (8 ft) below grade with two 6.1 m (20 ft) lengths of 10 cm (4 in.) perforated pipes placed perpendicularly to the first length of pipe, forming an H pattern. There is a 15 cm (6 in.) vertical riser, running from the bottom of the crib to approximately 7.6 cm (3 in.) above original grade, in the center of the crib. Two layers of sisal fiber paper separate the gravel fill from the backfill. The unit has about 2.4 m (8 ft) (280 m^3 [10,000 ft^3]) of gravel fill and has been backfilled.	The crib operated from 1956 to 1981. The site received 3,050,000 L (806,000 gal) of silica gel regeneration waste and pump house drainage from 203-A Acid Pump House (PUREX) and heating coil condensate drainage from the UNH storage pit tanks. The waste contained uranium, Cs-137, Sr-90, and Ru-106.	1.66 E+03 Less than rep site. (2.64E+03)	2.00 E-01 Similar to rep site. (1.74E-03)	(2.69E-05)	4.55 E-02 Similar to rep site. (2.45E-02)	4.31 E-02 Similar to rep site. (2.08E-02)	(4.65E+04)	(0)	(—)	(0)	3,050	952 Effluent volume to pore volume ratio: 3.2	As described below, the 216-A-3 Crib is analogous to or bounded by its representative site the 216-A-19 Trench, with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Configuration:* Both sites are unlined disposal sites of the same approximate depth, although this site is a specific retention crib and the representative site is a trench that is slightly smaller. 2. *Waste stream origin/volume:* The PUREX waste streams received by these sites are different, and this site received a greater volume of effluent. 3. *Contaminant inventory:* The contaminant inventory for this site for primary waste stream radionuclides is generally less or only slightly greater than the rep site (e.g., uranium was less, plutonium was slightly higher). However, the 216-A-19 Trench still bounds this site, because the site inventory identifies the same primary radionuclides (but not nitrates) but in higher quantities. 4. *Geology:* Both sites are located in the vicinity of PUREX in the 200 East Area, and their geology is similar. 5. *Extent of contamination:* Although effluent discharges to this site exceeded pore volume and the representative site did not, the contamination distribution should be similar and correlate with the conceptual contaminant distribution model. This is because the discharge occurred over a much longer period of time (<2 years for the rep site and 15 years for this site) so had less chance to overwhelm pore volume with large individual discharges. As a specific retention crib with an engineered retention capacity, this crib retained much of the contamination in the vicinity of the crib bottom (about 15 deep). 6. *Groundwater impact:* Although the volume of effluent exceeded crib pore volume at this site, the lower contaminant inventory of mobile contaminants (i.e., more mobile nitrates were not discharged to this site in significant quantities), so this site is not anticipated to have impacted groundwater.

Table 2-2. 200-PW-2/200-PW-4 Operable Unit Representative Sites and Associated Analogous Waste Sites. (25 Pages)

Waste Site*	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory: Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)	Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
216-A-18 Trench (216-A-18 Excavation, 216-A-18 Grave, 216-A-18 Sump, 216-A-18 Crib)	The 216-A-18 Trench is an unlined trench located outside the 200 East Area perimeter fence; east of the AX Tank Farm. It is approximately 24.4 m x 24.4 m (80 ft x 80 ft) at the bottom and is 4.9 m (16 ft) deep. The excavation side slope is 1:2. The trench is composed of a 40.6 cm (16 in.) fill pipe running horizontally at 2.1 m (7 ft) below grade with four 21 m (70 ft) lengths of 20 cm (8 in.) distribution pipes placed perpendicularly to the first length of pipe. These four distribution pipes are, in turn, connected to each other at their ends by two 20 cm (8-in.) pipes, 18 m (60 ft) in length. There are eight 10 cm (4 in.) vertical risers, two 20 cm (8 in.) vertical risers, and two 20 cm (8 in.) vent filters. There is approximately 2.1 m (7 ft) of coarse rock below the fill and distribution pipes and approximately 2.1 m (7 ft) of backfill above these pipes. The site was surface stabilized in 1990.	The 216-A-18 Trench operated during 1955 and received 488,000 L (129,000 gal) of depleted uranium waste from the cold startup run at the 202-A Building (PUREX). Later it received contact condenser cooling water from the 241-A-431 Tank Farm Ventilation Building via the 216-A-34 Ditch. The site was deactivated by removing the above-ground piping and backfilling the excavation after the specific retention capacity was reached.	1.39 E+03 Less than rep site. (6.82E+02)	1.0 E-01 Equal to rep site. (0)	 (0)	4.44 E-02 Equal to rep site. ((0)	4.20 E-02 Equal to rep site. (0)	730 Less than rep site. (5.29E+03)	 (0)	 (—)	 (0)	488	13,050 Effluent volume to pore volume ratio: 0.04	As described below, the 216-A-18 Trench is analogous to or bounded by its representative site the 216-A-19 Trench with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Configuration:* Both sites are unlined trenches of the same depth, although this site is much larger. 2. *Waste stream origin/volume:* Both sites received the same waste stream (PUREX cold startup waste and condenser cooling water from the 241-A-431 Tank Farm Ventilation Building) although this site received far less effluent. 3. *Contaminant inventory* The inventory of primary radionuclides at this site is similar, although less nitrates are reported. 4. *Geology:* These trenches are located adjacent to each other, and their geology is similar. 5. *Extent of contamination:* The 216-A-19 Trench should be a bounding condition for distribution of contamination because it received more effluent and the quantity of effluent was greater relative to site size (pore volume). This site also received the same or smaller quantities of the primary radionuclides. 6. *Groundwater impact:* This site received a similarly low volume of effluent relative to site pore volume and had a much smaller reported incidence of highly mobile nitrates, indicating a low potential for this site to have impacted groundwater.
216-A-20 Trench (216-A-20 Test Hole, 216-A-20 Grave, 216-A-20 Sump, 216-A-20 Crib)	The 216-A-20 Trench was constructed in 1955 for disposal of PUREX cold startup waste from the 202-A Building. It is located east of the 200 East Area perimeter fence and north of the 216-A-8 Crib. It is approximately 7.6 m x 7.6 m (25 ft x 25 ft) long and is 4.57 m (15 ft) deep. The trench was fed by aboveground piping. The site was deactivated by removing the above-ground piping and backfilling the excavation after the specific retention capacity was reached. The site was surface stabilized in 1990.	The 216-A-20 Trench operated during 1955 and received 961,000 L (254,000 gal) of PUREX 202-A cold start-up waste containing depleted uranium and nitric acid. Later it received contact condenser cooling water from the 241-A-431 Tank Farm Ventilation Building from overflow of the 216-A-34 Ditch.	4.01 E+02 Less than rep site. (6.21E+02)	1.0 E-01 Equal to rep site. (6.06E-03)	 (2.70E-03)	4.44 E-02 Equal to rep site. (0)	4.20 E-02 Equal to rep site. (4.15E-04)	210 Less that rep site. (1.45E+03)	 (0)	 (—)	 (0)	961	1,274 Effluent volume to pore volume ratio: 0.75	As described below, the 216-A-20 Trench is analogous to or bounded by its representative site the 216-A-19 Trench with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Configuration:* Both sites are unlined trenches that are essentially the same size and depth. 2. *Waste stream origin/volume:* Both sites received the same waste stream (PUREX cold startup waste and condenser cooling water from the 241-A-431 Tank Farm Ventilation Building at similar volumes and essentially the same volume relative to site pore volume. 3. *Contaminant inventory:* This site contains significantly less uranium and nitrates that are mobile constituents and the same or smaller quantities of the other primary radionuclides. 4. *Geology:* These trenches are located in the 200 East Area adjacent to each other, and their geology is similar. 5. *Extent of contamination:* The 216-A-19 Trench should be a bounding condition for distribution of contamination, because this site received less effluent overall, less effluent relative to size and pore volume, and equal or lesser quantities of primary radionuclides. 6. *Groundwater impact:* This site received a similarly low volume of effluent relative to site pore volume, and lower quantities of more mobile uranium and nitrates and, therefore, as with the representative site, had little potential to have impacted groundwater.

Table 2-2. 200-PW-2/200-PW-4 Operable Unit Representative Sites and Associated Analogous Waste Sites. (25 Pages)

Waste Site*	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory									Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
216-A-22 French Drain (216-A-22 Crib)	The 216-A-22 French Drain began operating in 1955 for disposal of incidental spillage during uranyl nitrate hexahydrate (UNH) transfers. This drain was located along the north wall of the PUREX 203-A Acid Pump House. The drain was approximately 4.9 m (16 ft) in diameter at grade and 1.8 m (6 ft) in diameter at the bottom with a truncated cone shape and was 4.9 m (16 ft) deep, with a side slope of 3:1. Two 10 cm (4 in.) effluent pipes are associated with the French drain. One pipe entered the crib 0.5 m (1.5 ft) above the original grade but was covered over by contaminant stabilization. The pipe from the truck loadout apron enters the site horizontally, 2.4 m (8 ft) below grade. Approximately 3 m (10 ft) of gravel fills the excavation bottom, which was covered with sisal fiber paper, and then the site was backfilled.	The 216-A-22 French Drain operated from 1955 to 1958 and received 10,000 L (2,600 gal) of liquid drainage from the 203-A Acid Pump House (PUREX) truck loadout apron, 203-A Acid Pump House enclosure sump waste, and heating coil condensate from the P-1 through P-4 UNH tanks. This waste was low in salt, neutral to basic, and contained uranium. The site was covered over with clean soil after a release was reported in 1959 (UPR-200-E-17) and another release in 1961 when a UNH tank truck overflowed on the loading apron at 203-Z into the French drain. The 216-A-22 French Drain is no longer visible. After 1961, this waste was diverted to the 216-A-28 Crib.	—	—	—	—	—	—	—	—	—	10	68 Effluent volume to pore volume ratio: 0.15	As described below, the 216-A-22 French Drain is analogous to or bounded by its representative site the 216-A-19 Trench with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Configuration:* Both sites are unlined excavations, both approximately 15 to 16 ft deep, although the 216-A -19 Trench is much larger. 2. *Waste stream origin/volume:* Both sites received liquid waste from PUREX operations containing uranium, but the quantity of effluent was small in comparison to that received by the 216-A-19 Trench, and an inventory of primary radionuclide contaminants was not developed for this site. 3. *Contaminant inventory:* The french drain received primarily uranium and in far less quantity, making the 216-A19 Trench a bounding condition. 4. *Geology:* Both units are located near PUREX in the 200 East Area and have similar geology. 5. *Extent of contamination:* The extent of contamination is bounded by the 216-A-19 Trench, because the french drain received far less effluent, received less effluent relative to pore volume and waste contained (primarily uranium), and has no reported inventory of other radionuclides. 6. *Groundwater impact:* Volume of effluent is very small and is low relative to soil pore volume and, . similar to the 216-A-19 Trench, has no reasonable potential to have impacted groundwater.
UPR-200-E-17 (Overflow at 216-A-22, UN-200-E-17)	The UPR-200-E-17 site was a spill to the surface of the 216-A-22 French Drain that occurred sometime between 1955, when the drain entered operations, and July 1959 when the spill was reported. The spill and drain are located north of PUREX and the 203-A Acid Pump House, near the 216-A-28 Crib. This area is within the 203-A Acid Pump House chained radiation zone. The contamination is assumed to be 3 ft deep into the otherwise clean crib overburden. Waste site dimensions are unknown.	UPR-200-E-17 occurred sometime between 1955 when the 216-A-22 French Drain began operations and July 1959 when report HW-60807 was issued. The report indicated that the spill occurred when the 216-A-22 French Drain inlet failed, releasing waste to the 216-A-22 French Drain surface and turning the ground surface yellow with uranium. In 1959, the spill area was covered with dirt. The uranium was from uranyl nitrate hexahydrate (UNH) storage. However, the volume released is unknown.												As described below, UPR-200-E-17, which occurred to the surface of the 216-A-22 French Drain is analogous to or bounded by the French drain's representative site, the 216-A-19 Trench, with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact. 1. *Configuration:* Both sites are discharges to bare soil, this release being a discharge to clean backfill over the contaminated 216-A-22 French Drain. The release is conservatively estimated to cover the entire surface of the French drain at a depth of 3 ft, because there were no hydraulic drivers beyond normal precipitation. 2. *Waste stream origin/volume:* Both sites received liquid waste from PUREX operations that contained uranium and no significant quantities of other radionuclides. However, because the trench was a designated deposal site, the UPR site effluent volume was much smaller, making the 216-A-19 Trench a bounding condition. 3. *Contaminant inventory:* The UPR received UNH that was primarily uranium and in far less quantity than the 216-A-22 French Drain that was bound by the 216-A-19 Trench, making the trench a bounding condition for this UPR. 4. *Geology:* The spill has the same geology as the 216-A-22 French Drain that is analogous to and bounded by the 216-A-19 Trench representative waste site. 5. *Extent of contamination:* As a spill of UNH to the otherwise clean backfill surface of the 216-A-22 French Drain, the contamination is expected to be similar (primarily uranium) and is included in the 216-A-22 French Drain contaminant inventory that is itself bounded by 216-A-19 Trench. Although this site has been covered over with clean soil, as a shallow contamination, it has potential for low human health and ecological direct contact risks in the 0 to 5 ft zone that have not been evaluated by the representative site investigation. 6. *Groundwater impact:* As incidental spill(s) and not routine discharges, the volume of effluent is small relative to soil pore volume, and the risk to groundwater from this UPR is bounded by the 216-A-19 Trench, which had no groundwater impact.

Table 2-2. 200-PW-2/200-PW-4 Operable Unit Representative Sites and Associated Analogous Waste Sites. (25 Pages)

Waste Site*	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory									Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
216-A-28 Crib	The 216-A-28 Crib began operations in 1958 for disposal of liquid waste from PUREX 203-A Acid Pump House sumps and heating coil condensate from the UNH tanks. This crib is located near the northwest corner of the 203-A Acid Pump House. It was constructed in a truncated cone shape, is circular, is 6.1 m (20 ft) in diameter at grade, and is 3 m (10 ft) at the bottom, and 3.35 m (11 ft) deep. The crib contains a 10 cm (4 in.) perforated pipe approximately 5.2 m (17 ft) long extending horizontally 1.2 m (4 ft) below grade and a 5 cm (2 in.) diameter perforated stainless steel liquid level riser pipe, 4 m (13 ft) long. The excavation contained approximately 2.7 m (9 ft) of gravel fill and was backfilled to grade. A polyethylene layer separates the gravel fill from the backfill.	The 216-A-28 Crib operated from 1958 to 1967 and received 30,000 L (7,900 gal) of liquid waste from the 203-A Acid Pump House sumps and from heating coil condensate from the UNH tanks. The waste was low in salt and neutral to basic and contained uranium. Until 1958, this waste stream had gone to the 216-A-22 French Drain. In November 1967, the effluent flow rate to the site exceeded the infiltration capacity and the site was deactivated. In 1981, the center of the unit was excavated and disposed of and backfilled to grade.	6.27 E+02 Less than rep site.	---	---	---	---	300 Less than rep site.	---	---	---	30	191 Effluent volume to pore volume ratio: 0.16	As described below, the 216-A-28 Crib is analogous to or bounded by its representative site the 216-A-19 Trench with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Configuration:* Both sites are unlined excavations, except that this site is shallower (11 ft vs 15 ft) and is much smaller. 2. *Waste stream origin/volume:* Both sites received liquid waste from PUREX operations that contained uranium but, because the effluent volume was small in comparison to that received by normal process waste disposal sites, the 216-A-19 Trench is a bounding condition. 3. *Contaminant inventory:* The crib waste was occasionally corrosive, was primarily uranium and nitrate, and was far less in quantity, making the 216-A-19 Trench a bounding condition. 4. *Geology:* Both units are located near PUREX in the 200 East Area and have similar geology. 5. *Extent of contamination:* The extent of contamination is bounded by the 216-A-19 Trench, because the crib received far less effluent, less effluent relative to pore volume, contained primarily uranium with no reported inventory of other radionuclides, and underwent extensive remediation activities in 1981. 6. *Groundwater impact:* Similar to 216-A-19 Trench, this site has no reasonable potential to have impacted groundwater, because the volume of effluent discharged to the site is far smaller than, and effluent volume is also low relative to, soil pore volume.

Table 2-2. 200-PW-2/200-PW-4 Operable Unit Representative Sites and Associated Analogous Waste Sites. (25 Pages)

Waste Site*	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory									Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
216-S-8 Trench (Cold Aqueous Trench, Cold Aqueous Crib, 216-S-3, Unirradiated Uranium Waste Trench, Cold Aqueous Grave	The 216-S-8 Trench began operating in 1951 for disposal of 202-S (REDOX) startup waste. The trench is located in the 200 West Area on the east side of SX Tank Farm and southwest of the 216-S-1&2 Cribs. It is unlined and is approximately 30.5 m x 18.3 m (100 ft x 60 ft) and is 7.6 m (25 ft) deep. This trench has been backfilled to grade.	The 216-S-8 Trench operated during 1951 and 1952 and received 10,000,000 L (3 Mgal) of unirradiated uranium startup waste from 202-S (REDOX.) that was acidic, containing uranium waste from REDOX startup and test runs. The crib was retired when startup testing was completed and the discharge of startup waste ceased. The crib was deactivated by removing the above-ground piping and backfilling the unit. In 1994, the crib surface was interim stabilized.	1.93 E+02 Less than rep site. (1.03E-01)	2.00 E+00 Greater than rep site. (0)	 (0)	4.92 E+00 Greater than rep site. (0)	3.86 E-01 Greater than rep site. (0)	100 Less than rep site. (1.40E+06)	 (0)	 (—)	 (0)	10,000	10,033 Effluent volume to pore volume ratio: 0.99	As described below, the 216-S-8 Trench is analogous to or bounded by its representative site the 216-A-19 Trench with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Configuration:* Both sites are unlined trenches but this site is deeper (25 ft vs 15 ft) and larger. 2. *Waste stream origin/volume:* 216-S-8 received 202-S (REDOX) waste and 216-A-19 Trench received (PUREX) waste. These waste streams were both from plant startup activities having uranium as the primary contaminant and some fission products. The 216-A-19 Trench contains significantly more uranium. This site received more effluent, but the same effluent quantity relative to soil pore volume (0.89 vs 0.99). 3. *Contaminant inventory:* The 216-A-19 Trench is bounding for the primary (and mobile) contaminants uranium and nitrate. However, this site contains more Cs-137 and Sr-90 than the representative site. 4. *Geology:* The 216-S-8 Trench is located in the 200 West Area, and the representative site is located in the 200 East Area. The geologies should be sufficiently similar for an analogous determination. 5. *Extent of contamination:* The 216-A-19 Trench is bounding for overall extent of contamination. Although this site received more of some contaminants and is 10 ft deeper, this site received significantly lower quantities of the more mobile contaminants uranium and nitrate and, although smaller, the representative site received the same quantity of effluent relative to pore volume creating the same hydraulic conditions. 6. *Groundwater impact:* Because this site received low mobility contaminants and the volume of effluent received did not exceed soil pore volume, this site is not likely to have contaminated groundwater.
216-A-34 Ditch (216-A-34 Crib)	The 216-A-34 Ditch began operations in 1955 for disposal of PUREX 241-A-431 Tank Farm Ventilation Building contact condenser cooling water. This site is located east of the 200 East Area perimeter fence and north of the 216-A-8 crib. It is approximately 85 m (280 ft) x 9 m (30 ft) long and is 1.8 m (6 ft) deep. The site consists of a headwall structure tapering off into an open ditch, which terminated at the 216-A-20 Trench. The ditch was extended to route this effluent to the 216-A-18, 216-A-19, and 216-A 20 Trenches. The ditch has been backfilled and was stabilized in 1990.	The 216-A-34 Ditch operated from 1955 to 1957 and received 2,100,000 L (555,000 gal) of PUREX 241-A-431 Tank Farm Ventilation Building contact condenser cooling water containing less than 1 Ci of total beta activity. The effluent volume received by this ditch was conservatively reported as a sum of the total volumes received by the 216-A-20 Trench (test hole) and the 216-A-19 Trench, although this approach does not consider that these sites received a different waste stream from aboveground piping.										2,100	11,990 Effluent volume to pore volume ratio: 0.175	As described below, the 216-A-34 Ditch is analogous to or bounded by its representative site the 216-A-19 Trench with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Configuration:* Both sites are unlined trenches, although this site is a shallower ditch (6 ft vs 15 ft). 2. *Waste stream origin/volume:* Both sites received PUREX waste streams, although this site received the lower activity contact condenser waste and the 216-A-19 Trench received PUREX startup waste. The actual volume of effluent received by this site was conservatively reported at a higher volume than it likely actually received. 3. *Contaminant inventory:* The 216-A-19 Trench received PUREX startup waste containing a significant inventory of radionuclide contaminants, whereas this site received only low-activity contact condenser waste and, as such, had no reportable contaminant inventory. 4. *Geology:* This site is collocated with the 216-A-19 Trench, and they have the same geology. 5. *Extent of contamination:* The extent of contaminant spread is bounded by the 216-A-19 Trench because this site is shallower, likely received less effluent than reported, and had a significantly lower activity level. As a shallower site, this site contamination is closer to the surface and represents a slightly different exposure scenario. 6. *Groundwater impact:* As a shallow ditch with no reportable contaminant inventory and with a low volume of low-activity effluent relative to pore volume, this site has no reasonable potential to have contaminated groundwater.

Table 2-2. 200-PW-2/200-PW-4 Operable Unit Representative Sites and Associated Analogous Waste Sites. (25 Pages)

Waste Site*	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory									Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
UPR-200-E-145 (W049H Green Soil, VCP Pipeline Leak)	UPR-200-E-145 was initiated in 1993 and is the site of a release of waste from the 216-A-8 Crib Proportional Sample Pit #2 to the 216-A-34 Ditch. This site is located east of the A Tank Farm entrance and northeast of the 242-A Evaporator Building. It is approximately 12 m (40 ft) x 1.8 m (6 ft) and 0.91 m (3 ft) deep.	Although initiated relatively recently (1993), the UPR-200-E-145 site contamination primarily was uranium oxide from past practices on the Hanford Site. The site was discovered when high radiation levels were found in an excavation, above a buried vitrified clay pipeline that carried waste from the 216-A-8 Crib Proportional Sample Pit #2 to the 216-A-34 Ditch, which was removed from service in 1957. The 216-A-34 Ditch primarily received PUREX 241-A-431 Tank Farm Ventilation Building contact condenser cooling water containing low levels of radioactivity (less than 1 Ci total beta activity). The volume released is unknown; however, the release would have occurred sometime between 1955 and 1957, when the crib was operating. Sampling showed that the soil contamination was primarily uranium oxide reaching to a depth of 3 ft.												As described below, UPR-200-E-145 is analogous to or bounded by its representative site the 216-A-19 Trench with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Configuration:* This site is contaminated soil resulting from a leaking VCP pipeline that remains in place and represents a much smaller and shallower area of contamination. 2. *Waste stream origin/volume:* Both sites received uranium-bearing PUREX waste. No volume of effluent has been assigned to this release, although this release from a sample line is presumed to be far less than the volume of effluent disposed of at the 216-A19 Trench disposal facility. 3. *Contaminant inventory:* No contaminant inventory has been identified for this release but the primary contaminant released is uranium. This site is bounded by the 216-A-19 Trench, which has a high uranium inventory, whereas an inventory for this site has not been estimated. 4. *Geology:* Because both sites are located in the same portion of the 200 East Area, their geology is the same. 5. *Extent of contamination:* Although a pipeline leak contaminant distribution model is different than a trench, this site is bounded regarding the extent of contamination, because this site is shallower, received less effluent volume, and contained primarily only uranium oxide. As a shallow contamination area, although low inventory, this site could present low human health and ecological risks in the 0 to 3 ft zone that have not been addressed by the rep site and may require consideration of an alternative remedial action. 6. *Groundwater impact:* As a UPR, this is not an engineered disposal site with a design pore volume. However, given that this site received essentially only uranium oxide and much less effluent than the 216-A-19 Trench (which has not anticipated groundwater), this site also has no reasonable potential to have contaminated groundwater.

Table 2-2. 200-PW-2/200-PW-4 Operable Unit Representative Sites and Associated Analogous Waste Sites. (25 Pages)

Waste Site*	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory									Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
REPRESENTATIVE SITE														
216-B-12 Crib (216-ER Crib, 216-ER-1,2,3 Cribs)	The 216-B-12 Crib was constructed in 1952 to dispose of condensate waste from 221-U (U Plant), 224-U (UO_3), and 221-B Plant (B Plant). The crib is located in the 200 East Area about 305 m (1,000 ft) northwest of the 221-B Building. The crib is approximately 49 m x 15 m (160 ft x 50 ft or 8,000 ft^2) at the bottom and is approximately 8 m (26 ft) deep on one end and 9 m (30 ft) deep on the downgradient end. The excavation has side slopes of 1:1. The crib is a series of three cascading, 5 m x 5 m x 3 m (16 ft x 16 ft x 10 ft)-high wooden boxes made from 15 cm x 20 cm (6 in. x 8 in.) Douglas-fir placed in an excavation 9 m (30 ft) deep. The wooden boxes are connected by a 15 cm (6 in.) vitrified clay pipe. The bottom 4 m (12 ft) of the crib contains 1.3 cm (0.5 in.) gravel backfill, 1.2 m (4 ft) of which underlie the boxes. It is not known whether the gravel backfill merely surrounds the boxes or fills them. The cribs subsided gradually to a final depression of 1.5 m (5 ft) in and the subsidence was backfilled (and the fill line blanked) in 1973. In 1974, the crib was stabilized with layers of sand and gravel, with a plastic liner to deter vegetation growth. An additional 0.6 m (2 ft) of clean soil was added in 1993. The cribs continue to have a possible cave-in potential.	The crib received process condensate from the 221-U and 224-U Buildings and the 221-B Building from November 1952 until December 1957. It was inactive from December 1957 until May 1967. From May 1967 until November 1973 the crib received process condensate from the 221-B Building via a 15 cm (6 in.) vitrified clay pipe, including limestone that was used for neutralization of the waste stream. During operations, the crib received approximately 520,000,000 L (140 Mgal) of liquid condensate that was low in salt, neutral to basic containing larger amounts of uranium, fission products, TBP, and ammonium nitrate (approximately 180,000 kg [396,832 lb]). The 216-B-12 Crib was deactivated in November 1973.	2.10 E+04 (1.51E+04)	3.74 E+02 (3.21E+00)	 (5.36E-02)	7.16 E+02 (3.26E+02)	7.93 E+01 (1.20E+02)	 (2.86E+06)	 (1.71E+01)	 (—)	 (0)	520,000	18,300 Effluent volume to pore volume ratio: 28.4	Radiological contamination was detected beneath the 216-B-12 Crib to a depth of 91.5 m (302 ft) bgs (water table). Maximum radionuclide concentrations were located at or above 12.1 m (40 ft) bgs, which is the major zone of contamination. When actively receiving effluent, the 216-B-12 Crib was about 7.9 m (26 ft) deep on one end and 9.1 m (30 ft) deep on the downgradient end. The crib was deactivated, backfilled, and covered with a plastic liner in 1974 and further stabilized with 0.6 m (2 ft) of clean soil in 1993. Maximum concentration for primary waste stream radionuclides detected in crib soils: • Thorium-230 1.19 pCi/g at 4.4 m (14.5 ft bgs) • Tin-126 0.742 pCi/g at 4.4 m (14.5 ft bgs) • Tritium 8.28 pCi/g at 4.4 m (14.5 ft bgs) • Cesium-137 61,900 pCi/g at 10.8 m (35.5 ft) bgs • Europium-155 34.9 pCi/g at 10.8 m (35.5 ft) bgs • Plutonium-239/240 3.90 pCi/g at 10.8 m (35.5 ft) bgs • Potassium-40 15.8 pCi/g at 60.2 m (197.5 ft) bgs • Total radioactive strontium 12,700 pCi/g at 10.8 m (35.5 ft) bgs • Uranium-233/234 4.90 pCi/g at 12.2 m (40 ft) bgs • Uranium-238 12.1 pCi/g at 12.2 m (40 ft) bgs. The following are maximum concentrations of other radionuclides discharged: Actinium-228 (1.02 pCi/g), Americium-241: (2.00 pCi/g), Bismuth-214 (1.05 pCi/g), Carbon-14 (3.30 pCi/g), Lead-214 (1.08 pCi/g), Radium-226 (1.05 pCi/g), Radium-228 (1.02 pCi/g), Thorium-228 (7.54 pCi/g), and Thorium-234 (2.01 pCi/g). Maximum concentrations for primary nonradioactive contaminants discharged to the crib: • Arsenic 7.30 mg/kg at 4.4 m (14.5 ft bgs) • Bis(2-ethylhexyl)phthalate 18.0 µg/kg at 4.4 m (14.5 ft bgs) • Boron 1.30 mg/kg at 4.4 m (14.5 ft bgs) • Nitrate (as N) 165 mg/kg at 4.4 m (35.5 ft bgs) • Nitrate/nitrite (as N) 126 mg/kg at 4.4 m (50 ft bgs) • Uranium (total) 28.0 mg/kg at 4.4 m (35.5 ft bgs). Geophysical logging and lab data for Cs-137, U-238, and Eu-154 generally agree on the vertical distribution of the radionuclides. Soil data, effluent discharge volume, and groundwater monitoring data confirm the conceptual model indicating that the 216-B-12 Crib may have impacted groundwater. The presence of nitrate in deep soils, identified in process history but not assigned a designated contaminant inventory, has been confirmed by sampling. However, current groundwater monitoring identifying I-129 and Nitrate (as N) plumes extending from B Plant, which are also possibly beneath the crib does not identify the crib as a source of the contamination and does not report exceedances of groundwater parameters in wells associated with the crib. Current modeling indicates that tritium could reach groundwater at trace levels after approximately 526 years. The conceptual contaminant distribution model (DOE/RL-2000-60, Rev. 1, Figure 3-12) correlates well with the characterization results (i.e. , most radionuclides and metals were found in the predicted high-contamination range [4.5 m to 19.7 m (15 to 65 ft) bgs], and those found in elevated concentrations farther down the borehole were in the predicted medium-contamination range [to 30.3 m (100 ft) bgs] [(except chromium at 30 p/m at the 91.5 m (302 ft) bgs level]).

Table 2-2. 200-PW-2/200-PW-4 Operable Unit Representative Sites and Associated Analogous Waste Sites. (25 Pages)

Waste Site*	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory: Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)	Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
ANALOGOUS WASTE SITES TO BE EVALUATED BY THE 216-B-12 CRIB MODEL														
216-B-60 Crib	The 216-B-60 Crib was constructed in 1967 for disposal of solid and liquid wastes generated from the cleanout of the 221-B Plant Canyon Building cell drain header. This crib is located in the 200 East Area at the west end of the 221-B Building under a portion of the 225-B Building (WESF). The crib was constructed of two steel vertical cascading caissons positioned side by side that are 2.4 m (8 ft) in diameter, 4.2 m (14 ft) tall, and covered by 46 cm (18 in.)-thick concrete tops. The south caisson has a 2.4 m x 4 m x 20 cm thick (8 ft x 13 ft x 8 in.) slab attached to its upper rim. The depth from grade level to the bottom of the caissons is 12.19 m (40 ft). The two caissons received waste via a 0.6 m (24 in.) line, which was plugged after cleanout, and the caissons were backfilled to grade. The site is covered by the southeast corner of the 225-B WESF and cannot be surveyed.	The 216-B-60 Crib was specifically built for solid and liquid wastes generated from the cleanout of the 221-B Building cell drain header and operated during November and December of 1967. The first caisson received 185,706 L (4887 gal) of sludge solids and was capped with concrete. The second caisson received a small volume of flush water. The crib received 18,900 L (5,000 gal) of effluent that was low in salt, neutral to basic containing uranium, plutonium, Ce-144, Cs-137, and Eu-154.	7.20 E+02 Less than rep site. (6.33E-01)	8.00 E-02 Less than rep site. (1.11E+00)	(2.93E-06)	8.00 E+00 Less than rep site. (2.79E-03)	(2.28E-03)	(1.84E+02)	—	(—)	(0)	18.9	438 Effluent volume to pore volume ratio: 0.04	As described below, the 216-B-60 Crib is analogous to or bounded by its representative site the 216-B-12 Crib with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Configuration:* Both sites are bottom-exit specific retention cribs but are constructed differently. The 216-B-60 crib is round steel caissons whereas the representative 216-B-12 Crib is square wooden boxes. This site, at 40 ft deep, is approximately 10 ft deeper. 2. *Waste stream origin/volume:* Both sites received 221-B cell waste streams, except that because the 216-B-60 Crib was for a single cell drain residual cleanout campaign, it received significantly less effluent but more sludge and solids. 3. *Contaminant inventory:* 216-B-12 Crib received waste streams containing the same primary radionuclides. However, as a single, short duration campaign, this site received significantly less effluent than the 216-B-12 Crib making the representative site a bounding condition. 216-B 12 Crib sampling confirms the presence of uranium, plutonium, Cs-137, and Europium isotopes detected in composite sampling of the 216-B-60 Crib solid waste (sample numbers B-814, B-815, and B-816) but not identified in the waste inventory for this site. Composite samples of the 216-B-60 Crib solid waste also detected Ce-144, which is not listed in the site inventory and was not detected at the 216-B-12 Crib. 4. *Geology:* Both sites are located near B Plant on the west side of the 200 East Area, making their geology similar. 5. *Extent of contamination:* Because the site received a quantity of effluent waste that was small and even smaller relative to pore volume, it is anticipated that much of the waste remains within and just below the crib structure, consistent with the 216-B-12 Crib contaminant distribution. 6. *Groundwater impact:* This site received significantly less effluent than the representative site and used only a small fraction of the calculated pore volume, suggesting that this site, contrary to the representative site that impacted groundwater, had little potential to have impacted groundwater.
216-C-3 Crib (201-C Leaching Pit)	The 216-C-3 Crib was constructed in 1953 for disposal of process condensate from C Plant (Hot Semiworks). It is located in the 200 East Area within the larger posted URM area known as the Stabilized Hot Semiworks Area (200-E-41). It is approximately 15.2 m x 3 m (50 ft x 10 ft) and is 3 m (10 ft) deep. The crib consists of 15 cm (6 in.) pipes resting on a welded wire fabric over a gravel bed, which created a drain-field-type crib. The inlet piping entered the crib 2.4 m (8 ft) below grade. The crib was deactivated by blanking the inlet pipeline and backfilling the excavation with sand and gravel. In 1979, the area containing this crib and several others was stabilized by leveling and adding sand, a layer of plastic, and gravel. More stabilization work was done in the area in 1992 and 1999, the latter related to the development of the 200-E-41 Stabilized Hot Semiworks Area waste site.	The 216-C-3 Crib operated during 1953 and 1954 and received 5,000,000 L (1.3 Mgal) of process condensate from 201-C, the 215-C Gas Preparation Building, and the 271-C Aqueous Makeup and Control Building, which contained nitric acid, uranium, and other fission products from experimental REDOX runs.	4.50 E+01 Less than rep site. (4.54E+00)	1.0 E+00 Less than rep site. (1.24E-02)	(2.84E-02)	4.24 E-02 Less than rep site. (2.19E+00)	8.04 E+00 Less than rep site. (9.78E+00)	(7.65E+04)	(0)	(—)	(0)	5,000	1,211 Effluent volume to pore volume ratio: 4.1	As described below, the 216-C-3 Crib is analogous to or bounded by its representative site the 216-B-12 Crib with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Configuration:* Both units are specific retention cribs but this site is a drain-field-type crib and the representative site is a box-type crib. This site is much smaller at 500 (vs 8000) ft^2 and much shallower at 10 ft (vs 26-30 ft) deep for the representative site. 2. *Waste stream origin/volume:* Both sites received process condensate generated during from REDOX startup testing, except that this site received significantly less effluent (100 times less) as condensate derived from processing of this waste at C Plant. 3. *Contaminant inventory:* The site has significantly lower inventories of the primary waste stream radionuclides, making the 216-B-12 Crib a bounding condition. 4. *Geology:* These sites are both located in the west portion of the 200 East Area, and their geology is similar. 5. *Extent of contamination:* The potential extent of contamination for this site is significantly less because the site is shallower, received significantly less effluent volume as a hydraulic driver, and has a smaller effluent-to-pore-volume ratio. 6. *Groundwater impact:* Although the effluent exceeded pore volume, the actual volume of effluent received was relatively low, suggesting that this site had a much lower potential to have affected groundwater.

Table 2-2. 200-PW-2/200-PW-4 Operable Unit Representative Sites and Associated Analogous Waste Sites. (25 Pages)

Waste Site*	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory: Total U (kg)	Contaminant Inventory: Total Pu (g)	Contaminant Inventory: Am-241 (Ci)	Contaminant Inventory: Cs-137 (Ci)	Contaminant Inventory: Sr-90 (Ci)	Contaminant Inventory: Nitrate (kg)	Contaminant Inventory: NPH (kg)	Contaminant Inventory: $Na_2Cr_2O_7$ (kg)	Contaminant Inventory: TBP (kg)	Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
216-C-5 Crib (200-E-41)	The 216-C-5 Crib was constructed in 1955 for disposal of 201-C (Hot Semiworks) high-salt waste from PUREX startup tests. The crib is located in the 200 East Area within the Stabilized Hot Semiworks Area (200-E-41). It is a drain-field-type crib approximately 6.1 m x 3 m (20 ft x 10 ft) at the bottom. The excavation has a truncated wedge-shaped cross section. The crib received waste via 15 cm (6 in.) diameter galvanized, corrugated, perforated piping placed horizontally at 3.4 m (11 ft) below grade. The waste release point is 1.5 m (5 ft) from the site bottom. The site was approximately 16 ft deep. Two 6.1 m (20 ft) lengths were placed perpendicularly to the 5 cm (2 in.) diameter inlet pipe, forming an H pattern. The site contains approximately 1.8 m (6 ft) or 74 m^3 (2,600 ft^3) of gravel fill and has been backfilled. The surface area was later stabilized in 1979 and is now known as the Stabilized Hot Semiworks Area 200-E-41. The crib was deactivated in 1955 by valving out the effluent pipeline when the specific retention capacity was reached	The 216-C-5 Crib operated during 1955 and received 37,900 L (10,000 gal) of PUREX startup run high-salt waste (HSW) from the 201-C Building, containing nitric acid, uranium, and other fission products. Some waste had passed through the 241-CX-71 Neutralization Tank.	5.40 E+01 Less than rep site. (2.07E+01)	1.00 E+00 Less than rep site. (0)	(0)	4.44 E-02 Less than rep site. (0)	4.20 E+00 Less than rep site. (0)	(4.22E+02)	(0)	(---)	(0)	38	484 Effluent volume to pore volume ratio: 0.08	As described below, the 216-C-5 Crib is analogous to or bounded by its representative site the 216-B-12 Crib with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Configuration:* Both units are specific retention cribs, but this site is a drain-field-type crib and the representative site is a box-type crib. This is much smaller at 2,200 (vs 8000) ft^2 and much shallower at 16 ft (vs 26-30 ft) deep for the representative site. 2. *Waste stream origin/volume:* This site received waste derived from experimental use of PUREX waste, although this site received significantly less effluent (13, 000 times less), making the 216-B-12 Crib a bounding condition. 3. *Contaminant inventory:* This site contains the same primary radionuclides but in significantly lower quantities and so is bounded by the 216-B-12 Crib. 4. *Geology:* These sites are both located in the west portion of the 200 East Area, and their geology is similar. 5. *Extent of contamination:* The potential extent of contamination at this site is considerably less than the bounding 216-B-12 Crib, because this site is smaller, shallower, received far less effluent, and effluent discharge did not exceed pore volume as did the 216-B-12 Crib. 6. *Groundwater impact:* Because of the low overall volume of effluent received by this site and because effluent volume did not exceed pore volume, this site had little likelihood of impacting groundwater.
216-C-7 Crib	The 216-C-7 Crib was constructed in 1961 for disposal of effluent from the 209-E Critical Mass Laboratory, which performed criticality experiments on Pu and enriched uranium solutions. The crib received condensate waste from the 209-E Critical Mass Laboratory Valve Pit and Hold Up Tank (209-E-TK-111) that contained plutonium and nitric acid. The crib is located in the 200 East Area, southwest of the 209-E Building, and inside the 209-E exclusion area fence. It is a drain-field-type crib that is approximately 13.7 m x 15.2 m (45 ft x 50 ft) at the surface; approximately 6.1 m x 6.1 m (20 ft x 20 ft) at the bottom, and 3.66 m (12 ft) deep. The crib received waste via a 5 cm (2 in.) diameter process waste line that fed into a 0.15 m (6 in.) diameter, perforated vitrified clay pipe placed horizontally 3 m (9 ft) below grade on a bed of gravel. Two lengths of clay pipe were placed perpendicularly to the first clay line, forming an H pattern. The site contains 123 m^3 (4,100 ft^3) of gravel fill and has been backfilled.	The 216-C-7 Crib operated from 1961 to 1983 and received 60,100 L (15,900 gal) of liquid waste from the 209-E Critical Mass Laboratory, generated during critical mass experiments that contained uranium, plutonium, and limited amounts of Cs-137, Sr-90, and Ru-106. The crib was placed on standby in 1983.	1.00 E-02 Less than rep site. (3.65E-05)	1.10 E+00 Less than rep site. (3.18E-08)	(0)	5.34 E-02 Less than rep site. (0)	5.12 E-02 Less than rep site. (0)	(0)	(7.87E-02)	(---)	(0)	60	967 Effluent volume to pore volume ratio: 0.06	As described below, the 216-C-7 Crib is analogous to or bounded by its representative site the 216-B-12 Crib with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Configuration:* Both are engineered cribs with a specific retention, although this site is a drain-field-type crib and the 216-B-12 Crib is a box crib. This site is shallower at 12 ft (vs 24-30 ft) deep and smaller at 2,250 ft^2 (vs 8,000 ft^2). 2. *Waste stream origin/volume:* Both sites received PUREX waste containing the same primary radionuclides, but as a laboratory disposal site, the 216-C-7 Crib received significantly less effluent (approximately 500 times less). 3. *Contaminant inventory:* Both sites contain the same primary radionuclides, but this site contains significantly less contaminant inventory. Although process knowledge identifies a potential for this site to have received Ru-106, representative site 216-B-12 sampling did not detect this constituent. 4. *Geology:* These sites are both located in the west portion of the 200 East Area, and their geology is similar. 5. *Extent of contamination:* The potential extent of contamination at this site is small compared to the bounding 216-B-12 Crib because this site is smaller, shallower, and received far less effluent, and the effluent discharged did not exceed pore volume as did the 216-B-12 Crib. 6. *Groundwater impact:* The low overall volume of effluent received by this site and the fact that effluent volume did not exceed pore volume, suggests that this site, contrary to the rep site, had little likelihood of impacting groundwater.

Table 2-2. 200-PW-2/200-PW-4 Operable Unit Representative Sites and Associated Analogous Waste Sites. (25 Pages)

Waste Site*	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory									Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
216-C-10 Crib	The 216-C-10 Crib was constructed in 1964 for disposal of process condensate from the 201-C Hot Semiworks Plant. The crib is located in the 200 East Area, southeast of the 201-C Building. It is approximately 9.8 m x 1.5 m (32 ft x 5 ft) and approximately 8 ft deep. Waste arrived via a 7.6 cm (3 in.) diameter stainless steel pipe, located horizontally, 1.2 m (4 ft) below grade. Because such cribs typically drained to at least 3 to 4 ft of gravel for waste retention, this crib is expected to have been about 8 ft deep. The site slope is 1:1.5. The site contains 48 m^3 (1,700 ft^3) of gravel fill and has been backfilled with dirt. The crib was surface stabilized in 1989, and in July 2000 the vent risers were sealed to prevent possible passive radioactive emissions.	The 216-C-10 Crib operated from 1964 to 1969 and received 897,000 L (237,000 gal) of process condensate and acidic liquid waste from the 201-C Building containing strontium, cerium, cesium, and promethium from strontium and rare-earth metal recovery experiments.	5.00 E-02 Less than rep site. (6.52E-03)	1.50 E-01 Less than rep site. (2.12E-02)	 (1.42E-01)	8.55 E-02 Less than rep site. (4.40E+00)	3.45 E+00 Less than rep site. (1.96E+01)	 (1.07E+01)	 (0)	 (—)	 (0)	897	387 Effluent volume to pore volume ratio: 2.3	As described below, the 216-C-10 Crib is analogous to or bounded by its representative site the 216-B-12 Crib with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Configuration:* Both are engineered specific retention cribs, although this site is a drain-field-type crib and the 216-B-12 Crib is a box crib. This site is shallower (8 ft vs 24-30 ft) and significantly smaller (160 ft^2 vs 8,000 ft^2). 2. *Waste stream origin/volume:* Both sites received PUREX derived waste, although this waste was from 201-C Building rare-earth recovery experiments using PUREX waste. This site received significantly less effluent (approximately 580 times less). 3. *Contaminant inventory:* Both sites contain the same primary radionuclides, but this site contains a significantly smaller inventory. Process knowledge identifies a potential for promethium and cerium because of the nature of the 201-C rare-earth recovery experiments performed using PUREX waste. However, these radionuclides were not detected in 216-B-12 Crib soils. 4. *Geology:* These sites are both located in the west portion of the 200 East Area, and their geology is similar. 5. *Extent of contamination:* The potential extent of contamination at this site is small compared to the bounding 216-B-12 Crib, because this site is smaller, shallower, and received far less effluent, although effluent volume exceeded pore volume (by 2 times), as did the 216-B-12 Crib. 6. *Groundwater impact:* The low overall volume of effluent received by this site, even though effluent volume exceeded pore volume, suggests that this site, contrary to the representative site, had little likelihood of impacting groundwater.
209-E-W3-S (Critical Mass Laboratory Valve Pit and Hold-Up Tank (209-E-TK-111), IMUST, Inactive Miscellaneous Underground Storage Tank)	The 209-E-WS-3 site is the 209-E Critical Mass Laboratory Valve Pit and Hold-Up Tank (209-E-TK-111) that is located underground, near the south end of the 209-E Critical Mass Laboratory in the 200 East Area. This tank began operating in 1960 for storage of condensate from the 209-E Critical Mass Laboratory prior to release to the 216-C-7 Crib. The valve pit is a 1.5 m x 2.1 m x 2.1 m deep (5 ft x 7 ft x 7 ft), in-ground concrete pit with 15 cm (6 in.) thick walls, which extends 0.9 m (3 ft) above grade and has a steel lid. It houses an air filter, sample port, pump assembly, valves, and associated piping. Tank 209-E-TK-111 has a 189 L (50-gal) capacity, is located beneath the valve pit, and is lined with cadmium. It is approximately 2.4 m long x 9 cm wide x 1.2 m deep (8 ft x 3.5 in x 3.8 ft). The elevation at the bottom of the tank is 205.86 m (675.4 ft). The tank rests on an approximately 2.4 m x 30 cm (7.6 ft x 12 in.) settling pad that is 15 cm (6 in.) thick.). The north edge of the tank is about 0.9 m (3 ft) south of the south wall of the 209-E Critical Mass Laboratory 's Critical Assembly Room and abuts the east side of the exhaust equipment pad.	This site operated from 1960 to 1989 to hold condensate from the 209-E Critical Mass Laboratory, which contained plutonium and nitric acid. The tank currently is considered inactive but may still contain some condensates, primarily water with only small concentrations of plutonium. Condensate drained from the 209-E Critical Mass Laboratory into the holding tank underneath the valve pit. There is no history of leaks from this tank.												As described below, the 209-E-WS-3 site is analogous to or bounded by its representative site the 216-B-12 Crib with regard to process history, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Configuration:* This site is a storage tank and concrete valve pit, as opposed to an unlined disposal crib and is therefore configured differently. However, this site is bound by the 216-B12 Crib because it is much smaller (overall 35 ft^2) and shallower (3.8 ft deep). 2. *Waste stream origin/volume:* Both sites received the same 209-E Critical Mass Laboratory waste, although as a waste conduit and not a disposal site, this site has no reportable effluent volume. 3. *Contaminant inventory:* As a temporary holding tank that acted as a waste conduit with no known history of leaks, this tank does not have a reported soil column inventory. However, the tank could currently contain some residual waste (<50 gal). 4. *Geology:* This site is close to the 216-B-12 Crib in the 200 East Area, and their geology is the same. 5. *Extent of contamination:* The 216-B-12 Crib is bounding for extent of contamination for the tank (and for any tank removal area), because the current site inventory is limited to the tank volume (<50 gal) and any waste residues remaining on tank surfaces, and because this waste site has no reported soil column inventory. If waste had been discharged via unreported leaks, the releases would be shallower, because the tank bottom is only 3.8 deep and would have constituents similar to those of the 216-C-7 Crib, which also is bound by the 216-B-12 Crib. 6. *Groundwater impact:* As a storage tank with no reported history of contamination and no reported soil column inventory, this site has no reasonable potential to have impacted groundwater.

Table 2-2. 200-PW-2/200-PW-4 Operable Unit Representative Sites and Associated Analogous Waste Sites. (25 Pages)

Waste Site*	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory									Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
270-E-1 (270-E CNT, 270-E Condensate Neutralization Tank, 216-ER-1)	The 270-E-1 site is the 270-E Condensate Neutralization Tank, 216-ER-1, which was installed in 1952 as part of the 270-E Neutralization Facility. This facility is located in the 200 East Area for neutralization of acidic process condensate from the 221-B Plant and 224-B Concentration Facility from the 241-ER-151 Diversion Box. The tank is located west of the 221-B Plant, near the southwest corner of the 216-B-64 Retention Basin. The condensate neutralization tank is 2.7 m (9 ft) in diameter with an approximate 15,840 L (4,185 gal) capacity. This is an underground steel tank with a 1 m (40 in.) carbon steel charging riser used for adding limestone (neutralizing agent). The tank is buried approximately 20 ft (derived) deep and also had a 15 cm (6 in.) diameter riser extending to the surface from the tank top. The tank stands vertically on a 0.46 m (1.5 ft) thick concrete pad. Waste entered the tank through a 7.6 cm (3 in.) inlet pipe at the base of the tank, which forced the waste through the neutralizing limestone bed and the 15.2 cm (6 in.) overflow outlet piping that discharged 2.4 m (8 ft) above the tank bottom. Because of the design of the tank and the orientation of the inlet and outlet piping, waste may remain in the tank and some of the inlet piping. The inlet and outlet lines have been capped	The 270-E-1 Neutralization Tank operated from 1952 to 1957 as part of the 270-E Neutralization Facility to neutralize acidic process condensate from the 221-B and 224-B facilities, via the 241-ER-151 Diversion Box. The waste contained acidic process condensate precipitates, salt, uranium, minor plutonium, TBP, and other beta emitters. Tank inspection in 1974 estimated the sludge volume at 14.4 m^3 (3,800 gal). Volume of releases (if any) is unknown, because there is no reported history of leaks. The neutralized waste was discharged to the 216-B-12 Crib. The description of waste site UPR-200-E-64 documents that ants brought contamination to the surface in the vicinity of the 270-E-1 Neutralization Tank and caused contamination to spread to surrounding soil.												As described below, the 270-E-1 waste site is analogous to or bounded by its representative site the 216-B-12 Crib with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Configuration:* This site is a buried metal waste neutralization tank that acted as a conduit to the 216-B-12 Crib for waste and is not an unlined near-surface liquid waste disposal site. At approximately 20 ft deep, this site is 6 to 10 ft shallower than the crib and is much smaller in size. 2. *Waste stream origin/volume:* Both sites received 221-B waste streams although, because this site was a waste conduit and not a disposal site, the volume of waste received is inconsequential. 3. *Contaminant inventory:* Both sites received the same primary radionuclides but, as a waste conduit with no known history of spills, no contaminant inventory has been identified for this site. The current tank inventory is limited to only the waste that could not drain from the tank under normal operating conditions and waste residues on tank surfaces. Because such residual waste and waste released from the tank, if any, would be shallower, of much smaller quantity, and would contain similar constituents, the 216-B-12 Crib is bounding for the tank. 4. *Geology:* Both sites are located in the 200 East Area, and their geology is the same. 5. *Extent of contamination:* The potential extent of contamination for this site will be much less because there is no known history of spills, which (if any) would be smaller, shallower, and incidental versus designed disposal. 6. *Groundwater impact:* There was no known history of disposal of waste to the soil column at this site, so no potential exists for groundwater contamination from this tank.
UPR-200-E-64 (UN-216-E-64, Radioactive Soil and Ant Hills, UN-200-E-64, UN-216-E-36)	UPR-200-E-64 was initiated in 1984 to identify radiological near-surface soil contamination (speck contamination) located in the 200 East Area adjacent to the west side of 216-B-64 Retention Basin. The most likely source for this is a 'swab riser' associated with an underground pipeline in the vicinity of the 270-E-1 Neutralization Tank. As of 1995, this site it was approximately 8,100 m^2 (2 a). In March 2001, the contaminated area was surface stabilized with 2 ft of clean backfill and reposted as an Underground Radioactive Materials area.	The UPR-200-E-64 site consists of migrating radioactive speck contamination that was identified in 1984. The contamination was transported to the surface by ants as they burrowed into contaminated soil. This location is a posted radiological surface contamination area that has increased in size because of wind and, as of 1995, was approximately 8,100 m^2 (2 acres). The contamination consists primarily of Cs-137 and Sr-90. The volume of contamination released is unknown, and the depth of contamination also is unknown but is conservatively placed at 3 ft.												As described below, the UPR-200-E-64 waste site is analogous to or bounded by its representative site the 216-B-12 Crib with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Configuration:* This site is near-surface speck contamination (not a disposal structure) that, although it is larger in surface area, is shallower (now 2 ft deep since the site was stabilized). It was primarily wind spread. 2. *Waste stream origin/volume:* This site did not receive effluent, but instead received the same waste constituents in the form of contaminated residues tracked to the surface by ants and then spread by wind, accounting for the current site size. 3. *Contaminant inventory:* As very near-surface (2-3 ft deep) speck contamination, the contaminant inventory is minimal, shallow, and bound by the 216-B-12 Crib. 4. *Geology:* The sites are both located in the 200 East Area, and their geology is similar. 5. *Extent of contamination:* Although larger in surface area, this site as a speck contamination area did not receive effluent, contains no designated waste inventory, is much shallower, and so is bounded by the 216-B-12 Crib. Because the near-surface contamination is shallower than the 216-B12 Crib, this site has potential human health and ecological risks in the 0 to 15 ft zone that have not been evaluated by the representative site investigation. 6. *Groundwater impact:* This site does not represent a release of effluent and so has no potential to have impacted groundwater.

Table 2-2. 200-PW-2/200-PW-4 Operable Unit Representative Sites and Associated Analogous Waste Sites. (25 Pages)

Waste Site*	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory									Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
REPRESENTATIVE SITE														
216-S-7 Crib (216-S-15)	The 216-S-7 Crib was constructed in 1956 for disposal of liquid waste from 202-S (REDOX) D-1 and D-2 cell tanks. The crib is located in the 200 West Area northwest of the 202-S Building. This crib replaced the 216-S-1 and 216-S-2 Cribs. The waste site consists of two roofed wooden boxes, each 4.9 x 4.9 m (16 x 16 ft) square by 1.6 m (5.2 ft) centered 15.2 m (50 ft) apart. The excavation was 15.2 x 30.4 m (50 x 100 ft) at the bottom, 6.7 m (22 ft) deep, and has side slopes of 1:1. The excavation was 28.7 x 43.9 m (94 x 144 ft) at the surface. The boxes received liquid waste through a 7.6 cm (3 in.), 304 L stainless steel pipeline buried approximately 4.6 m (15 ft) bgs. The pipe was covered with a gravel and sand cover and then covered by a vapor barrier (two layers of heavy construction paper) that extended over the entirety of the gravel bed and lapped up the side of the excavation 0.61 m (2 ft). Two schedule 40, 10 cm (4 in.) risers extended from the roof of the boxes to above grade (above grade portions have since been removed). In 1992, at least 0.61 m (2 ft) thickness of clean soil was placed over the site.	The 216-S-7 Crib operated from 1956 to 1965 and received 390,000,000 L (103,000,000 gal) of 202-S process waste cell drainage and process condensate containing 10,000 kg of nitrate, 40,000 kg of aluminum nitrate, 250,000 kg of nitric acid, and 7,000 kg of sodium nitrate, sodium, plutonium, uranium, and fission products. The initial inventory may have included 25 Ci of Co-60 and 1,500 Ci of Ru-106 and methyl isobutyl ketone (hexone) as a primary separation chemical for the REDOX process.	2.56 E+03 (3.41E+02)	4.40 E+02 (1.18E+03)	 1.68E+01)	7.03 E+02 (9.79E+02)	1.39 E+03 (1.47E+03)	110,000 (4.32E+05)	 (0)	 (—)	 (0)	390,000	8,361 Effluent volume to pore volume ratio: 46.6	Contamination was detected beneath the 216-S-7 Crib to a depth of 68.8 m (225.f ft) bgs (groundwater table) in Borehole C4557. Maximum concentrations for most radiological and chemical contaminants were near the crib bottom at 6.7 m (22 ft). Crib subsidence was backfilled in 1992 and possibly again later making backfill material depth greater than 0.6 m (2 ft). Maximum concentration of primary waste stream radionuclides detected in crib soils were: • Americium-241 1,900 pCi/g at 7.3-8.1 m (24-26.5 ft) bgs • Cesium-137 20,000 pCi/g at 7.3-8.1 m (24-26.5 ft) bgs • Neptunium-237 6.80 pCi/g at 7.3-8.1 m (24-26.5 ft) bgs • Nickel-63 13.7 pCi/g at 7.3-8.1 m (24-26.5 ft) bgs • Plutonium-238 190 pCi/g at 7.3-8.1 m (24-26.5 ft) bgs • Plutonium 239/240 11,000 pCi/g at 7.3-8.1 m (24-26.5 ft) bgs • Potassium-40 16.2 pCi/g at 13.4-14.2 m (44-46.5 ft) bgs • Strontium-90 53,000 pCi/g at 7.3-8.1 m (24-26.5 ft) bgs • Technetium-99 14.7 pCi/g at 7.3-8.1 m (24-26.5 ft) bgs • Thorium-228 4.78 pCi/g at 7.3-8.1 m (24-26.5 ft) bgs • Tritium 1,410 pCi/g at 47.3-48.0 m (155-157.5 ft) bgs • Uranium 233/234 230 pCi/g at 7.3-8.1 m (24-26.5 ft) bgs • Uranium-235 25.0 pCi/g at 7.3-8.1 m (24-26.5 ft) bgs • Uranium-238 200 pCi/g at 7.3-8.1 m (24-26.5 ft) bgs Maximum concentration for nonradioactive contaminants in crib soils: • Arsenic 7,090 μg/kg at 47.3-48.0 m (155-157.5 ft) bgs • Hexavalent chrome 7.2 mg/kg at 4.4 – 5.2 m (14.5 to 17 ft) bgs • Mercury 1.7 mg/kg at 4.4 – 5.2 m (14.5 to 17 ft) bgs • Nitrate 53,000 μg /kg at 38.4-39.2m (126-128.5 ft) bgs • Nitrate/nitrite 45,000 μg /kg at 68 –68.8m (223-225.5 ft) bgs • Silver 3.9 mg/kg at 4.4 – 5.2 m (14.5 to 17 ft) bgs • Uranium 463,000 μg/kg at 7.3-8.1 m (24-26.5 ft) bgs. Geophysical logging data for Borehole C4557 and adjacent boreholes correlate well for Cs-137 and other primary radionuclides. Borehole and laboratory data also generally agree on the vertical distribution of the radionuclides (although the relative laboratory sample results for the same depths are consistently lower). Soil data, effluent discharge volume, pore volume to discharge ratio, and groundwater monitoring data confirm the conceptual model indicating that the 216-C-7 Crib likely impacted groundwater. The conceptual contaminant distribution model for 200-PW-2 and 200-PW-4 sites correlates well with the characterization results (i.e. , most radionuclides and metals were found in the predicted high-contamination range, near the crib bottom at 6.7 m (22 ft), and drop off markedly down the borehole, except for the highly mobile contaminants (e.g., tritium) found in the vadose zone to groundwater.

Table 2-2. 200-PW-2/200-PW-4 Operable Unit Representative Sites and Associated Analogous Waste Sites. (25 Pages)

Waste Site*	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory: Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)	Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
ANALOGOUS WASTE SITES TO BE EVALUATED BY THE 216-S-7 CRIB MODEL														
216-S-1&2 Cribs (216-S-5 Crib)	The 216-S-1&2 Cribs were constructed in 1952 for disposal of cell drainage and process condensate from REDOX (202-S). The crib is located in the 200 West Area east of the SX Tank Farm and southwest of the 241-S-151 Diversion Box. It was approximately 27.4 m x 12.2 m (90 ft x 40 ft) and is approximately 35 ft deep. The site contains two open-bottomed, square wooden crib boxes, placed 1.8 m (5.9 ft) into a gravel layer. The bottom 3 m (10 ft) was filled with screened, crushed stone. The crib boxes were constructed with 15 cm x 15 cm (6 in x 6 in.) timbers and cross braces. The two crib boxes were connected in series, with overflow from the 216-S-1 Crib flowing into the 216-S-2 Crib via a pipe.	The 216-S-1&2 Cribs operated from 1952 to 1956 and received 160,000,000 L (42 Mgal) of acidic cell drainage and process condensate from REDOX (202-S) liquid containing nitrate, aluminum nitrate, nitric acid, sodium, Sr-90, Cs-137, plutonium, and uranium. When the crib was abandoned it had received approximately 750,000 Ci of mixed fission products. Waste was routed to the 216-S-7 Crib after the 1956 release to groundwater through a nearby well casing (UPR-200-W-36).	2.25 E+03 Less than rep site. (2.22E+03)	1.20 E+03 Greater than rep site. (1.24E+03)	 (2.44E+01)	1.10 E+03 Greater than rep site. (8.27E+02)	1.25 E+03 Less than rep site. (9.59E+02)	60,000 Less than rep site (2.11E+05)	(0)	(—)	(0)	160,000 Less than rep site	6,020 Effluent volume to pore volume ratio: 26.6	As described below, the 216-S-1&2 Cribs are analogous to or bounded by the representative site the 216-S-7 Crib with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Contamination:* Both sites are similar box-type specific retention cribs, and overall this site has a smaller surface area but is deeper. 2. *Waste stream origin/volume:* Both sites received the same 202-S (REDOX) cell drainage and process condensate waste, although this site received less effluent. 3. *Contaminant inventory:* This site contains more plutonium and Cs-137, but less uranium and Sr-90 and received less, but still significant, quantities of nitrates. 4. *Geology:* These sites essentially are colocated in the 200 West Area, making their geology similar. 5. *Extent of contamination:* Although this site is deeper at 22 (vs 35) ft, the 216-S-7 Crib should bound this site for extent of contamination, because the effluent volume was smaller, this site exceeded its pore volume by a smaller multiplier, and this site contains less of the more mobile contaminants (uranium, Sr-90, and nitrates). 6. *Groundwater impact:* The effluent discharge to this site exceeded its pore volume significantly, and reports of groundwater contamination (UPR 200-W-36) suggest that this site also impacted groundwater.
UPR-200-W-36 (Groundwater contamination at 216-S-1 and 216-S-2)	UPR-200-W-36 is an unplanned release from the 216-S-1&2 Cribs to groundwater from a ruptured test well 299-W22-3 casing that was identified in 1955. The well is located near the east end of the 216-S-1&2 Cribs, east of the SX Tank Farm.	UPR-200-W-36 was identified in August 1955 and resulted from an unplanned release to groundwater via a failed well casing that allowed a potentially significant quantity of process waste sent to the 216-S-1&2 Cribs from June to August 1955 (7,500,000 L [1.9 million gal]), to bypass the crib soil column and go directly to the base of the groundwater monitoring well and therefore to groundwater. The waste contained aluminum, nitrate, nitric acid, sodium, Co-60, Am-241, Cs-137, uranium, and plutonium. This contamination is known to have reached groundwater.												As described below, UPR-200-W-36 is analogous to or bounded by its representative site the 216-S-7 Crib with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Contamination:* This site is a contaminated groundwater monitoring well casing located at the east end of this crib and is not a box-type disposal crib but, by design, is deeper, going directly to groundwater level. 2. *Waste stream origin/volume:* This site received the same waste stream as the 216-S-1&2 Crib with which it is colocated and that is bounded by the 216-S-7 Crib. As a contaminated structure, no significant inventory of contaminants remains. 3. *Contaminant inventory:* This site is the well casing with residual contamination. No soil contamination is associated with this release, because this site received waste from the surrounding crib soils, all of which went down the casing to groundwater. 4. *Geology:* This site is essentially colocated with the 216-S-7 Crib in the 200 West Area, making their geology similar. 5. *Extent of contamination:* The contamination is expected to be limited to the well casing and the affected groundwater. The exposure scenario is expected to be from contaminated groundwater. 6. *Groundwater impact:* Although the volume of effluent discharged is unknown, it is known that the effluent went directly to groundwater and, therefore, this site impacted groundwater.

Table 2-2. 200-PW-2/200-PW-4 Operable Unit Representative Sites and Associated Analogous Waste Sites. (25 Pages)

Waste Site*	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory									Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
216-S-4 French Drain (216-S-7, 216-S-4 Sump or Crib, UN-216-W-1)	The 216-S-4 French Drain was constructed in 1953 for disposal of condensate and cooling water from condensers on the 241-S-101 and 241-S-104 tanks in the S Tank Farm. The crib is located in the 200 Waste Area, east of the 216-U-10 Pond, and northwest of the 216-S-21 Crib. It consists of two rock-filled 0.8 m (2.5 ft) diameter culvert pipes placed vertically side by side and fed by an aboveground pipe. The culverts are 20 ft deep at the bottom. The site was deactivated by removing the aboveground piping. The site was surface stabilized in 1991 with clean backfill.	The 216-S-4 French Drain operated from 1953 to 1956 and received 1,000,000 L (264,000 gal) of liquid condensate and cooling water from condensers on the 241-S-101 and 241-S-104 tanks in the S Tank Farm that contained small quantities of nitrate and fission products.	—	—	—	—	—	1	—	—	—	1,000	150 Effluent volume to pore volume ratio: 6.7	As described below, the 216-S-4 French Drain is analogous to or bounded by its representative site the 216-S-7 Crib with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Contamination:* Both sites for disposal of liquid waste to the soil column are 20 ft deep, but this site and the vertically placed metal culverts are much smaller. 2. *Waste stream origin/volume:* Both sites received REDOX-related waste, but this site received a much smaller fraction of the effluent volume. 3. *Contaminant inventory:* Waste stream constituents are potentially the same, but the volume of waste received at this site is so low that a contaminant inventory for this site was not established. 4. *Geology:* Both sites are located in the 200 West Area, and their geology is similar. 5. *Extent of contamination:* Although this site is the same depth and the volume of effluent received at this site exceeded its pore volume, the site received far less effluent and has a smaller effluent-to-pore-volume ratio; the effluent is not expected to have traveled as deeply in the soil column. 6. *Groundwater impact:* Because effluent volume substantially exceeded pore volume, this site may have contaminated groundwater.
216-S-23 Crib	The 216-S-23 Crib was constructed in 1969 for disposal of process condensate from the D-2 Receiver Tank in 202-S (REDOX). The crib is located in the 200 West Area northeast of the SY Tank Farm and north of the 216-S-9 Crib. It is approximately 110 m x 3 m (360 ft x 10 ft) and is approximately 28 ft deep. This is a drain-field-type crib consisting of a perforated pipe set in a gravel layer, running the length of the crib. At one end of the crib a filter and gage well riser connects to the pipe. The rest of the crib contains backfill. The site was interim stabilized with 0.6 m (2 ft) of clean fill in 1995 after soils from UPR-200-W-165 were scraped up and placed on the surface of the crib.	The 216-S-23 Crib operated from 1969 to 1972 and received 34,000,000 L (9 Mgal) REDOX process condensate from the D-2 Receiver Tank, containing low-salt process condensate with uranium, plutonium, fission products, and nitric acid. This crib replaced the 216-S-9 Crib.	2.90 E-01 Less than rep site. (1.57E-05)	9.94 E-01 Less than rep site. (4.38E_05)	(3.39E-06)	3.47 E+00 Less than rep site. (5.88E-02)	1.14 E+00 Less than rep site. (1.15E-03)	0 (1.91E+03)	(0)	(—)	(0)	34,100	6,020 Effluent volume to pore volume ratio: 5.7	As described below, the 216-S-23 Crib is analogous to or bounded by its representative site the 216-S-7 Crib with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Contamination:* Both sites are retention cribs, although this site is a drain-field-type crib (not a box-type crib) that is 6 ft deeper and is much smaller. 2. *Waste stream origin/volume:* Both sites received the same REDOX D-2 cell waste stream except that this site received significantly less volume. 3. *Contaminant inventory:* This site received the same primary radionuclides and nitric acid as the 216-S-7 Crib but in much lower quantities. 4. *Geology:* Both sites are located in the same vicinity of the 200 West Area, and their geology is similar. 5. *Extent of contamination:* The extent of contaminant is bounded by the representative site, because this site received significantly less effluent volume, and the volume of effluent exceeded the pore volume by a smaller factor (6 times vs 46 times). 6. *Groundwater impact:* The relatively low volume of effluent received, the low effluent-to-pore-volume ratio, the predominance of low mobility contaminants in the waste stream, and the low quantity or absence of high mobility contaminants in the waste stream (e.g., uranium nitrates) suggests that this site has a limited potential to have impacted groundwater.

Table 2-2. 200-PW-2/200-PW-4 Operable Unit Representative Sites and Associated Analogous Waste Sites. (25 Pages)

Waste Site*	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory									Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
216-T-20 Trench (216-TX-2, 216-T-20 Crib, 241-TX-155 Contaminated Acid Grave)	The 216-T-20 Trench is a small, single-use pit dug in 1952 for disposal of contaminated nitric acid from the 241-TX-155 Diversion Box Catch Tank. The pit is located adjacent to the north end of the 200 West Area Power House Pond and is approximately 3 m x 3 m (10 ft x 10 ft) and 4 ft deep. A concrete block structure with a metal lid is situated on the surface of the site. During deactivation, the aboveground piping was removed and the site was backfilled.	In 1952 the 216-T-20 Trench received 18,900 L (5,000 gal) of waste from the 241-TX-155 Diversion Box Catch Tank containing contaminated nitric acid and fission products.	5.00 E+00 Less than rep site. (1.07E-03)	 (2.90E-03)	 (5.27E-05)	4.40 E-01 Less than rep site. (3.19E-01)	3.88 E-01 Less than rep site. (7.64E-02)	15,000. (1.96E+01)	 (0)	 (—)	 (0)	18.9	66 Effluent volume to pore volume ratio: 0.29	As described below, the 216-T-20 Crib is analogous to or bounded by its representative site the 216-S-7 Crib with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Contamination:* Both sites are unlined disposal sites, but this site is a much smaller and shallower pit and is not an engineered disposal crib. 2. *Waste stream origin/volume:* The waste streams for this site were from T Plant, and the 216-S-7 Crib waste was from S Plant (REDOX), but because during this time both plants were using the same bismuth/phosphate plutonium separation process, the waste is expected to be similar. However, this site, as a single-use pit, received a significantly smaller quantity of effluent. 3. *Contaminant inventory:* Both sites received nitrates and the same primary radionuclides (except plutonium) but this site received these constituents in much smaller quantities. This site is likely to have received plutonium but in such small quantities that a contaminant inventory was not established. 4. *Geology:* Both sites are located the 200 West Area, and their geology is similar. 5. *Extent of contamination:* The extent of contaminant distribution is bounded by the representative site, because this site is much smaller, much shallower (4 ft vs 20 ft deep), the quantity of waste received was much smaller, and the effluent volume did not exceed site pore volume. As a shallower contamination area, although low inventory, this site could present human health and ecological risks in the 0 to 15 ft zone that have not been evaluated by the representative site investigation. 6. *Groundwater impact:* The overall low volume of effluent received and the fact that the effluent received did not exceed the pore volume suggests that this site did not impact groundwater.
216-S-22 Crib	The 216-S-22 Crib was constructed in 1957 for disposal of liquid waste from the acid recovery facility in the 293-S Offgas Treatment Facility. This crib is located in the 200 West Area east of the 202-S Building and northeast of 216-S-20 Crib and is approximately 30.5 m x 1 m (100 ft x 3.5 ft) at the bottom and is 2.98 m (10 ft) deep. The crib is a drain-field-type gravel structure with a side slope of 1:1.5. A pipe enters the unit below grade, branches out at right angles downward to the bottom, and runs along the bottom for the length of the unit. The section of pipe along the crib bottom has open joints. The rest of the structure is filled with backfill.	The 216-S-22 Crib operated from 1957 to 1967 and received 98,400 L (26,200 gal) of liquid waste from the acid recovery facility in the 293-S Building containing nitrate, sodium, and fission products. The crib was retired when production operations were shut down at REDOX.	5.00 E-02 Less than rep site. (4.52E-08)	1.01 E-01 Less than rep site. (1.26E-07)	 (977E-09)	4.78 E-01 Less than rep site. (1.7E-06)	4.55 E-01 Less than rep site. (3.31E-06)	7,000 (6.44E+01)	 (0)	 (—)	 (0)	98	585 Effluent volume to pore volume ratio: 0.17	As described below, the 216-S-22 Crib is analogous to or bounded by its representative site the 216-S-7 Crib with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Contamination:* Both sites are unlined retention cribs, although this site is a drain-field-type crib (not a box-type crib) that is long and narrow, having a much smaller surface area, and is shallower (10 ft vs 20 ft deep). 2. *Waste stream origin/volume:* Both sites received REDOX waste streams that were acidic and radioactive, but this site received only a small fraction of the quantity of effluent. 3. *Contaminant inventory:* This site received the same primary radionuclides and chemicals (nitrate and sodium) but contains a much smaller inventory of all contaminants and so is bounded by the 216-S-7 Crib. 4. *Geology:* Both sites are located in the 200 West Area, and their geology is similar. 5. *Extent of contamination:* The extent of contamination is bounded by the 216-S-7 Crib, because this site received a significantly lower quantity of effluent volume and contains a much smaller soil contaminant inventory, and the effluent discharge did not exceed site pore volume. 6. *Groundwater impact:* The very low volume of effluent received, the low effluent discharged relative to pore volume ratio, and the low contaminant inventory suggest that this site did not impact groundwater.

Table 2-2. 200-PW-2/200-PW-4 Operable Unit Representative Sites and Associated Analogous Waste Sites. (25 Pages)

Waste Site*	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory									Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
REPRESENTATIVE SITE														
216-A-10 Crib	The 216-A-10 Crib began operating in 1956 for disposal of PUREX process distillate discharge. The crib was initially a spare crib for the 216-A-5 Crib. This crib is located in the 200 East Area approximately 82 m (270 ft) south of the southwest corner of the 202-A (PUREX Plant) Building. The crib has a wedge-shaped cross section and is rock filled. It is approximately 96 m x 14 m (316 ft x 45 ft) at the surface and is 14 m (45 ft) deep. The excavation has side slopes of 1:1.5. Elevation at the surface was 218 m (714 ft). It has two layers of vinyl plastic separating the gravel from the backfill, two vent structures, a vent box on a concrete pad, and three 15 cm (6 in.) risers extending from the bottom to the vent structure. In 1962, the original piping, a 203 mm (8 in.) vitrified clay distribution pipe placed horizontally 9 m (30 ft) below grade at the crib centerline, was replaced with a 203 mm (8 in.) stainless steel effluent pipeline located on the east side of the crib. Following operational use, the crib was backfilled.	The 216-A-10 Crib operated from 1956 to 1987 and received 3.2×10^9 L (8.5×10^8 gal) of liquid effluent. This site received only water from 1956 to 1961, which was the date that this crib began receiving contaminated liquid. From 1961 to 1986 (except for 1978 to 1981 when it was inactive) , it received acidic liquid process condensate and distillate discharge from the 202-A Building that contained uranium, nitrate, tritium, Sr-90, I-129, Am-241, Cs-137, Pm-147, total Pu (Pu-238, Pu-239, Pu-241, and 241). This site was originally identified as one of two RCRA TSD units in the 200-PW-2 OU.	2.41 E+02 (3.58E+02)	3.50 E+02 (9.76E+02)	7.73 E-01 (7.53E+01)	8.05 E+01 (2.84E+01)	8.25 E+01 (1.84E+01)	 (1.92E+06)	 (0)	 (-)	 (0)	3,210,096	28,072 Effluent volume to pore volume ratio: 114.4	Contamination was detected beneath the 216-A-10 Crib to a depth of 96.1 m (317 ft) bgs for radionuclides. When actively receiving effluent, the crib was about 13.6 m (45 ft) deep. Maximum concentrations are mainly just below the bottom of the crib from 15.8 m to 18.9 m (52 to 62.5 ft) bgs. The crib was backfilled after 1986. Maximum concentration of primary radionuclides discharged to the crib: • Americium-241 1,320 pCi/g at 15.9 m (52 ft) bgs • Cesium-137 2,950 pCi/g at 19.1 m (62.5 ft) bgs • Plutonium-238 316 pCi/g at 15.9 m (52 ft) bgs • Plutonium 239/240 7,110 pCi/g at 15.9 m (52 ft) bgs • Strontium-90 44.7 pCi/g at 38.9 m (127.5 ft) bgs. Other radionuclides detected at lower concentrations: Carbon-14 (7.50 pCi/g), Nickel-63 (2.13 pCi/g), Radium-228 (1.27 pCi/g), Technetium-99 (1.03 pCi/g), Thorium-228 (2.11 pCi/g), Thorium-230 (1.10 pCi/g), Tritium (835 pCi/g), Uranium 233/234 (1.39 pCi/g), Uranium-238 (1.22 pCi/g), Iodine-129 (38.8 pCi/g), and Potassium-40 (27.0 pCi/g). Maximum concentration of primary nonradiological constituents discharged to the crib: • Nitrate (as N) 26.8 mg/kg at 15.9 m (52 ft) bgs Other nonradioactive constituents (maximum concentration): Beta-1,2,3,4,5,6-hexachlorocyclohexane (0.007 mg/kg), Boron (0.890 mg/kg), 2-Butoxyethanol (0.025 mg/kg), 1-Chloropropane (.38 mg/kg), Methylene chloride (0.029 mg/kg), Pentachlorophenol (0.020 mg/kg), TPH-diesel (10,000 mg/kg), and Tributyl phosphate (2,000 mg/kg). Logging and analytical sample results agree with regard to the primary radiological constituent, maximum concentration, and general distribution. Geophysical logging of Borehole C3247 identifies Cs-137 as the primary man-made radionuclide detected, with a maximum concentration of 2,800 pCi/g from 13.7 m (48 ft) bgs (bottom of the crib) to 25.6 m (84 ft) corroborating the maximum Cs-137 concentration found by sampling of 2,950 pCi/g at 62.5 ft. Moisture logging shows a wetter area at 18.8 (62 ft) bgs corresponding to the peak Cs-137 sample concentration. The Cs-137 and U-238 logging and the laboratory sample data in the same region are in good agreement, and both indicate natural levels of uranium throughout the entire soil column. The very high volume of effluent discharge relative to soil pore volume (114 times greater than soil pore volume) and current groundwater monitoring in the vicinity of the crib identifying tritium, nitrate (as N), I-129, Sr-90, and gross beta above groundwater protection standards at least partially attributable to this crib corroborate the likelihood that the 216-A-10 Crib impacted groundwater. Monitoring well water concentrations of nitrate exceeded the groundwater protection standards/guidelines in the vicinity of the crib (PNNL-13788) but nitrates did not exceed screening levels for soil concentrations protective of groundwater (WAC 173-340-747). The maximum tritium contamination at groundwater level is typical for the TSD and representative waste sites in the 200-PW-2 and 200-PW-4 OUs. Current modeling shows that I-129 would reach groundwater at concentrations of 2100 mrem/yr at 1,193 years and that Tc-99 and tritium could reach groundwater between 1,000 and 1,100 years resulting in doses of only a few millirem per year for each. In general, the contaminant distribution model (DOE/RL-2000-60, Figure 3-15) is well supported by the logging and sample data indicating that the highest contamination is in the 9.1 m to 27.3 m (30 ft to 90 ft) bgs range, medium contamination is to be found in the 27.3 m to 39.4 m (90 ft to 130 ft) bgs range, and contamination is present in the vadose zone to groundwater.

Table 2-2. 200-PW-2/200-PW-4 Operable Unit Representative Sites and Associated Analogous Waste Sites. (25 Pages)

Waste Site*	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory									Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
ANALOGUES WASTE SITES TO BE EVALUATED BY THE 216-A-10 CRIB MODEL														
216-A-5 Crib (216-A-5 Cavern)	The 216-A-5 Crib began operating in 1955 to dispose of acidic process condensate from 202-A (PUREX). The site is a drain-field-type crib located south of the 202-A Building between the inner and outer PUREX exclusion fences. The crib is 10.67 m x 10.67 m (35 ft x 35 ft) at the bottom and is 8.84 m (29 ft) deep. The side slope is 1:1.5 to a depth of 7.3 m (24 ft) deep and is 1:2 to the crib bottom. The crib is composed of a 20 cm (8 in.) vitrified clay pipe running horizontally at 7.3 m (24 ft) below grade in a bed of about 2.4 m (8 ft) (595 m^3 [21,000 ft^3]) of coarse rock fill (gravel) with two 10.67 m (35 ft) lengths of 20 cm (8 in.) vitrified clay pipes placed perpendicularly to the first length of pipe, forming an H pattern. A 15 cm (6 in.) vertical riser runs from the bottom of the crib to approximately 7.6 cm (3 in.) above originally grade, in the center of the crib. Fiber paper separates the gravel and backfill. In 1966, the crib was deactivated, and the effluent was rerouted to the 216-A-10 Crib. Lines between the crib and the process distillate discharge diversion tank (located upstream of the crib) were plugged with an expansion plug at the flange. The sample lines were sealed with aluminum plates.	The 216-A-5 Crib operated from 1955 to 1966 and received 1,630,000,000 L (431 Mgal) of acidic process condensate from PUREX containing nitric acid, uranium, and other fission products. From November 1961 to October 1966, the site was inactive until it received its final volume of process condensate from the 202-A building in October 1966.	2.61 E+02 Greater than rep site. (1.98E+02)	6.50 E+01 Less than rep site. (5.60E+02)	(4.30E+01)	1.21 E+01 Less than rep site. (1.16E+01)	4.16 E+01 Less than rep site. (3.03E+01)	1,000,000 (1.07E+06)	(0)	(__)	(0)	1,630,049	2,925 Effluent volume to pore volume ratio: 557.3	As described below, the 216-A-5 Crib is analogous to or bounded by its representative site the 216-A-10 Crib with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Contamination:* Both sites are drain-field-type cribs, but this site is 15 times smaller and shallower by 16 ft. 2. *Waste stream origin/volume:* Both sites received the same PUREX waste stream from the 202-A Building, composed of acidic process waste containing uranium and fission products, although this site received only half as much effluent. 3. *Contaminant inventory:* This sites has essentially equivalent or smaller inventories of the same primary radionuclides and nitrate. 4. *Geology:* The sites are located close together in the 200 East Area and have similar geology. 5. *Extent of contamination:* This site is bound by the 216-A 10 Crib, which is larger and deeper, and received more effluent. Effluent discharge at both sites overwhelmed their respective soil pore volumes, although this site exceeded its soil pore volumes by a greater margin. 6. *Groundwater impact:* This site received less effluent volume but the volume received contained significant quantities of mobile contaminants that greatly exceeded the soil pore capacity, suggesting a high potential for this site to have impacted groundwater.
216-C-1 Crib	The 216-C-1 Crib was constructed in 1953 for disposal of PUREX cold run waste and process condensate from the 201-C Hot Semiworks Plant. The crib is located in the 200 East Area, east of 209-E Critical Mass Laboratory Building. The crib is 8.2 m x 3.7 m (27 ft x 12 ft) and is 3.96 m (13 ft) deep. The excavation has side slopes of 1:2. The crib was constructed of concrete ties, spacer blocks, roof slabs, and gravel fill. It was fed by a 10 cm (4 in.) effluent pipe that entered the crib 0.9 m (3 ft) from the crib bottom and had a riser that extended approximately 0.6 m (2 ft) above original grade. The crib was later surface stabilized with 10 cm (4 in.) of gravel that left 1.5 m (5 ft) of excavation still unfilled. In 1979, the surface scrapings from the 216-C-3, C-4, and C-5 Cribs were used to backfill the depression of the C-1 Crib. The crib then was covered with a 10 cm (4 in.) sand pad, a layer of plastic, 0.3 m (1 ft) of sand, and 10 cm (4 in.) of pit run gravel.	The 216-C-1 Crib operated from 1953 to 1957 and received 23,400,000 L (6 Mgal) of high salt waste, cold-run waste, and process condensate from experimental operations conducted at C Plant from the 201-C (Hot Semiworks) test facility, using REDOX and PUREX waste. Waste neutralized in the 241-CX-71 Tank was discharged to this crib. The site was deactivated in 1957, when the specific retention capacity was reached.	3.00 E+02 Greater than rep site. (9.08E+02)	8.00 E+00 Less than rep site. (7.91E+00)	(1.42E-01)	4.55 E-02 Less than rep site. (1.00E+01)	8.55 E+01 Greater than rep site. (4.88E+01)	(2.76E+06)	(0)	(—)	(0)	23,400	785 Effluent volume to pore volume ratio: 29.8	As described below, the 216-C-1 Crib is analogous to or bounded by its representative site the 216-A-10 Crib with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Contamination:* Both sites are unlined, gravel filled, drain-field-type retention cribs, although this site is smaller and shallower (13 ft deep). 2. *Waste stream origin/volume:* This site also received PUREX waste, except that this site received only a small fraction of the effluent volume received by the 216-A-10 Crib. 3. *Contaminant inventory:* This site received the same primary radionuclides, in significantly lesser quantities, except for Am-241, which is expected to exist in at least trace quantities but had no defined inventory. 4. *Geology:* Both sites are located in the 200 East Area, and their geology is similar. 5. *Extent of contamination:* The extent of contaminant distribution for this site is bounded by the 216-A-10 Crib, which is larger and received significantly more effluent, and effluent discharges exceeded soil pore volume by a greater margin, although this site also exceeded its pore volume significantly. As a shallower contamination area, although low inventory, this site could present human health and ecological risks in the 0 to 15 ft zone that have not been evaluated by the representative site investigation. 6. *Groundwater impact:* This site received significantly less effluent volume and discharge volume and only slightly exceeded soil pore capacity, suggesting a low potential to have impacted groundwater.

Table 2-2. 200-PW-2/200-PW-4 Operable Unit Representative Sites and Associated Analogous Waste Sites. (25 Pages)

Waste Site*	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory									Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
216-A-45 Crib	The 216-A-45 Crib was constructed in 1986 for disposal of process condensate from 202-A (PUREX) that, until then, had gone to the representative waste site 216-A-10 Crib. This crib is located in the 200 East Area, south of the PUREX facility and southwest of the 216-A-10 Crib. It is 94.5 m x 18.3 m (310 ft by 60 ft) at the bottom and is 13.5 m (44.5 ft) deep. The site is a drain-field-type crib consisting of five 10 cm (4 in.) diameter perforated, fiberglass-reinforced pipes evenly spaced across the width on a bed of 1.7 m (5.5 ft) of clean rock, 8 to 13 cm (3 in. to 5 in.) in diameter. The crib was covered with 15 cm (6 in.) of clean rock, a 15 cm (6 in.) layer of 1.9 cm (3/4 in.) gravel, a sheet of 10-mil polyethylene, and a 10 cm (4 in.) layer of sand over the unit.	The 216-A-45 Crib Site operated from 1987 to 1991 and received 103,000,000 L (27.2 Mgal) of process condensate from 202-A Building (PUREX) that was acidic and contained uranium and nitrate. This crib replaced the 216-A-10 Crib.	6.69 E+00 Less than rep site. (7.82E+00)	 (8.39E+01)	1.10 E-01 Less than rep site. (1.25E+00)	9.70 E-03 Less than rep site. (1.59E+00)	8.34 E-03 Less than rep site. (6.99E-02)	 (8.00E+05)	 (0)	 (—)	 (0)	103,003	58,074 Effluent volume to pore volume ratio: 1.8	As described below, the 216-A-45 Crib is analogous to or bounded by its representative site the 216-A-10 Crib with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Contamination:* Both sites are drain-field-type specific retention cribs that are approximately 45 ft deep, although this site is larger. 2. *Waste stream origin/volume:* Both sites received the same PUREX 202-A process condensate waste, except that this site received only a small fraction of the effluent volume. 3. *Contaminant inventory:* This site received the same primary contaminants but in significantly lesser quantities, except for plutonium and nitrates, for which this site has no designated contaminant inventory but that are expected to exist in the soil column. 4. *Geology:* Both sites are relatively close together in the 200 East Area, and their geology is similar. 5. *Extent of contamination:* The extent of contaminant distribution is bounded by the 216-A-10 Crib, which had much larger effluent volume and a much higher effluent-to-pore-volume ratio. 6. *Groundwater impact:* Because of the relatively low volume of effluent received, low inventory of the mobile contaminants uranium and nitrate, and only a relatively slight exceedance of pore volume, the waste likely remains near the crib bottom, suggesting that this site had little potential to have impacted groundwater.

Table 2-2. 200-PW-2/200-PW-4 Operable Unit Representative Sites and Associated Analogous Waste Sites. (25 Pages)

Waste Site*	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory									Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
200-E-58 (216-A-5 Neutralization Tank, Tank A5) IMUST	The 200-E-58 site is also known as the 216-A-5 Neutralization Tank. This tank began operations in 1955 for neutralization of acid waste from PUREX prior to ground disposal, first to the 216-A-5 Crib (1955 to 1961) and then to the 216-A-10 Crib (1961 to 1987). The site is located in the 200 East Area, south of PUREX, inside the security fence, south of the 295-AB Process Distillate Discharge Sample Station and north of the 216-A-10 Crib. The neutralization tank is a 3.5 m (11.3 ft) diameter, 9.5 mm (3/8 in.) thick stainless steel tank with a 1 m (40 in.) carbon steel charging riser. The riser was used for adding limestone (neutralizing agent) to the tank and is located in the center of the tank. The riser is supported by eight 9.5 mm (3/8 in.) thick, 0.76 x 1.2 m (2.5 x 4 ft) gusset plates. Acidic liquid waste entered the tank from the bottom and was forced upward through a bed of limestone within the tank. Interaction with the limestone neutralized the waste before it overflowed through the outlet pipe. The tank is approximately 3 m (10 ft) high and has a capacity of approximately 28,400 L (7,500 gal). The stainless steel tank stands vertically on a 0.46 m (1.5 ft) thick concrete pad that is approximately 16 ft deep (WIDS). Waste entered the tank through a 20 cm (8 in.) inlet pipe at the base of the tank. The 20 cm (8 in.) overflow outlet piping discharged near the top of the tank. Because of the tank design and piping orientation, the tank and some piping sections likely still contain liquid waste.	The 200-E-58 Neutralization Tank operated from 1955 to 1981 to neutralize acid waste from the PUREX 202-A Building prior to ground disposal, first to the 216-A-5 Crib and then to the 216-A-10 Crib. The waste contained high levels of uranium and nitrate. There were no known reported releases of waste from this tank. Tank capacity of 28,400 L (7,500 gal).												As described below, the 200-E-58 Neutralization Tank is analogous to or bounded by its representative site the 216-A-10 Crib with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Contamination:* This site is a buried metal waste neutralization tank that acted as a conduit for waste and is not an unlined near-surface liquid waste disposal site. At approximately 16 ft deep, this site is 20 ft shallower than the crib and is much smaller in size. 2. *Waste stream origin/volume:* Both sites received the same PUREX 202-A waste except that the volume of effluent processed by the tank is inconsequential, because it acted only as a waste conduit and not as a disposal site. 3. *Contaminant inventory:* Both sites received the same primary radionuclides, but the 216-A10 Crib is bounding for the tank because the tank was only a waste conduit with no known history of spills to the location and so has no identified contaminant inventory. The current tank-site waste inventory is indeterminate and limited to only the waste that could not drain from the tank under normal operating conditions and waste residues on tank surfaces. 4. *Geology:* Both sites are located in the 200 East Area, and their geology is the same. 5. *Extent of contamination:* The potential extent of contamination for this site will be much less, because there is no known history of spills which, if any, would be smaller and shallower, and so is bound by the representative disposal site. Wastes, if any, that may have been discharged via leaks would be shallow and would contain COCs similar to those of the 216-A-5 and 216-A-10 Cribs. 6. *Groundwater impact:* There was no known disposal to the soil column of waste from this site, and if there were any, it would be of such a limited nature that no reasonable potential exists for groundwater contamination from this tank.

Table 2-2. 200-PW-2/200-PW-4 Operable Unit Representative Sites and Associated Analogous Waste Sites. (25 Pages)

Waste Site*	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory									Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
REPRESENTATIVE SITE														
216-A-36B Crib (216-A-36 Crib, PUREX Ammonia Scrubber Distillate (ASD) Crib)	The 216-A-36B Crib was constructed in 1966 for disposal of ammonia scrubber distillate (ASD) waste from the 202-A Building (PUREX). This crib is located in the 200 East Area about 366 m (1,200 ft) south of the 202-A Building, outside the security fence. This site is a drain-field-type crib that was constructed to bypass highly contaminated portions of the similarly constructed original 216-A-36 Crib. The crib was divided into 216-A-36A and 216-A-36B sections by injecting grout into the gravel layer of the crib to form a barrier between the two sections. The 216-A-36B Crib extends southward from 216-A-36A and is approximately 175.26 m x 26.21 m (575 x 86 ft) at the surface and is 7.3 m (24 ft) deep. The excavation has side slopes of 1:1.5. The 216-A-36B Crib contains a 10 cm (4 in.) perforated pipe placed horizontally 7 m (23 ft) below grade inside a 15 cm (6 in.) pipe from the 216-A-36A segment. The crib includes a 20 cm (8 in.) gage well, a plastic barrier between gravel and backfill, and a 20 cm (8 in.) vent with a 5 cm (2 in.) drain.	The 216-A-36B Crib operated from March 1966 to 1987 and received ammonia scrubber distillate (ASD) waste from the 202-A Building that the original 216-A-36 Crib had received from September 1965 to March 1966. This waste contained radioactive contaminants Am-241, Co-60, Pu-239, Sr-90 , tritium, Cs-137 , and U-238 and the chemical contaminants ammonium fluoride, ammonium nitrate, and sodium dichromate. In May 1970, about 14,000 Ci were discharged to the crib from a leaking valve in the scrubber drain to the catch tank. Discharges continued until October 1972 when the crib was temporarily removed from service. The crib was placed back in service in November 1982 for the restart of the PUREX Plant and remained active until use of the crib was discontinued in the spring of 1988 and the facility was backfilled. No stabilization actions have taken place at the waste site. The 216-A-36B Crib is one of two RCRA TSD units in the 200-PW-2 OU.	2.62 E+02 (1.22E+02)	2.58 E+02 (1.02E+00)	2.17 E-01 (2.26E_01)	1.20 E+03 (2.92E+02)	1.31 E+03 (2.75E+02)	 (2.68E+05)	350 (0)	178 (—)	0.0569 (0)	318,080	16,327 Effluent volume to pore volume ratio: 19.5	Contamination was detected beneath the 216-A-36B Crib to a depth of 96.5 m (318.5 ft) bgs. Maximum radionuclide contaminant concentrations are present in the crib to a depth of 87.1 m (287.5 ft) bgs. The zone of maximum radiological contamination is at 25 ft (crib bottom) to about 40 ft. Consistent with this, the radioactive contaminants are markedly elevated at the 7.6 m (25 ft) bgs depth (i.e., base of the crib), the concentration falls again at 12.1 m (40 ft) bgs, and rise again from 15.2 m to 18.2 m (50 ft to 60 ft) bgs. This behavior is true of Am-241, C-14, Co-60, Cs-137, Ni-63, Pu-239/240, Tc-99, Sr-90, and all uranium isotopes plus total uranium. When actively receiving effluent, the crib was about 7.6 m (25 ft) deep. The crib was backfilled in 1988, and no other stabilization has occurred at the site. Maximum concentrations of primary waste stream radionuclides detected in crib soil: • Technetium-99 41.9 pCi/g at 7.6 m (25 ft) bgs • Americium-241 40,000 pCi/g at 7.6 m (25 ft) bgs • Cobalt-60 623 pCi/g at 7.6 m (25 ft) bgs • Cesium-137 2,650,000 pCi/g at 7.6 m (25 ft) bgs • Plutonium 239/240 98,000 pCi/g at 7.6 m (25 ft) bgs • Total radioactive strontium 208,000 pCi/g at 7.6 m (25 ft) bgs • Europium-154 1,800 pCi/g at 7.6 m (25 ft) bgs • Nickel-63 181,000 pCi/g at 7.6 m (25 ft) bgs • Uranium-233/234 81.2 pCi/g at 9.2 m (30 ft) bgs • Uranium-238 70.9 pCi/g at 7.6 m (25 ft) bgs. Maximum concentration of other radionuclides: Carbon-14 (116 pCi/g), Potassium-40 (19.4 pCi/g), Radium-226 (1.27 pCi/g), Radium-228 (1.15 pCi/g), Thorium-230 (11.4 pCi/g), Thorium-232 (4.84 pCi/g), Thorium-234 (1.58 pCi/g), Tritium (121 pCi/g), Uranium-235 (3.29 pCi/g), Uranium-236 (4.54 pCi/g). The maximum concentration of nonradioactive constituents detected in crib soil: • Nitrate (as N) 289 mg/kg at 7.6 m (25 ft) bgs • Nitrate/nitrite (as N) 287 mg/kg at 16.3 m (53.5 ft) bgs • Nitrite (as N) 18.8 mg/kg at 7.6 m (25 ft) bgs • Silver 3.12 mg/kg at 3.8 m (12.5 ft) bgs • Total Uranium 36.8 mg/kg at 9.2 m (30 ft) bgs • Isophorone 0.50 mg/kg at 60.2 m (197.5 ft) bgs. Radionuclide sample data from 1988 (Crib Borehole 299-E17-55) showing that the maximum concentrations of primary radionuclides, Am-241 (48,100 pCi/g), Cs-137 (3,280,000 pCi/g), Co-60 (1,025 pCi/g), and U-235 (1,225 pCi/g) were found at 9.2 m (30 ft) bgs closely correlates with current analytical sample data. Current sample results show ammonia (as N) from 40 mg/kg to 60 mg/kg at 16.2 m [53.5 ft] bgs as expected at sites that received ammonia scrubber waste, although no contaminant inventory is identified. This is higher than 1988 laboratory data from adjacent boreholes showing nitrate concentrations (as N) from 0.021 to 9.40 mg/kg and maximum ammonia concentrations (as N) of 23.5 mg/kg indicating limited lateral contaminant flow. Geophysical logging for primary man-made radionuclides Cs-137 and Co-60 correlate well with lab data. SGLS data show Cs-137 at a maximum concentration of 2,000,000 pCi/g at 8.2 m (27 ft) bgs, decreasing at greater depths as did the analytical data. The Co-60 was detected between 38 and 60 ft bgs and sporadically to 116 ft bgs. Moisture logging confirms sample data showing wet areas near 87.6 m (289 ft) bgs that correlate with higher Th-232 at this depth. This pattern is consistent with the conceptual contaminant distribution model (DOE/RL-2000-60, Rev. 1, Figure 3-16). The high volume of effluent discharged to this site and groundwater monitoring showing nitrate, I-129, Sr-90, and gross beta (some of which was contributed by the crib) above groundwater protection standards, indicates that the 216-A-36B Crib impacted groundwater. Modeling has shown that Tc-99 will reach groundwater at 1,025 years with 15.3 mrem/yr dose. The high levels of Pu-239/240 and Am-241 in waste sample B17487 indicate the possibility that some of the soil from this crib may designate as transuranic waste.

Table 2-2. 200-PW-2/200-PW-4 Operable Unit Representative Sites and Associated Analogous Waste Sites. (25 Pages)

Waste Site*	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory									Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
ANALOGOUS WASTE SITES TO BE EVALUATED BY THE 216-A-36B CRIB MODEL														
216-A-36A Crib	The 216-A-36A Crib is the north portion of the original 216-A-36 Crib that was constructed in 1965 for disposal of PUREX ASD waste. The crib is located south of 202-A Building, outside the security fence. It is approximately 51.25 m x 23.4 m (168 ft x 77 ft). The 216-A-36A Crib portion was used until 1966, when high contamination resulted in its abandonment and replacement with the 216-A-36B Crib. The replacement crib was created by walling off the crib with grout and extending the crib discharge pipe southward.	The 216-A-36A Crib operated from 1965 to 1966 and received 1,070,000 L (283,000 gal) of ASD wastes from the 202-A Building that was low in salt and neutral to basic and contained 400,000 Ci of fission products including 1,600 Ci of Cs-137; also 625 Ci of Sr-90.	(1.45E+02)	(4.46E+01)	(2.38E+02)	(6.87E+02)	(7.89E+02)	(9.09E+02)	(0)	(--)	(0)	See Rationale	See Rationale	This CERCLA action will address the 216-A-36A and 216-A-36B Cribs as a single site. The representative 216-A-36B Crib physically adjoins this site and they are considered twin sites with regard to construction, waste stream chemistry, contaminant inventory, effluent volume received, and potential to have impacted groundwater. 1. *Contamination:* Both sites are drain-field-type specific retention cribs that are adjoining, although this site is smaller. 2. *Waste stream origin/volume:* Both received the same PUREX ASD waste, although this site received a smaller volume of this effluent. 3. *Contaminant inventory:* Reference documents include the contaminant inventory for this crib in the contaminant inventory for the 216-A-36B Crib, making the contaminant inventory identical. 4. *Geology:* Both are adjoining and have the same geology. 5. *Extent of contamination:* Because these are considered as a single waste site, they are considered identical with regard to extent of contamination and contaminant distribution, although the 216-A-36B Crib is actually a bounding condition because it is larger, operated longer, and received more effluent. 6. *Groundwater impact:* As twin sites that will be addressed as a single unit, both sites have a similarly high likelihood of having impacted groundwater based on high effluent volume, high effluent volume relative to soil pore volume, and the existence of moderately to highly mobile contaminants in the waste stream (uranium, Sr-90, and nitrates).
UPR-200-E-39 (Release from 216-A-36B Crib Sampler (295-A) Building, UN-200-E-39)	UPR-200-E-39 site is the site name for an unplanned release that occurred in 1968 on the ground and blacktop outside the 216-A-36B Crib Sampler Shack that is located in the 200 East Area inside the PUREX fence, south of 202-A. This site (including the asphalt) is approximately 7.9 m x 7.9 m (26 ft x 26 ft).	UPR-200-E-39 sites is the result of a one-time release in February 1968 from the vent filter at the 216-A-36B Crib Sampler Shack. The waste was PUREX ASD waste containing uranium and fission products. The volume released is unknown, but based on the limited nature of the spill response (i.e., blacktop hose off), the volume is anticipated to be relatively small. As a low-volume surface release, the contamination in the gravel area is conservatively presumed to be approximately 3 ft deep.												As described below, the UPR-200-E-39 is analogous to, or bounded by, its representative site the 216-A-36B Crib with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Contamination:* Although this site also is a discharge to soil, as a single accidental discharge primarily to blacktop that was then hosed down to adjacent gravel and the soil beneath the gravel, it constituted a much smaller area (676 ft^2) of contamination, released an insignificant quantity of contaminants relative to the disposal site, and was shallower release based on a conservative assumption that contamination penetrated the soil column to a depth of 3 ft (given that contaminant transport would only be driven by natural precipitation). 2. *Waste stream origin/volume:* The waste stream also is effluent that went to the 216-A-36 B Crib but as a one-time accidental release from sample equipment, it would be much smaller in volume and diluted by the response action (hose-down of the asphalt pad). 3. *Contaminant inventory:* The primary radionuclide contaminants would be the same, but the contaminant inventory would be much smaller. 4. *Geology:* Both sites are in the 200 East Area, and their geology is similar. 5. *Extent of contamination:* The extent of contamination is bounded by the crib, because this site contamination is much shallower, is a one-time low-volume surface release that could be driven further into the soil column only by natural precipitation, and is not planned disposal. As a shallower contamination area, although low inventory, this site could present human health and ecological risks in the 0 to 15 ft zone that have not been evaluated by the representative site investigation. 6. *Groundwater impact:* The volume of effluent released is of such a small quantity and limited nature, as characterized in the spill report, that this site has no reasonable potential to affect groundwater.

Table 2-2. 200-PW-2/200-PW-4 Operable Unit Representative Sites and Associated Analogous Waste Sites. (25 Pages)

Waste Site*	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory									Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
Representative Site														
207-A-South Retention Basin (207-A, 207-A Retention Basin, Process Condensate Basins 1, 2, and 3 [i.e., PC-1, PC-2, and PC-3])	The 207-A-South Retention Basin was constructed in 1977 for interim storage and sampling of 242-A Evaporator process condensate before its discharge to the 216-A-37-1 Crib for disposal. This site is located in the 200 East Area directly east of the 242-A Evaporator. It has overall dimensions of approximately 40.5 m x 29 m (133 ft x 95 ft) and is 2 m (7 ft) deep. The retention basin consists of three concrete cells. Each cell is 16.8 m (55 ft) long, 3.0 m (10 ft) wide at the bottom, and 2.1 m (7 ft) deep and has side slopes of 1:2. The cells were fed from a pump pit located between the 207-A South and 207-A North basins. A 10 cm (4 in.) fill line entered each cell inside the basin structure. A 7.6 cm (3 in.) drain line exits at the bottom of each cell. All three cells were coated to prevent constituents from penetrating the concrete.	The 207-A South Retention Basin operated from 1977 to 1989 storing 242-A Evaporator process condensate that was a mixed waste derived from processing of 241-AW-102 DST waste composed of PUREX, B Plant, 300 Area and 400 Area laboratory, PFP, and 100 N waste. This waste potentially contained spent solvents, ammonia, tributyl phosphate, and fission products. The basin was cleaned out and emptied in September 1989. The basins could have managed 793,469 kg (1,749,300 lb) of waste annually. The 207-A South Retention Basin is one of two RCRA TSD units in the 200-PW-4 OU.	—	—	—	—	—	—	—	—	—			The basin currently consists of three, below-grade, coated concrete cells, 2.1 m (7 ft) deep. As a storage site that was cleaned out upon deactivation, no waste remains in the basins. Site characterization samples were collected of the concrete basin (and elastomeric lining) and of soil beneath each cell (to a depth of 4.2 m (14 ft) bgs). No concrete samples exceeded screening levels. Maximum contaminant concentrations are nearly all present in the top 1.8 m (6 ft) of the borehole and are low (at MDA). Maximum concentrations were found beneath the east cell except for the Sr-90 maximum concentration found beneath the middle cell. No geophysical logging data were collected for the shallow 207-A South Retention Basin boreholes [4.2 m (14 ft)]. Maximum concentrations of radionuclides found in shallow soil beneath the basin: • Niobium-94 0.032 pCi/g 0.6-0.9 m (2-3 ft) bgs • Radium-226 0.859 pCi/g 1.8-2.1 m (6-7 ft) bgs • Thorium-230 1.26 pCi/g 0.3-0.6 m (1-2 ft) bgs • Tritium 16.6 pCi/g 1.8-2.1 m (6-7 ft) bgs. Maximum concentrations of other detected radionuclides found in soil: Cesium-137 (1.07 pCi/g), Radium-228 (1.10 pCi/g), and total radioactive strontium (1.40 pCi/g). Maximum concentrations of nonradiological constituents detected in soils beneath the basin: • Arsenic 9.98 mg/kg at 1.8-2.1 m (6-7 ft) bgs • Butylbenzyl phthalate 110 µg/kg at 0.3-0.6 m (1-2 ft) bgs • Silver 5.01 mg/kg 1.8-2.1 m (6-7 ft) bgs • 2,4-dichlorophenoxyacetic acid 7.1 µg/kg at 0.3-0.6 m (1-2 ft) bgs • 2-(2,4,5-trichlorophenoxy) propionic acid 3.3 µg/kg at 0.3-0.6 m (1-2 ft) bgs • Nitrate/Nitrite (as N) 20.9 mg/kg at 0.6-0.9 m (2-3 ft) bgs. Soil samples showed relatively little radionuclide contamination in the vadose zone beneath the 207-A South Retention Basin, consistent with the conceptual contaminant distribution model (DOE/RL-2000-60, Figure 3-17). Organics (elastomer related) and tributyl phosphate are present in small amounts in the concrete but none exceeded screening levels. The conceptual contaminant distribution model for this site indicates that contamination is unlikely to be present more than about 4.5 m (15 ft) bgs, because the coated concrete effectively protected the soil from contamination. As a storage unit that retained its containment integrity (i.e., no cracks), no significant volume of waste was discharged to soil to impact groundwater, as indicated by monitoring reports showing no exceedance of groundwater parameters near the basin. Modeling shows tritium reaching groundwater at trace levels at 698 years.

Table 2-2. 200-PW-2/200-PW-4 Operable Unit Representative Sites and Associated Analogous Waste Sites. (25 Pages)

Waste Site*	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory									Effluent Volume (m^3)	Soil Pore Volume (m^3)	Rationale
			Total U (kg)	Total Pu (g)	Am-241 (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
ANALOGUES WASTE SITES TO BE EVALUATED BY THE 207-A SOUTH RETENTION BASIN MODEL														
200-W-22 (203-S/204-S/205-S Stabilization Area)	The 200-W-22 Unplanned Release site is an underground RMA, and the visible portion of this site is the stabilized surface area where aboveground portions of the S Plant (REDOX) (203-S Uranyl Nitrate Hexahydrate Tank Farm, 204-S Tank Farm & Pumphouse, 205-S Process Vault & Chemical Makeup Building, 205-S Uranyl Nitrate Hexahydrate Processing Facility) were removed in 1983. This site is located in the 200 East Area, northwest of 202-S building. Decommissioning included removal of aboveground equipment and structures and removal of process equipment and tanks representing the bulk of radioactive structures. Structures were removed to 2 ft belowgrade and the area was leveled with clean backfill. It is approximately 84 m x 68 m (276 ft x 223 ft) at the surface. The belowground materials remaining in place are concrete and metal materials and structures that include buried piping, the 203-S Basin, the 204-S Basin, 205-S Vault, 205-S Building base pad, the concrete pipe trench from REDOX to the tank farm, and the REDOX chemical sewer system.	The 200-W-22 Unplanned Release site is associated with the 203-S and 205-S UNH Processing Facilities and the REDOX UNH Unloading Facility that operated from 1952 to 1983. The site has various UPRs (i.e., UPR-200-W-10, UPR-200-W-32, UPR-200-W-69, UPR-200-W-83, UPR-200-W-86, UPR-200-W-116, and UPR-200-123) associated with it because of different activities performed. The volume of waste released at this site is unknown. The remaining belowground structures and materials potentially contain residues from processing of contaminated UNH from REDOX and PUREX, thorium nitrate from PUREX, N Reactor decontamination waste and 300 Area lab waste. In 1952, the ground around the 203-S UNH storage tanks was found to be contaminated with uranium and was covered with blacktop and surrounded with a wooden rail fence.												As described below, the 200-W-22 is analogous to, or bounded by, its representative site the 207-A South Retention Basin with regard to process knowledge, contaminant inventory and distribution, effluent volume received, and/or groundwater impact: 1. *Contamination:* Both sites are belowgrade RMAs having contaminated belowgrade concrete structures with associated buried pipelines, but this site contains substantially more buried materials. 2. *Waste stream origin/volume:* As storage and processing facilities, not disposal sites, neither site received effluent in other than small, incidental quantities. Both sites contain belowgrade and/or buried materials contaminated with waste residues. This site is contaminated with constituents from the buried REDOX UNH processing facilities, and the representative site contains waste from the 242-A Evaporator, which processed DST waste that included UNH processing waste. 3. *Contaminant inventory:* As storage and processing facilities, not disposal sites, neither site contains a reported contaminant inventory. Both sites contain belowgrade and/or buried materials contaminated with waste residues. For this site the residues originated from REDOX UNH processing and decontamination activities that generated waste containing primarily uranium and low levels of incidental fission products. For the representative site, residues were from the 242-A Evaporator processing of DST waste that also included 204-AR Waste Unloading Facility UNH waste. 4. *Geology:* This site is located in the 200 West Area, and the 207-A- South Basin is located in the 200 East Area. At both sites, the contaminated structures are expected to be confined to shallow soils (upper 10 ft). Because the geology for the 200 East and 200 West Area is essentially the same in the upper 10 ft and the buried materials are not anticipated to have impacted soil significantly below that depth, the geology for these sites is similar. 5. *Extent of contamination:* The extent of contamination and contaminant distribution are similar because the depth of the structures and the extent of residual contamination are expected to be similar and because substantial migration of waste residues on buried structures is not anticipated to migrate significantly. 6. *Groundwater impact:* Neither site was a disposal unit, neither site discharged significant quantities of effluent through spills, and so neither site had any reasonable potential to have impacted groundwater.

Table 2-2. 200-PW-2/200-PW-4 Operable Unit Representative Sites and Associated Analogous Waste Sites. (26 Pages)

Waste Site*	Waste Site Configuration, Construction, and Purpose	Site and Discharge History	Contaminant Inventory									Contaminant Inventory	Contaminant Inventory	Contaminant Inventory
			Total U (kg)	Total U (kg)	Total U (kg)	Total U (kg)	Total U (kg)	Total U (kg)	Total U (kg)	Total U (kg)	Total U (kg)			
TREATMENT, STORAGE, AND/OR DISPOSAL UNIT (TSD) WASTE SITE														
216-A-37-1 Crib	The 216-A-37-1 Crib was constructed in 1977 for disposal of 242-A Evaporator process condensate to the soil column. This crib is located outside of the 200 East Area perimeter fence, about 610 m (2,000 ft) east of the 202-A Building. The crib is a gravel-filled drain-field-type crib that is approximately 213 m x 3 m (700 ft x 10 ft) at the bottom and is 3.35m (11 ft) deep. The crib excavation has side slopes of 1:1. The crib is fed by a 254 mm (10-in.) galvanized steel distribution pipe placed 2 m (7 ft) below grade along the centerline of the crib. The pipe was covered with gravel and sand and was backfilled to grade. A valve station that has surface radiation warning signs and a light chain barricade is at the south end of the crib; a vent is located at the north end.	The 216-A-37-1 crib is one of two RCRA TSD units in the 200-PW-4 OU. The crib operated from 1977 to 1989 and received 377,000,000 L (99,590,000 gal) of 242-A Evaporator process condensate from the 207-A South Retention Basin that was in contact with spent solvents and contained ammonia (as N), tributyl phosphate, and was thought to contain Am-241, Cs-137, tritium, I-129, Pm-147, Pu-239, Ru-106, Sn-113, and Sr-90. Discharge of the evaporator process condensate to the crib was terminated on April 12, 1989.	3.24 E+01 (1.93E-01)	2.83 E-02 (2.82E+02)	3.69 E-04 (1.20E-01)	9.47 E-02 (0)	5.42 E-02 (1.85E-01)	600 (2.04E+02)	(0)	(—)	(0)	377,011	15,879 Effluent volume to pore volume ratio: 23.7	Radionuclide contamination was detected beneath the 216-A-37-1 Crib to a depth of 83.1 m (272.5 ft) bgs (water table at 84.1 m [277.5 ft] bgs). Maximum radionuclide concentrations are present from 3.8 m to 14.4 m (12.5 ft to 47.5 ft) bgs. This site received 242-A Evaporator effluent from the 207-A South Retention Basin that was relatively low in contaminants. Highly mobile contaminants are present to the maximum depth, and moderately mobile contaminants were found down to 107 ft bgs. When actively receiving effluent, the crib was about 2.4 m to 4.3 m (8 to 14 ft) deep. The crib surface is essentially level with the surrounding area and is not contaminated. Maximum concentrations for primary waste stream radionuclides detected in site soils: • Cesium-137 1.7 pCi/g at 3.8 m (12.5 ft) bgs • Tritium 267 pCi/g at 3.8 m (12.5 ft) bgs. Maximum concentrations of other radionuclide detected in site soils: total radioactive strontium (1.70 pCi/g), Nickel-63 (14.4 pCi/g), Potassium-40 (9.15 pCi/g). Maximum concentrations of nonradioactive constituents detected in site soils: • Nitrate (as N) 385 mg/kg at 3.8 m (12.5 ft) bgs • Nitrate/nitrite as N 489 mg/kg at 3.8 m (12.5 ft) bgs • Tributyl Phosphate at 3.8 m (12.5 ft) bgs. Maximum concentrations of other nonradioactive constituents detected in site soils: Acetone (.013 mg/kg), Aluminum (15,000 mg/kg), Barium (165 mg/kg), Bis(2-ethylhexyl)phthalate (0.021 mg/kg), Boron (0.510 mg/kg), Cobalt (15.9 mg/kg), Manganese (652 mg/kg), and Thallium (1.54 mg/kg). Geophysical borehole logging found Cs-137 at the surface at a maximum of 0.3 pCi/g and from 2.7 m to 11.0 m (9 and 36 ft) bgs at a maximum of 30 pCi/g at 3 m (10 ft) bgs. Logging of nearby wells found only Cs-137, which was detected sporadically and only at concentrations near the MDL (0.2 pCi/g) indicating low potential for lateral spread of contamination. Neutron moisture logging showed low moisture levels from 21.4 m to 32.6 m (70 ft to 107 ft) bgs consistent with analytical data reporting Cs-137 near MDL. Logging data compared relatively well with laboratory data that showed low levels for Cs-137 (only two results and only slightly above the MDA), 0.113 pCi/g (MDA of 0.014) at 3.8 m (12.5 ft) bgs and 0.018 pCi/g (MDA of 0.012) at 5.3 m (17.5 ft) bgs. Sample results from 8.3 m (27.5 ft) bgs were below the MDA of 0.003 pCi/g and would have been expected to be around 10 pCi/g based on the logging. Sample data showing Cs-137 at 11.4 m (37.5 ft) at below the MDA (0.01 pCi/g) compared well to logging at 10.9 m (36 ft) bgs, showing Cs-137 at about 0.2 pCi/g (the approximate MDA). Laboratory data show low maximum concentrations of contaminant. Although the site received a relatively high (24 times pore volume) volume of effluent, the discharge generally was low in contamination. Groundwater monitoring data shows tritium and I-129 plumes near the crib, but no exceedances of groundwater parameters in wells associated with this crib. This suggests that the 216-A-37-1 Crib has a low potential to have impacted groundwater. Modeling indicates that tritium will reach groundwater in trace quantities at 168 years. The conceptual contaminant distribution model for this site (DOE/RL 2000-60, Figure 3-18) indicates that the high site contamination may be expected from 3.3 m to about 9.1 m (11 ft to 30 ft), and medium contamination may be expected from 9.1 m to about 12.1 m (30 ft to 40 ft) bgs. The characterization data are well correlated with this model.

*All information on this table was derived from the Work Plan (DOE/RL-2000-60, *Uranium-Rich/General Process Condensate and Process Waste Group Operable Units RI/FS Work Plan and RCRA TSD Unit Sampling Plan; Includes 200-PW-2 and 200-PW-4 Operable Units*), the *Waste Information Data System* database, the Implementation Plan (DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*), DOE/RL-96-81, *Waste Site Grouping for 200 Areas Soil Investigations*), and/or RPP-26744, *Hanford Soil Inventory*.

"—" No site inventory developed for this contaminant, generally because it was not a significant component of the site-specific waste stream.
HW-60807, *Unconfined Underground Radioactive Waste and Contamination in the 200 Areas - 1959*.
PNNL-13788, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*.
WAC 173-340-747, "Deriving Soil Concentrations for Ground Water Protection."

ASD = ammonia scrubber distillate.
bgs = below ground surface.
CNT = condensate neutralization tank.
COC = contaminant of concern.
DST = double-shell tank.
HSW = high-salt waste.
IMUST = inactive miscellaneous underground storage tank.
MDA = minimum detectable activity.
MDL = minimum detection level.
NPH = normal petroleum hydrocarbon.
OU = operable unit.
PFP = Plutonium Finishing Plant.
PRG = preliminary remediation goal.
PUREX = Plutonium-Uranium Extraction (Plant or process).
RCRA = *Resource Conservation and Recovery Act of 1976*.
REDOX = Reduction-Oxidation (Plant or process).
RMA = Radioactive Material Area.
SGLS = Spectral Gamma-Ray Logging System.
TBP = tributyl phosphate.
TPH = total petroleum hydrocarbon.
TSD = treatment, storage, and/or disposal (unit).
UNH = uranyl nitrate hexahydrate.
UPR = unplanned release.
URM = Underground Radioactive Material (area or posting).
V/H = vertical/horizontal.
VCP = vitrified clay pipeline.
WESF = Waste Encapsulation and Storage Facility.
WIDS = *Waste Information Data System* database.

Table 2-3. List of Sampled and/or Logged Boreholes. (2 Pages)

Borehole Number	Approximate Location	Coordinates (Wash. State Plane, NAD83[91]	
		Northing	Easting
A6816 (299-E28-65)	Within the boundaries of the 216-B-12 Crib	136600.469	573127.558
A6817 (299-E28-66)	Within the boundaries of the 216-B-12 Crib	136618.537	573127.34
A6794 (299-E28-16)	South of the 216-B-12 Crib	136562.635	573136.748
C3246	216-B-12 Crib	136589.76	573128.81
A4728 (299-E17-1)	Southern edge of the 216-A-10 Crib	135386.153	574977.079
A4755 (299-E24-2)	Northern edge of the 216-A-10 Crib	135493.023	574973.639
A5916 (299-E24-59)	Eastern edge of the 216-A-10 Crib	135435.478	574985.793
A5917 (299-E24-60)	Western edge of the 216-A-10 Crib	135435.779	574964.093
C3247	216-A-10 Crib	135438.80	574979.08
C4107	216–A-10 Crib	135481.19	574978.22
C4108	216–A-10 Crib	135456.04	574982.48
C4110	216-A-10 Crib	135417.16	574980.89
C4111	216-A-10 Crib	135438.80	574977.33
C4112	216-A-10 Crib	135402.70	574977.78
A4739 (299-E17-5)	Western edge of the 216-A-36B Crib	135278.548	575093.967
A5883 (299-E17-11)	Within the boundaries of the 216-A-36B Crib	135347.191	575109.138
A5886 (299-E17-51)	Within the boundaries of the 216-A-36B Crib	135230.501	575109.364
C3248	216-A-36B Crib	135355.10	575104.55
C4160	216-A-36B Crib	135355.28	575106.04
A6301 (299-E25-17)	South of the 216-A-37-1 Crib	135702.51	575760.245
A4764 (299-E25-18)	North of the 216-A-37-1 Crib	135699.304	575817.379
A4765 (299-E25-19)	South of the 216-A-37-1 Crib	135659.027	575852.333
A4767 (299-E25-20)	North of the 216-A-37-1 Crib	135654	575910.942
C4106	216-A-37-1 Crib	135640.23	575917.54
A4967 (299-W22-22)	216-U-12 Crib	134464.315	567617.274
A7874 (299-W22-23)	216-U-12 Crib	134444.974	567586.716
A4969 (299-W22-28)	216-U-12 Crib	134465.777	567433.699
A7879 (299-W22-75)	216-U-12 Crib	134490.42	567595.19
C3245	216-A-19 Trench	136269.73	575660.99
A7770 (299-W19-70)	216-U-8 Crib, Center	134697.757	567615.853
A7771 (299-W19-71)	216-U-8 Crib, Southern Third	134679.76	567616.01
C4557	Within the boundaries of the 216-S-7 Crib	134176.07	567172.76
299-W22-12	Eastern edge of the 216-S-7 Crib	134184.891	567191.077
299-W22-13	Western edge of the 216-S-7 Crib	134172.135	567142.834
299-W22-14	Southern edge of the 216-S-7 Crib	134166.146	567186.931

Table 2-3. List of Sampled and/or Logged Boreholes. (2 Pages)

Borehole Number	Approximate Location	Coordinates (Wash. State Plane, NAD83[91]	
		Northing	Easting
299-W22-32	Within the boundaries of the 216-S-7 Crib	134173.538	567178.833
299-W22-33	Within the boundaries of the 216-S-7 Crib	134168.017	567154.625

NAD83 (91), *North American Datum of 1983.*

Table 2-4. Intruder Risk and Dose Summary for Future Rural Resident.

Waste Site	Intruder Dose at 150 Years (mrem/year)	Intruder Dose at 500 Years (mrem/year)
207-A South Retention Basins	1.9 E-02	5.4 E-03
216-A-10 Crib	58	32
216-A-19 Trench	5.4 E-04	1.0 E-04
216-A-36B Crib	2,720	84
216-A-37-1 Crib	1.4 E-03	9.5 E-05
216-B-12 Crib	148	8.9 E-02
216-S-7 Crib	105	27

Table 2-5. Nonradioactive Constituents of Concern Removed. (2 Pages)

Constituent*	Site	Risk
Acetone	216-A-37-1 Crib	Ecological
Aluminum	216-A-37-1 Crib	Groundwater
Arsenic	216-A-19 Trench	Groundwater
	216-B-12 Crib	Groundwater Ecological
	216-S-7 Crib	Groundwater
	207 A South Retention Basin	Groundwater Ecological
Barium	216-A-37-1 Crib	Ecological
Boron	216-A-37-1 Crib	Ecological
	216-A-19 Trench	Ecological
	216-A-10 Crib	Ecological
	216-B-12 Crib	Ecological
Butylbenzyl phthalate	207-A South Retention Basin	Ecological
2,4-dichlorophenoxy-acetic acid	207-A South Retention Basin	Ecological
2-(2,4,5-trichlorphenoxy) propionic acid	207-A South Retention Basin	Ecological

Table 2-5. Nonradioactive Constituents of Concern Removed. (2 Pages)

Constituent*	Site	Risk
B-BHC (beta-1,2,3,4,5,6-Hexachlorocyclohexane)	216-A-10 Crib	Groundwater Ecological
bis(2-ethylhexyl) phthalate	216-A-37-1 Crib	Ecological
	216-A-19 Trench	Ecological
	216-B-12 Crib	Ecological
Chromium VI	216-S-7 Crib	Ecological
Manganese	216-A-37-1 Crib	Groundwater
	216-A-19 Trench	Groundwater
Nitrate/nitrite	207-A South Retention Basin	Groundwater
	216-A-10	Groundwater
Pentachlorophenol	216-A-10 Crib	Groundwater
Methylene chloride	216-A-10 Crib	Groundwater
Isophorone	216-A-36B Crib	Groundwater
Oil and grease	216-A-10 Crib	Groundwater
	216-A-36B Crib	Groundwater
Silver	216-S-7 Crib	Ecological
	216-A-36B Crib	Ecological
	207-A South Retention Basin	Ecological
TPH-kerosene	216-A-10 Crib	Groundwater
Tributyl phosphate	216-A-37-1 Crib	Ecological
	216-A-10 Crib	Groundwater
	216-A-19 Trench	Groundwater Ecological
Vanadium	216-A-19 Trench	Ecological

*Removal methodology detailed in Appendix E.
TPH = total petroleum hydrocarbon.

Table 2-6. Radioactive Constituents of Concern Removed.

Constituent*	Site	Risk
Potassium-40	216-A-10 Crib	Ecological
Thorium-230	216-B-12 Crib	Ecological
	207-A South Retention Basin	Ecological
Niobium-94	207-A South Retention Basin	Ecological
Neptunium-237	216-A-10 Crib	Ecological
Tin-126	216-B-12 Crib	Ecological
Nickel-63	216-A-19	Ecological
Technetium-99	216-S-7	Groundwater

*Removal methodology detailed in Appendix E.

Table 2-7. Evaluation of Potential Human Health and Ecological Risk at Shallow Analogous Waste Sites.

Representative Site	Analogous Site	Potential Risk	
		Human Health	Ecological
216-A-19 Trench	216-A-1 Crib	NA	NA
	216-A-3 Crib	NA	NA
	216-A-18 Crib	NA	NA
	216-A-22 Crib	NA	NA
	216-A-28 Crib	NA	NA
	216-A-34 Crib	NA	NA
216-B-12 Crib	216-C-3 Crib	NA	X
	216-C-5 Crib	NA	X
	216-C-7 Crib	NA	NA
	216-C-10 Crib	NA	X
216-A-10 Crib	216-C-1 Crib	NA	NA
216-S-7 Crib	216-T-20 Trench	NA	NA
	216-S-22 Crib	NA	NA

NA = no risk identified during shallow site evaluation (Section 2.6 and Appendix G).

Table 2-8. Waste Site Risk and Protectiveness Summary. (2 Pages)

Risk Element [a]	207-A South Retention Basin	216-A-10 Crib	216-A-19 Trench	216-A-36B Crib	216-A-37-1 Crib	216-B-12 Crib	216-S-7 Crib
HUMAN HEALTH [b]							
Chemicals							
Site meets WAC 173-340-745?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Radionuclides							
Site meets PRGs? ('no cover' [c])	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Meet PRGs? ('cover' [d])	Yes	Yes	Yes	Yes	Yes	Yes	Yes
GROUNDWATER PROTECTION							
Chemicals							
Site meets screening level PRGs?	Yes	Yes	No [e]	No [e]	No [e]	No [e]	No [e]
Chemicals potentially reaching groundwater > MCL	NA	NA	Nitrate, Nitrate/Nitrite Uranium	Nitrate, Nitrite, Nitrate/Nitrite, Uranium	Nitrate, Nitrate/Nitrite	Nitrate, Nitrate/Nitrite, Uranium	Nitrate, Nitrate/Nitrite, Uranium
Radionuclides							
Site meets groundwater protection standards (RESRAD)?	Yes	No [e]	Yes	No [e]	Yes	Yes	No [e]
Radionuclides predicted to reach groundwater > MCL (RESRAD) within 1,000 years.	NA	NA	NA	NA	NA	NA	Tritium
Radionuclides predicted to reach groundwater > MCL (RESRAD) beyond 1,000 years.	NA	I-129	NA	Tc-99	NA	NA	NA
ECOLOGICAL							
Chemicals							
Meets chemical PRGs? [f]	Yes	Yes	No [g]	Yes	Yes	Yes	Yes
Constituents > PRGs	NA	NA	Uranium	NA	NA	NA	NA
Radionuclides							
Meets radiological PRGs?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constituents > PRGs	NA	NA	NA	NA	NA	NA	NA
INTRUDER (Radionuclides only) [g]							
Meets target dose rates at 150 yrs?	Yes	No [e]	Yes	No [e]	Yes	No [e]	No [e]
Radionuclides > target dose rates at 150 yrs	NA	Cs-137 Pu-239	NA	Cs-137	NA	Cs-137	Cs-137 Sr-90
Meets target dose rates at 500 yrs?	Yes	No [e]	Yes	No [e]	Yes	Yes	No [e]
Radionuclides > target dose rates at 500 yrs	NA	Pu-239	NA	Cs-137 Am-241	NA	NA	Pu-239

Table 2-8. Waste Site Risk and Protectiveness Summary. (2 Pages)

Risk Element [a]	207-A South Retention Basin	216-A-10 Crib	216-A-19 Trench	216-A-36B Crib	216-A-37-1 Crib	216-B-12 Crib	216-S-7 Crib

[a] Table summarizes primary risk contributors identified in RI Report (DOE/RL-2004-25) and Appendix D of this feasibility study, after further feasibility study evaluation.
[b] Shallow zone contamination [0 to 4.6 m (0 to 15 ft) bgs] below PRGs.
[c] Assumes that no credit is taken for the protectiveness of the existing cover modeled at 150 and 500 years.
[d] Assumes that the existing cover provides some protection.
[e] Site requires protection for identified risk from identified contaminant.
[f] Screening levels based on WAC 173-340-900, Table 749-3.
[g] Based on Intruder Assessment, Appendix D, Attachment B.

DOE/RL-2004-25, *Remedial Investigation Report for the 200-PW-2 Uranium-Rich Process Waste Group and 200-PW-4 General Process Condensate Group Operable Units.*
WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties."
WAC 173-340-900, "Tables."

MCL = maximum contaminant level.
NA = not applicable.
PRG = preliminary remediation goal.
RESRAD = RESidual RADioactivity (dose model).

3.0 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIATION GOALS

This chapter defines the land use for the 200-PW-2 and 200-PW-4 OUs and the region, the RAOs, the elements for the development, and PRGs against which remedial action alternatives are evaluated later in this FS. The Implementation Plan (DOE/RL-98-28) provided preliminary RAOs. The Work Plan (DOE/RL-2000-60) and the RI Report (DOE/RL-2004-25) provide RI data to help define RAOs for the waste sites. For this FS, Implementation Plan information was compared to data collected during the RI activities and refinements were made as appropriate for the 200-PW-2 and 200-PW-4 OU waste sites.

The RAOs are media-specific or OU-specific objectives for protecting human health and the environment and describe remediation goals so that an appropriate range of remedial options can be developed for evaluation. The RAOs are developed considering land use, contaminants of potential concern (COPC), potential applicable or relevant and appropriate requirements (ARAR), and exposure pathways (conceptual model). The RAOs are defined as specifically as possible without limiting the range of GRAs that can be applied.

The RAO process requires identification of potential future land use and refinement of representative site COPCs (Work Plan, Tables 3-7 and 3-8) to contaminants of concern (COC) through the risk assessment process. This information ensures that the remedial alternatives being considered can adequately address the types of contaminants present, and facilitates refinement of potential ARARs. The RAOs also provide the basis for developing the GRAs that will satisfy the objectives of protecting human health and the environment.

3.1 LAND USE

To identify appropriate cleanup objectives, the future land use of a site must be considered. Current and future land uses of the 200 Areas and the Central Plateau are discussed in the following sections.

3.1.1 Current Land Use

All current land-use activities associated with the 200 Areas and the Central Plateau are industrial in nature. The facilities located in the Central Plateau were built to process irradiated fuel from plutonium production reactors located in the 100 Areas. Most of the large and contaminated facilities directly associated with fuel reprocessing are now inactive and awaiting final disposition. Several waste management facilities operate in the 200 Areas, including permanent waste disposal facilities such as the ERDF, low-level radioactive waste burial grounds, and a mixed-waste trench permitted under RCRA. Construction of a facility for vitrification of tank waste facilities in the 200 Areas began in 2002 and the 200 Areas are the planned disposal location for the vitrified low-activity tank wastes. Past-practice disposal sites in the 200 Areas are being evaluated for remediation that is likely to include institutional controls (e.g., deed restrictions or covenants) as part of the selected remedy. Federal agencies other than the DOE, such as the U.S. Department of the Navy, use the Hanford Site 200 Areas nuclear waste TSD facilities. A commercial low-level radioactive waste disposal facility, operated by US Ecology, Inc., currently operates on a portion of a tract in the 200 Areas leased to the State of Washington.

The DOE-selected land use for the 200 Areas, documented through the land-use ROD (64 FR 61615, "Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement (HCP EIS)," is industrial (exclusive) for sites located within the exclusive use zone (Chapter 1.0, Figure 1-1). This land-use designation is for those areas suitable and desirable for TSD of hazardous, dangerous, radioactive, and nonradioactive wastes, and related activities consistent with industrial-exclusive uses.

According to DOE/EIS-0222-F, *Final Hanford Comprehensive Land Use Plan Environmental Impact Statement* (HCP), industrial (exclusive) land use would preserve DOE control of the continuing remediation activities and would use the existing compatible infrastructure required to support activities such as dangerous waste, radioactive waste, and mixed-waste TSD facilities. The DOE and its contractors and the U.S. Department of Defense and its contractors could continue their federal waste disposal missions; and the Northwest Interstate Compact for Low-Level Radioactive Waste Management could continue using the US Ecology, Inc., site for commercial radioactive waste. Research supporting dangerous waste, radioactive waste, and mixed-waste management facilities also would be encouraged within this land-use designation. New uses of radioactive materials, such as food irradiation, could be developed and the products could be packaged for commercial distribution under this land-use designation.

3.1.2 Anticipated Future Land Use

The reasonably anticipated future land use for the Core Zone, as described by the Tri-Parties response to HAB Advice #132 (HAB 2002), is continued industrial (exclusive) activities for the foreseeable future. Eventually, portions of the Core Zone may be used for non-DOE-related industrial uses. The DOE worked for several years with cooperating agencies and stakeholders, including the U.S. Department of Interior, Tribal Nations, states of Washington and Oregon, local county and city governments, economic and business development interests, environmental groups, and agricultural interests, to define land-use goals for the Hanford Site and develop future land-use plans. The results were reported in *The Future for Hanford: Uses and Cleanup, The Final Report of the Hanford Future Site Uses Working Group* (Drummond 1992) and culminated in the HCP (DOE/EIS-0222-F) and associated ROD (64 FR 61615) issued in 1999. The HCP was written to address the growing need for a comprehensive, long-term approach to planning and development on the Hanford Site because of DOE's separate missions of environmental restoration, waste management, and science and technology. The HCP analyzes the potential environmental impacts of alternative land-use plans for the Hanford Site, considers the land-use implication of ongoing and proposed activities, and identifies the land-use designation for sites inside the exclusive use zone as industrial (exclusive).

Under the preferred land-use alternative selected in the ROD (64 FR 61615), the area inside the exclusive use boundary of the Central Plateau was designated for industrial (exclusive) use. The current vision for all of the 200 Areas is continued use for management of hazardous, dangerous, radioactive, and nonradioactive wastes. The HCP and ROD incorporate this vision in the selected alternative, describe the means by which new projects will be sited, and focus on using existing infrastructure and developed areas of the Hanford Site for new projects. To support the current vision, the 200 Areas projects will maintain current facilities for continuing missions, remediate soil waste sites and groundwater as necessary to support industrial land uses, lease facilities for waste disposal (i.e., US Ecology, Inc.), and demolish facilities that have no further beneficial use. Based on the HCP and associated ROD, and consistent with other Hanford Site waste management decisions, this FS assumes an industrial land use for all the waste sites, because they are within the Core Zone. Risk assessments for the industrial land use are conducted considering a non-Hanford Site worker industrial receptor to bound the industrial land-use exposure possibilities.

3.1.3 Regional Land Use

Communities in the region of the Hanford Site consist of the incorporated cities of Richland, West Richland, Kennewick, and Pasco, and numerous other smaller communities within Benton and Franklin Counties. The estimated population of the region in 2000 was 186,600, with the population of Benton County being 140,700 and the population of Franklin County being 45,900. There are no residences on the Hanford Site. The inhabited residences nearest to the 200 Areas are farmhouses on land approximately 16 km (10 mi) north across the Columbia River. The City of Richland corporate boundary is approximately 27 km (17 mi) to the south (PNNL-6415, *Hanford Site National Environmental Policy Act (NEPA) Characterization*).

3.1.4 Groundwater Use

The HCP indicates that contamination in the groundwater would restrict use. Groundwater beneath the Central Plateau currently is contaminated, is not withdrawn for beneficial uses, and is not expected to be suitable for beneficial uses for the next 300 years. This FS evaluates potential future impacts to groundwater from current vadose zone contaminants at the representative sites, but does not evaluate groundwater remediation. This issue will be addressed through the evaluation of the groundwater OUs (i.e., 200-UP-1, 200-BP-5, 200-ZP-1, and/or 200-PO-1) and through other sitewide assessments.

3.2 CONTAMINANTS OF POTENTIAL CONCERN

Contaminants that have the potential to contribute significantly to site risk are referred to as COPCs. Identification of COPCs is an important process because it determines the list of contaminants for which further risk evaluations will be developed. Development of COPCs in the data evaluation and risk assessment process is discussed in EPA/540/1-89/002, *Risk Assessment Guidance for Superfund (RAGS), Volume 1 -- Human Health Evaluation Manual, (Part A) Interim Final*, OSWER 9285.7-01A. Those contaminants that are COPCs are determined by comparing contaminant concentrations with screening factors (e.g., background) and developing a set of data for use in risk assessment. The evaluation of COPCs is presented in the RI Report (DOE/RL-2004-25) and Appendix D of this FS for the 207-A South Retention

Basin, 216-A-10 Crib, 216-A-19 Trench, 216-A-36B Crib, 216-B-12 Crib, and the 216-A-37-1 Crib; and Appendix A of this FS for the 216-S-7 Crib.

A summary of COPCs for all representative sites is provided in Appendix D, Tables D-1 and D-2. This list of COPCs is carried forward and presented in risk assessment results. The risk assessment process compares containment concentrations, appropriate radiological risk and dose limits, and risk-based cleanup standards through computed modeling and/or screening. Only those constituents that exceed one more of these criteria and were not removed by further FS evaluation (Section 2.6.6) are retained as COCs.

3.3 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Appendix C identifies the potential ARARs for the waste sites in this FS. Appendix C also identifies the ARAR identification process for applicability or for relevance and appropriateness.

3.4 REMEDIAL ACTION OBJECTIVES

The RAOs are media-specific or OU-specific objectives for protecting human health and the environment and describe what the remedial action is expected to accomplish. The RAOs are developed considering land use, COPCs, potential ARARs, and exposure pathways (conceptual model). The RAOs help measure how well a remedial alternative will comply with ARARs and/or meet human health and environmental risk protection requirements. This chapter describes RAO development and the RAOs against which alternatives are evaluated.

3.4.1 Remedial Action Objective Development

The RAOs describe what the remedial action is expected to accomplish (i.e., medium-specific or site-specific goals for protecting human health and the environment). They are defined as specifically as possible and usually address the following variables:

- Media of interest (e.g., contaminated soil, solid waste)
- Types of contaminants (e.g., radionuclides, inorganic and organic chemicals)
- Potential receptors (e.g., humans, animals, plants)
- Possible exposure pathways (e.g., external radiation, ingestion)
- Levels of residual contaminants that may remain following remediation (i.e., contaminant levels below cleanup standards or below a range of levels for different exposure routes).

The RAOs help determine whether a specific remedial alternative complies with potential ARARs and/or reduces risk to human health or the environment appropriately. Preliminary RAOs specific to the entire 200 Areas for soils, solid wastes, and groundwater were developed in the Implementation Plan (DOE/RL-98-28). Based on these preliminary RAOs, RAOs for the 200-PW-2 and 200-PW-4 OU sites are as follows.

- RAO 1 – Prevent unacceptable risk to human health and ecological receptors by exposure to nonradiological constituents in soils and debris at concentrations above the industrial-use criteria, as defined in WAC 173-340-745(5), "Soil Cleanup Standards for Industrial Properties," "Method C Industrial Soil Cleanup Levels."

- RAO 2 – Prevent unacceptable risk to human health and ecological receptors by exposure to radiological constituents in soils and debris, by performing the following.

  - Prevent exposure to radiological constituents at concentrations that will cause a dose greater than 15 mrem/yr above background for industrial workers (EPA/540/R-99/006, *Radiation Risk Assessment at CERCLA Sites: Q&A*, Directive 9200.4-31P). A dose rate limit of 15 mrem/yr above background generally achieves the EPA ELCR threshold, which ranges from 1×10^{-6} to 1×10^{-4}.

  - Protect ecological receptors based on a dose rate limit of 0.1 rad/day for terrestrial wildlife populations (DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*), which is a To Be Considered criterion).

- RAO 3 – Prevent migration of contaminants through the soil column to groundwater or reduce soil concentrations below WAC 173-340-747, "Deriving Soil Concentrations for Ground Water Protection," and 40 CFR 141.66, "Maximum Contaminant Levels for Radionuclides," groundwater protection criteria so that no further degradation of the groundwater results from contaminant leaching from the 200-PW-2/200-PW-4 OU waste sites.

- RAO 4 – Prevent adverse impacts to cultural resources and threatened or endangered species and minimize wildlife habitat disruption.

The RAOs will be finalized in the ROD for these waste sites.

3.4.2 Remedial Action Objective Achievement

After the ROD is approved finalizing the RAOs, the remedial design report/remedial action work plan will be prepared to describe how the RAOs will be achieved.

3.4.2.1 Achievement of Remedial Action Objective 1

For carcinogenic chemicals, RAO 1 will be achieved by prevention or reduction of human health carcinogenic risks from waste or contaminated soil in an industrial scenario such that the CERCLA ELCR goal of 10^{-5} cancer risk for carcinogens, equal to screening levels calculated using the equations in WAC 173-340-745(5), is not exceeded.

For non-carcinogenic chemicals, RAO 1 is defined as prevention or reduction of risks from direct contact with waste or contaminated soils that exceed a hazard quotient (HQ) of 1, calculated using industrial-exposure assumptions and the equations in WAC 173-340-745(5).

Exposure of ecological receptors to wastes or soil contaminated with nonradiological constituents will be prevented or reduced so that the HQ does not exceed 1.

3.4.2.2 Achievement of Remedial Action Objective 2

RAO 2 will be considered achieved for DOE and industrial site workers for protection from radionuclide contaminants when for DOE site workers dose rates do not exceed 500 mrem/yr for the next 50 years, and for industrial workers when dose rates caused by exposure to waste or contaminated soil do not exceed 15 mrem/yr above background (generally equaling to the EPA ELCR of 1×10^{4} to 1×10^{-6}) for the period from 50 to 1,000 years from the present. In addition, RAO 2 is achieved when waste is beneath the point of compliance (4.3 m [15 ft] bgs). For ecological receptors, exposure to wastes or soil contaminated with radionuclides will be prevented or reduced such that dose rates shall not exceed 0.1 rad/day for terrestrial organisms and 1.0 rad/day for aquatic organisms and terrestrial plants.

3.4.2.3 Achievement of Remedial Action Objective 3

RAO 3 prevents further degradation of groundwater. RAO 3 is achieved by preventing or reducing migration of contaminants through the soil column to groundwater such that concentrations reaching groundwater do not exceed maximum contaminant levels (MCL) under 40 CFR 141 and/or State of Washington drinking water standards (WAC 246-290, "Department of Health," "Public Water Supplies") and WAC 173-340-720, "Ground Water Cleanup Standards."

3.4.2.4 Achievement of Remedial Action Objective 4

RAO 4 is achieved by implementing existing Hanford Site standards for protection of cultural resources and wildlife habitat, and by enforcing appropriate institutional controls and monitoring requirements. DOE has integrated natural resource concerns into this FS in accordance with DOE policies.

3.5 PRELIMINARY REMEDIATION GOALS

This section describes PRGs for direct human and ecological exposure for chemical and radiological constituents, and protection of groundwater. PRGs (i.e., cleanup levels) are numeric representations of the RAOs using the anticipated future land use as the exposure model for applicable contaminants and exposure pathways. Typically, PRGs are identified for individual hazardous substances identified as COCs. COCs are a subset of the COPCs (Appendix D, Tables D-1 and D-2) determined by the risk assessment and further FS evaluation to exceed applicable standards (Section 2.6). If multiple contaminants are present at a site, the suitability of using individual PRGs as final cleanup values protective of human health and the environment is evaluated based on site-specific information and the potential for contaminant interaction.

These numeric soil PRGs were developed for the protection of human health, the protection of ecological receptors, and the protection of groundwater (DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*). These PRGs then were compared to each other to determine which offered the most restrictive value that would be protective of all pathways, provided it is greater than background concentrations and the required detection limit. If the lowest of the PRGs is lower than background concentrations or the required detection limit, then background concentrations or the required detection limit, whichever is higher, becomes the PRG according to WAC 173-340-700(6)(d), "Overview of Cleanup Standards," "Requirements for Setting Cleanup Levels," "Natural Background and Analytical Considerations." The purpose of this process is to identify those constituents that may pose an unacceptable risk. Tables 3-1 and 3-2 summarize the PRGs for the COCs retained.

PRGs and the potential ARARs can be met by reducing concentrations (or activities) of contaminants or by eliminating potential exposure pathways/routes. PRGs for direct exposure and protection of groundwater typically are presented numerically as concentrations (milligrams per kilogram or milligrams per cubic meter) or radioactivity (picocuries per gram). Final remedial action goals are developed from the PRGs and specified in the ROD that will identify the selected remedial alternative for the 200-PW-2 and 200-PW-4 OUs.

Residual risks following completion of remediation of the waste sites must meet the RAOs (i.e., 10^{-4} to 10^{-6} ELCR for radiological, 10^{-5} ELCR for carcinogenic chemicals; nonradiological chemical constituents must be below an HQ of 1.0 for non-carcinogens). Actual soil contaminant concentrations achieving these cleanup objectives will be presented in a cleanup verification package for the facility. The cleanup verification package will demonstrate how and where specific criteria have been applied and how the remedy protects receptors from the COCs identified for the waste sites.

3.5.1 Direct-Exposure Preliminary Remediation Goals for Nonradioactive Contaminants

This subsection describes the PRGs for direct exposure to nonradioactive contamination for human and ecological receptors.

3.5.1.1 Human Exposure to Nonradioactive Contaminants

For human receptors, PRGs for direct exposure to nonradioactive contamination in soils are based on risk-based standards. Risk-based standards for individual hazardous substances are established using applicable federal and state laws and the risk equations. Risk-based standards for individual carcinogens in an industrial-exposure scenario are based on CERCLA guidelines of 10^{-5} ELCR. Risk-based standards for individual non-carcinogenic substances are set at concentrations that would result in no acute or chronic toxic effects on human health and the environment and which correspond to an HQ of less than 1. Consistent with this approach, the methodology described for industrial properties under WAC 173-340-745(5) is used to calculate the risk-based standards, or Method A, as appropriate.

Table 3-1, which summarizes nonradiological PRGs, does not include any COCs for direct human exposure, because none of the representative sites analyzed possessed contamination more shallow than 4.3 m (15 ft) bgs.

3.5.1.2 Ecological Exposure to Nonradioactive Contaminants

The 200-PW-2 and 200-PW-4 OU waste sites are all within the exclusive use area identified in the HCP (DOE/EIS-0222-F) and HCP ROD (64 FR 61615) as industrial (exclusive). The industrial (exclusive) land-use designation allows for continued waste management operations within the 200 Areas consistent with past *National Environmental Policy Act of 1969* (NEPA), CERCLA, and RCRA commitments and development of new waste management facilities. Sites within the industrial (exclusive) zone currently have limited habitat suitable for the establishment of ecological communities and food webs to support a hierarchy of terrestrial receptors. Maintenance of the industrial (exclusive) use will prevent future human inhabitation. However, cleanup to industrial land-use standards may not continue to be protective of ecological receptors after loss of institutional controls (greater than 150 years). A screening-level ecological risk assessment has been used to develop soil PRGs for the protection of terrestrial wildlife.

Because the waste sites in this FS are all within the Core Zone, only terrestrial wildlife risks were evaluated. Consistent with this approach, WAC 173-340-7490(3)(b), "Terrestrial Ecological Evaluation Procedures," "Goal," specifies that for industrial or commercial properties, current or potential exposure to soil contamination only need be evaluated for terrestrial wildlife protection. Plants and soil biota need not be considered unless the species is protected under the federal *Endangered Species Act of 1973*. Currently, no federally listed threatened or endangered species are known to exist at the waste sites of this FS. Surveys conducted during field activities will confirm the absence of protected species.

For sites with controls that prevent excavation of deeper soil, a conditional point of compliance for ecological receptors may be set at the biologically active soil zone. This zone is assumed to extend to a depth of 2.7 m (9 ft), based on the conditional point of compliance requirements stated in WAC 173-340-7490(4), "Terrestrial Ecological Evaluation Procedures," "Point of Compliance" (DOE/RL-2001-06, *Comments on Hanford 2012: Accelerating Cleanup and Shrinking the Site*). Priority chemicals of ecological concern and their soil-screening levels are listed in WAC 173-340-900, "Tables," Table 749-3. These soil-screening levels were used in conjunction with the risk assessment to develop PRGs for the COCs that are protective of ecological receptors, as indicated in Table 3-1. Table 3-1 includes only uranium as a COC for ecological exposure at the 216-A-19 Trench.

3.5.2 Direct-Exposure Preliminary Remediation Goals for Radionuclides

The following subsections describe the PRGs for direct exposure to radioactive contamination for human and ecological receptors.

3.5.2.1 Human Radionuclide Exposure

For locations within the industrial (exclusive) land-use area, the DOE dose limits (currently, 500 mrem/yr) for radiological workers will be in effect for as long as waste management operations continue. After a period of 50 years, all waste management facilities are assumed to be closed. However, access to the 200 Areas is assumed restricted for an additional 100 years by enforcement of effective institutional controls. Institutional controls still would exist after that time; however, an intruder presumably could obtain access to the area and establish a residence.

After the cessation of waste management operations, remediation goals for radioactive wastes and radioactively contaminated soils for human receptors are considered to be based on the EPA radionuclide soil cleanup guidance. As established by 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," CERCLA cleanup actions generally should achieve a level of risk within the 10^{-4} to 10^{-6} ELCR based on the reasonable maximum exposure for an individual. Furthermore, EPA policy has noted that the upper boundary of the risk range is not a discrete line at 10^{-4} and that a specific risk estimate around 10^{-4} may be considered acceptable, if justified based on site-specific conditions (EPA/540/R-99/006). The goal of remediation is to achieve the 10^{-4} to 10^{-6} risk range, using a dose of 15 mrem/yr above background as an operational guideline to achieve this goal. Achievement of the 10^{-4} to 10^{-6} residual risk-range goal will be verified through sampling during closeout of individual sites.

The individual PRGs for the identified COCs are calculated using the RESidual RADioactivity (RESRAD) dose assessment model (ANL/EAD-4, *User's Manual for RESRAD, Version 6*) and are provided in Table 3-2. Numerical values of radionuclide PRGs corresponding to the 15 mrem/yr guidance limits for the identified COCs depend on the specific exposure scenario selected for remedial design and site-specific parameters (e.g., the area/extent of the waste site). Radionuclide PRGs corresponding to the 15 mrem/yr guidance limits for direct exposure to contaminated soil were calculated for the industrial scenario, as described in Section 2.6 of this FS. In addition, COCs corresponding to potential intruder exposure are included in Table 3-2.

Uranium-soluble salts present non-carcinogenic chemical toxicity hazard effects that are evaluated by an HQ in addition to the incremental cancer risks from the radioactive isotopes of uranium. Because the dose from total uranium will exceed the 15 mrem/yr radioactivity hazard guidance limits at an activity or concentration less than the concentration corresponding to an HQ of 1, it is expected that cleanup to meet the radioactivity hazard will address the chemical toxicity hazard.

3.5.2.2 Ecological Radionuclide Exposure

No promulgated screening or cleanup levels are available to assess the potential effects of residual radioactive surface contamination on ecological receptors. As a result, the DOE has produced DOE-STD-1153-2002. This technical standard provides a graded approach to ecological risk assessment for radionuclides and screening-level biota concentration guides (BCG) that can be used to demonstrate compliance with DOE dose limits and assess ecological effects of radiological exposure when conducting ecological risk assessments.

This approach for evaluating radiation doses to biota consists of a three-step process that is designed to guide a user from an initial, conservative general screening to a more rigorous analysis using site-specific information (if needed) and is consistent with the EPA methodology for conducting ecological risk assessments. The process includes (1) assembling radionuclide concentration data and knowledge of sources, receptors, and routes of exposure for the area to be evaluated; (2) applying a general screening methodology that provides limiting radionuclide concentration values (i.e., BCGs) in soil, sediment, and water; and (3) if needed, conducting a risk evaluation through site-specific screening, site-specific analysis, or a site-specific biota dose assessment conducted within an ecological risk framework, similar to that recommended by EPA/630/R-95/002F, *Guidelines for Ecological Risk Assessment.* Any of the steps within the graded approach may be used at any time, but the general screening methodology is usually the simplest, most cost-effective, and least time-consuming process.

Soil concentrations less than the BCGs are not considered to pose a threat to terrestrial receptors. The BCGs contained in DOE-STD-1153-2002 include conservative screening concentrations that are judged to be protective of the most sensitive terrestrial organisms in environmental media (i.e., soil, sediment, or water), assuming a dose of 0.1 rad/day,[1] which would not exceed the DOE's established or recommended dose standards for biota protection.

3.5.3 Preliminary Remediation Goals for the Protection of Groundwater

Remediation goals for the protection of groundwater must address contamination reaching the groundwater and residual contamination remaining in the ground after remediation. The remediation goals must consider risk-based standards where contamination might have contacted groundwater and standards for residual contamination that might migrate through the vadose zone to groundwater. Residual vadose zone contamination must be below activities or concentrations that could cause groundwater to exceed protective levels, if contaminant migration occurs. The following subsections present remediation goals for groundwater and for residual contamination in the vadose zone and a discussion for achieving these remediation goals.

3.5.3.1 Nonradionuclide Preliminary Remediation Goals for the Protection of Groundwater

The PRGs for nonradionuclides in the vadose zone that are protective of groundwater are developed from the more stringent of potential ARARs (e.g., MCLs as defined in 40 CFR 141) and published risk-based standards. Consistent with this approach, soil concentrations protective of groundwater are established pursuant to the provisions of WAC 173-340-747 unless it can be demonstrated that a higher contaminant concentration is protective of groundwater (WAC 173-340-747[3][e], "Deriving Soil Concentrations for Ground Water Protection," "Overview of Methods," "Alternative Fate and Transport Models"). Values of soil concentrations protective of groundwater were calculated using formulas from WAC 173-340-747 and inputs from Ecology 94-145, *Cleanup Levels and Risk Calculations*

[1]Terrestrial plant species are assumed to be protected at sites containing a dose of up to 1 rad/day (DOE-STD-1153-2002).

under the Model Toxics Control Act Cleanup Regulation; CLARC, Version 3.1. Table 3-1 provides the PRGs for nonradionuclides identified as COCs. These calculated values are conservative and were used for remedy evaluation (see Chapters 6.0 and 7.0). These values will be refined using detailed fate and transport modeling based on site-specific parameters to yield final PRGs. Thus, a to-be-determined (TBD) value also is indicated in Table 3-1.

3.5.3.2 Radionuclide Preliminary Remediation Goals for the Protection of Groundwater

MCLs for radionuclide contaminants in drinking water are specified in 40 CFR 141. PRGs for radionuclide contaminants in water, protective of both groundwater and surface water, are based on achieving these MCLs. For radionuclides in the vadose zone, concentrations of residual contaminants are considered protective of groundwater if the residual levels do not result (via migration through the vadose zone) in concentrations that exceed groundwater remediation goals. Remediation goals for radionuclides in water, considered protective of human health, also are considered protective of potential ecological receptors at the groundwater/river interface.

In accordance with 40 CFR 141, the average annual activity of beta particle and photon radioactivity from manmade radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 mrem/yr (40 CFR 141.66, "National Primary Drinking Water Regulations," "Maximum Contaminant Levels for Radionuclides"). The MCLs for Sr-90 and tritium are 8 pCi/L and 20,000 pCi/L, respectively (40 CFR 141.66). The MCLs for all other manmade radionuclides causing a 4 mrem/yr dose (except Ra-226 and Ra-228) are calculated based on a 2 L/day drinking water intake using the 168-hour data listed in NBS Handbook 69, *Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air or Water for Occupational Exposure.* The EPA has calculated drinking water MCLs for radionuclides in 40 CFR 141, based on NBS Handbook 69. These values of radionuclide drinking water MCLs also are presented in EPA/540/R-00/007, *Soil Screening Guidance for Radionuclides: User's Guide*, OSWER Directive 9355.4-16A, Table D.2. If two or more radionuclides are present, the sum of their annual dose shall not exceed 4 mrem/yr (40 CFR 141.66).

The MCL for uranium in drinking water is 30 μg/L, as promulgated by the EPA (65 FR 76708, "National Primary Drinking Water Regulations; Radionuclides; Final Rule"). Based on the isotopic distribution of uranium on the Hanford Site, the 30 μg/L MCL corresponds to an activity of 21.2 pCi/L (BHI Calculation No. 0100X-CA-V0038, *Calculation of Total Uranium Activity Corresponding to a Maximum Contaminant Level of Total Uranium of 30 Micrograms per Liter in Groundwater*).

Groundwater protection PRGs are included in Table 3-2. Conservative values calculated per EPA/540/R-00/006, 2000, *Soil Screening Guidance for Radionuclides: Technical Background Document*, OSWER 9355.4-16, were used for remedy evaluation (see Chapters 6.0 and 7.0). These values will be refined using detailed fate and transport modeling based on site-specific parameters to yield final PRGs. Thus, a TBD value also is indicated in Table 3-2.

Table 3-1. Summary of Soil Preliminary Remediation Goals for Nonradionuclides for All Pathways. (2 Pages)

Constituent	Hanford Site Background[a] (mg/kg)	Direct Contact[b] (mg/kg)	Groundwater Protection[c] (mg/kg)	Terrestrial Wildlife Protection[d] (mg/kg)	Overall PRG[e] (mg/kg)	Rationale[f]
207-A South Retention Basin (No Nonradionuclide Contaminants of Concern)						
216-A-10 Crib (No Nonradionuclide Contaminants of Concern)						
216-A-19 Trench						
Nitrate (as N)	11.7	[h]5.6x10^{6}	TBD-40	--	TBD-40	Groundwater protection
Nitrate/nitrite (as N)	11.7	[h]5.6x10^{6}	TBD-40	--	TBD-40	Groundwater protection
Total uranium	3.21	[h]1.05x10^{4}	TBD-1.32	5.9[g]	TBD-3.21	Background
216-A-36B Crib						
Nitrate (as N)	11.7	[h]5.6x10^{6}	TBD-40	--	TBD-40	Groundwater protection
Nitrate/nitrite (as N)	11.7	[h]5.6x10^{6}	TBD-40	--	TBD-40	Groundwater protection
Nitrite (as N)	--	[h]3.50x10^{5}	TBD-4.0	--	TBD-4.0	Groundwater protection
Total uranium	3.21	[h]1.05x10^{4}	TBD-1.32	5.9[g]	TBD-3.21	Background
216-A-37-1 Crib						
Nitrate (as N)	11.7	[h]5.6x10^{6}	TBD-40	--	TBD-40	Groundwater protection
Nitrate/nitrite (as N)	11.7	[h]5.6x10^{6}	TBD-40	--	TBD-40	Groundwater protection
216-B-12 Crib						
Nitrate (as N)	11.7	[h]5.6x10^{6}	TBD-40	--	TBD-40	Groundwater protection
Nitrate/nitrite (as N)	11.7	[h]5.6x10^{6}	TBD-40	--	TBD-40	Groundwater protection
Total uranium	3.21	[h]1.05x10^{4}	TBD-1.32	5.9[g]	TBD-3.21	Background
216-S-7 Crib						
Nitrate	11.7	[h]5.6x10^{6}	TBD-40	--	TBD-40	Groundwater protection
Nitrate/nitrite	11.7	[h]5.6x10^{6}	TBD-40	--	TBD-40	Groundwater protection
Total uranium	3.21	[h]1.05x10^{4}	TBD-1.32	5.9[g]	TBD-3.21	Background

Table 3-1. Summary of Soil Preliminary Remediation Goals for Nonradionuclides for All Pathways. (2 Pages)

Constituent	Hanford Site Background[a] (mg/kg)	Direct Contact[b] (mg/kg)	Groundwater Protection[c] (mg/kg)	Terrestrial Wildlife Protection[d] (mg/kg)	Overall PRG[e] (mg/kg)	Rationale[f]

[a] Background concentrations are 95th percentile values of the log normal distribution of sitewide soil background data from DOE/RL-92-24, Volume 1, Table 2. Uranium background value is based on the combined background for the specific isotopes found in DOE/RL-96-12, Table 5-1, lognormal distribution 90%.

[b] Direct-contact values represent vadose zone concentrations that are protective of human receptors from direct contact with contaminated solids. Listed WAC 173-340-745(5) Method C cleanup standards for industrial soil are obtained from the Washington State Department of Ecology CLARC Version 3.1 tables (updated November 2001) (Ecology 94-145) and are used to evaluate the top 4.6 m (15 ft) (WAC 173-340-745).

[c] TBD PRG values for uranium and nitrogen compounds (e.g., nitrate) will be established using site-specific fate and transport modeling (e.g., STOMP). Definitive values are calculated using the conservative *Washington Administrative Code* three-phase model for protection of drinking water (WAC 173-340-747[4], amended February 12, 2001). These values are used for initial remedy evaluation purposes.

[d] Industrial soil levels protective of terrestrial wildlife are obtained from WAC 173-340-900, Table 749-3. For uranium, see note g.

[e] Listed values represent the most restrictive PRG of the direct exposure, terrestrial wildlife, and groundwater protection pathways and evaluation of this value to ensure that it is not less than natural background and for analytical considerations as indicated in WAC 173-340-700(6)(d).

[f] Identifies the technical basis (rationale) for the overall PRG values selected based on discussion in note e (above).

[g] Terrestrial wildlife screening level for uranium calculated following WAC 173-340-900 methodology (WMP-20570, Appendix D).

[h] Not a contaminant of concern for the given exposure consideration (e.g., direct contact, groundwater protection, or terrestrial wildlife exposure) at this waste site. However, the associated risk-based concentration is provided for reader information.

DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes.*
DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides.*
Ecology 94-145, *Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation; CLARC, Version 3.1.*
WAC 173-340-700(6)(d), "Overview of Cleanup Standards," "Requirements for Setting Cleanup Levels," "Natural Background and Analytical Considerations."
WAC 173-340-745(5), "Soil Cleanup Standards for Industrial Properties," "Method C Industrial Soil Cleanup Levels."
WAC 173-340-747(4), "Deriving Soil Concentrations for Ground Water Protection," "Fixed Parameter Three-Phase Partitioning Model,"WMP-20570, *Central Plateau Terrestrial Ecological Risk Assessment Data Quality Objectives Summary Report – Phase I.*
WAC 173-340-900, "Tables."
WMP-20570, *Central Plateau Terrestrial Ecological Risk Assessment Data Quality Objectives Summary Report – Phase I.*

-- = no criteria established.
CLARC = cleanup levels and risk calculations.
PRG = preliminary remediation goal.
STOMP = PNNL-11216, *STOMP -- Subsurface Transport Over Multiple Phases: Application Guide.*
TBD = to be determined.

Table 3-2. Summary of Soil Preliminary Remediation Goals for Radionuclides for All Pathways.

Constituent	Hanford Site Background	Industrial Direct Exposure[a] (pCi/g)	Terrestrial Wildlife BCG[b] (pCi/g)	Groundwater Protection[c] (pCi/g)	Overall PRG[d] (pCi/g)	Rationale[e, f]
207-A South Retention Basin (No Radiological Contaminants of Concern)						
216-A-10 Crib						
Iodine-129	--	3,081	5,670	TBD-0.00373	TBD-0.00373	Groundwater protection
216-A-19 Trench (No Radiological Contaminants of Concern)						
216-A-36B Crib						
Technetium-99	--	412,000	4,490	TBD-5.01	TBD-5.01	Groundwater protection
216-A-37-1 Crib (No Radiological Contaminants of Concern)						
216-B-12 Crib (No Radiological Contaminants of Concern)						
216-S-7 Crib						
Tritium	--	79,010	174,000	TBD-290	TBD-290	Groundwater protection

[a]Direct-exposure values represent activities for individual radionuclides corresponding to a 15 mrem/yr dose rate in an industrial scenario. Listed value is used to evaluate top 4.6 m (15 ft.) of soil.
[b]DOE-STD-1153-2002, Table 6.4 of Module 1 and the associated calculator. Listed value is used to evaluate top 4.6 m (15 ft) of soil.
[c] PRG values will be established based on anticipated site-specific fate and transport modeling (e.g., STOMP).
[d]Listed values represent the most restrictive PRG derived from evaluation of the direct exposure, terrestrial wildlife, and groundwater protection pathways; and evaluation of this value to ensure that it is not less than natural background; and analytical considerations as identified in WAC 173-340-700(6)(d).
[e]Identifies the technical basis (rationale) for the selected overall PRG values selected based on the discussion provided in note d (above).
[f]High concentration contaminants (e.g., Cs-137, Sr-90, Am-241, Pu) that were not shown by the formal baseline risk assessment to impact human health and the environment based on their location in site soils, were eliminated from further consideration as COCs and were not assigned a PRG value. At sites where such contaminants could potentially impact an inadvertent intruder, the impact was evaluated through the CERCLA long-term effectiveness and permanence criterion.

DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota.*
WAC 173-340-700(6)(d), "Overview of Cleanup Standards," "Requirements for Setting Cleanup Levels," "Natural Background and Analytical Considerations."

--	=	no criteria established.
NA	=	not applicable.
PRG	=	preliminary remediation goal.
STOMP	=	PNNL-11216, *STOMP -- Subsurface Transport Over Multiple Phases: Application Guide.*
TBD	=	to be determined.

4.0 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

This chapter presents the process for identifying potentially viable technologies for remediation of the 200-PW-2 and 200-PW-4 OU waste sites and the technologies retained by the FS based on understanding of GRAs necessary to address site risks.

4.1 GENERAL RESPONSE ACTIONS

The initial process of identifying viable remedial action alternatives is described in the Implementation Plan (DOE/RL-98-28) as consisting of the following steps.

1. Define RAOs.

2. Identify GRAs to satisfy RAOs.

3. Identify potential technologies and process options associated with each GRA.

4. Screen process options to select a representative process for each type of technology based on effectiveness, implementability, and cost.

5. Assemble viable technologies or process options retained in Step 4 into alternatives representing a range of removal, treatment, containment, and institutional controls options plus a no-action option.

Chapter 3.0 identifies RAOs for this FS. The Implementation Plan identified and provided a detailed description of the following preliminary GRAs:

- No action
- Institutional controls
- Containment
- Removal, treatment, and disposal
- Ex situ treatment
- In situ treatment.

These GRAs are intended to cover the range of options necessary to meet the RAOs. Significant modifications to these GRAs were not necessary, based on new information collected and evaluated in the RI Report (DOE/RL-2004-25). Detailed descriptions of each GRA are included in the Implementation Plan.

4.2 SCREENING AND IDENTIFICATION OF TECHNOLOGIES

Potentially applicable technology types and process options were identified and screened in the Implementation Plan in accordance with CERCLA guidance using effectiveness, implementability, and relative cost as criteria to eliminate those options least feasible and to retain those options considered most viable.

The initial identification and screening of remedial technologies described in Appendix D (Sections D5.0 to D5.6 and Table D-1) of the Implementation Plan (DOE/RL-98-28) are refined for this FS based on the information obtained from the RI risk assessment that identified the waste site risks evaluated to support this FS. The following sections update information on existing technologies since the writing of the Implementation Plan, discuss screening of new technologies identified since creation of the Implementation Plan, and discuss those technologies that are retained for the 200-PW-2 and 200-PW-4 OUs. The technologies are discussed by GRA group. Table 4-1 represents a roadmap for technology selection between the Implementation Plan and this FS.

4.2.1 Rescreening of Implementation Plan Remedial Technologies Based on Risk Assessment Results

Because the initial screening in the Implementation Plan was preliminary, and because additional site-specific risk assessment and characterization information are available, the remedial technologies presented in the Implementation Plan were rescreened for application to the 200-PW-2 and 200-PW-4 OUs. The following is a brief screening discussion of the technologies and the results of the refinements.

4.2.1.1 No Action

The National Contingency Plan (40 CFR 300) requires that a no-action alternative be evaluated as a baseline for comparison with other alternatives. The no-action alternative represents a situation where no restrictions, controls, or active remedial measures are applied to the site. The no-action alternative implies a scenario of "walking away" from the site and taking no measures to monitor or control contamination. The no-action alternative requires that a site pose no unacceptable threat to human health and the environment. The no-action alternative was retained in the Implementation Plan for 200-PW-2 and 200-PW-4 OUs and is carried forward in this FS. The no-action alternative only will be retained for analogous waste sites as a preliminary remedy until completion of confirmatory sampling.

4.2.1.2 Institutional Controls

Institutional controls consist of (1) physical and/or legal barriers to prevent access to contaminants, (2) monitoring groundwater and/or vadose zone, and (3) maintaining existing soil cover. Institutional controls usually are required when contaminants remain in place at concentrations above cleanup levels; controls likely will be a component of remedial alternatives.

Physical methods of controlling access to waste sites are access controls, which include signs, fences, and entry control; artificial or natural barriers; and active surveillance. Physical restrictions are effective in protecting human health by reducing the potential for contact with contaminated media and avoiding adverse environmental, worker safety, and community safety impacts arising from the potential release of contaminants associated with other remedial technologies (e.g., removal). However, physical restrictions are not effective in treating, containing, or removing contaminants. Physical restrictions also require ongoing monitoring and maintenance.

Legal restrictions include both administrative and real-property actions intended to reduce or prevent future human exposure to contaminants remaining on site by restricting use of land, including groundwater use. Land-use restrictions and controls on real-property development are effective in providing a degree of human-health protection by minimizing potential for contact with contaminated media. Restrictions can be imposed through land covenants, which would be enforceable by the United States and, under Washington State law, Ecology. Land-use restrictions are somewhat more effective than access controls if control of a site transfers from the DOE to another party, because land-use restrictions use legal and administrative mechanisms already available to the community and the State.

Disadvantages of land-use restrictions are similar to those for access control: these do not contain, remove, or treat contaminants. In addition, land-use restrictions are not self-enforcing. Land-use restrictions only can be triggered by an effective system for monitoring land use to ensure compliance with imposed restrictions.

Sampling and environmental monitoring are an integral part of institutional controls and are necessary to verify that contaminants are attenuating as expected, to ensure contaminants remain isolated, and to ensure that whatever remedial measures are in place are meeting their performance objectives. Periodic sampling activities would include sampling of actual contaminants and verification of overall site characteristics (geochemical, hydrogeologic, and biological properties). Environmental monitoring would be conducted to ensure waste containment is achieved and no further degradation of groundwater occurs. Surface radiation surveys and sampling of local biota might be necessary if contaminants remain near the surface.

Depending on remedial action taken and results of sampling and monitoring, it would be necessary to maintain existing soil cover or barrier to ensure continued isolation of contaminants.

Based on results of the RI activities, no changes are made to this technology from what appeared in the Implementation Plan. Institutional controls technologies are incorporated in remedial alternatives in Chapter 5.0 for evaluation.

4.2.1.3 Containment

Containment includes physical measures to restrict accessibility to in-place contaminants or to reduce migration of contaminants from their current location. Containment technologies include engineered surface barriers (caps) and vertical barriers (slurry walls and grout walls), which are used to prevent or limit infiltration and/or intrusion into the contaminated zone.

4.2.1.3.1 Engineered Surface Barriers

Surface barriers, or capping, technologies are applicable for groundwater, human health, and ecological protection. Several different types of surface barriers have been evaluated for use on the Hanford Site. DOE/RL-93-33, *Focused Feasibility Study of Engineered Barriers for Waste Management Units in the 200 Areas*, evaluated four conceptual barrier designs for different types of waste sites: the Hanford Barrier, the Modified RCRA Subtitle C Barrier, the Modified RCRA Subtitle D Barrier, and the Standard RCRA Subtitle C Barrier. Based on the results of this evaluation, the Implementation Plan identified three of these engineered barriers as being suitable for use at waste sites in the 200 Areas: the Hanford Barrier, the Modified RCRA Subtitle C Barrier, and the Modified RCRA Subtitle D Barrier.

Generally, capping consists of constructing surface barriers over contaminated waste sites to control the amount of water infiltrating into contaminated media, thereby reducing or eliminating leaching of contamination to groundwater. In addition to hydrological performance, barriers also might function as physical barriers to prevent intrusion by human and ecological receptors, limit wind and water erosion, and attenuate radiation.

Surface barriers proposed in this FS are evapotranspiration (ET) barriers, which predominantly rely on the water-holding capacity of a soil, evaporation from the near-surface, and plant transpiration to control water movement through the barrier. Precipitation infiltrates at the surface, where precipitation is retained in the soil by absorption and adsorption until ET processes move the water back to the atmosphere. Such designs particularly are suitable for semiarid and arid climates with a low annual amount of precipitation and a relatively high ET potential. When precipitation exceeds ET, water is stored; and when ET exceeds precipitation, water is released. Water balance studies on the Hanford Site show vegetation and soil type control the downward movement of precipitation, and for finer grained soils with a healthy plant cover of shrubs and grasses, net recharge is close to zero (Gee et al. 1992, "Variations in Recharge at the Hanford Site").

The ET barriers can be divided into two categories: capillary barriers and monolithic barriers. Barriers retained in the Implementation Plan (i.e., the Hanford Barrier, the Modified RCRA Subtitle C Barrier, and the Modified RCRA Subtitle D Barrier) are capillary barriers, which consist of a fine-grained soil layer overlying a relatively coarse-grained soil layer. Monolithic barriers rely on a relatively thick single layer of fine-textured soil. The advantage of the monolithic barrier is its simplicity. A single soil layer simplifies construction and maintenance.

A capillary barrier relies on maintaining a planar textural interface, which would be susceptible to differential settlements or subsidence. This is an important consideration for waste sites with void space or solid waste susceptible to subsidence. Differential settlements can disrupt the continuity of layers (i.e., offset layers), which can create large macropores. However, a broad range of options is available (e.g., dynamic compaction, compaction grouting) to mitigate the subsidence potential before barrier construction. Given the same soil type, the monolithic barrier requires additional soil thickness relative to capillary barriers for an equivalent water storage capacity. Should the thickness of the soil required for water-holding capacity exceed the rooting depth, water removal capacity diminishes. However, the additional thickness also can be advantageous in providing increased intruder protectiveness.

Three cap designs retained in the Implementation Plan (the Hanford Barrier, the Modified RCRA Subtitle C Barrier, and the Modified RCRA Subtitle D Barrier) were designed to address various categories of waste (e.g., TRU, low-level, hazardous, and sanitary, respectively). All three designs are ET-type barriers, but include additional layers for added levels of containment or redundancy. The term "modified" reflects that the design varies in certain key respects from conventional barrier designs, but is expected to be equivalent to, or to exceed the performance of, the conventional design. The Modified RCRA C Barrier design was developed for sites containing hazardous, low-level waste or low-level mixed waste to provide long-term containment and hydrologic protection for a performance period of 500 years (DOE/RL-93-33). The Modified RCRA C Barrier also was developed because the conventional RCRA C Barrier design is aimed at areas with much higher precipitation and is not effective for arid climates. The design includes the components of a capillary barrier overlying a secondary barrier system using a low-permeability layer. The secondary barrier layers are provisional, depending on the site-specific need for redundancy in hydrologic protection, a vapor barrier, and/or a more robust biointrusion layer.

The Hanford Barrier design was developed for sites containing greater-than-Class C low-level waste and/or significant inventories of TRU constituents. This barrier remains functional for a performance period of 1,000 years. In addition, of the evaluated designs, the Hanford Barrier provides the maximum available degree of containment and hydrologic protection. The design consists of nine layers of durable material with a combined thickness of 4.5 m (14.7 ft). Barrier layers are designed to maximize moisture retention and ET capabilities and to minimize moisture infiltration and biointrusion, considering long-term variations in Hanford Site climate.

A 4-year (fiscal years 1995 through 1998) treatability test was completed successfully on a prototype of the Hanford Barrier constructed in fiscal year 1994 over the 216-B-57 Crib. The primary purpose of the test was to document surface barrier constructability, construction costs, and physical and hydrologic performance in support of remedial decision making and remediation at similar waste sites on the Hanford Site. Results of the treatability test are reported in DOE/RL-99-11, *200-BP-1 Prototype Barrier Treatability Test Report*. Results demonstrate the barrier easily is constructed with standard construction equipment, performance criteria were met or exceeded, and the Hanford Barrier and associated design components are highly effective. Subsequent to the treatability test, monitoring activities have continued at the barrier. Results of the monitoring activities are reported in annual letter reports, the most recent being CP-14873, *200-BP-1 Prototype Hanford Barrier Annual Monitoring Report for Fiscal Year 2002*.

The ET barriers are and continue to be evaluated within the DOE Complex (Sandia National Laboratory, Los Alamos National Laboratory, Idaho National Engineering and Environmental Laboratory, Nevada Test Site, Hanford Site), and by the EPA. The Alternative Cover Assessment Program, sponsored by the EPA, is evaluating a number of field-scale test covers throughout the United States. Results to date indicate that alternative barrier designs at semiarid and arid sites generally exhibit little percolation (Albright et al. 2003, "Examining the Alternatives").

Supporting documentation and Hanford Site-specific field data demonstrate that capillary barriers perform well (DOE/RL-99-11; PNNL-13033, *Recharge Data Package for the Immobilized Low-Activity Waste 2001 Performance Assessment*). The Modified RCRA C Barrier could be considered as an appropriate process option for FS waste sites requiring exceptional protectiveness from cover performance. This process option forms the basis for evaluating capping alternatives at soil waste sites not contaminated with TRU constituents. The Hanford Barrier is considered to be an appropriate process option for soil waste sites contaminated with significant concentrations of TRU constituents.

Although the Modified RCRA C Barrier process option is the basis for evaluating this technology, this barrier does not preclude use of other ET designs (e.g., monolithic barrier). Performance and design parameters would be determined during remedial design. Both monolithic and capillary barriers are shown to be equivalent to or to exceed the performance of the standard RCRA Subtitle C Barrier design, and both are approved or planned for use in several western states (DOE/RL-93-33).

4.2.1.3.2 Vertical Barriers (Slurry Walls and Grout Walls)

Slurry walls and grout walls were retained in the Implementation Plan (DOE/RL-98-28). Slurry walls are formed by vertically excavating a trench and filling it with a slurry, typically a mix of soil, bentonite, and water, to form a continuous low-permeability barrier. Grout walls are formed by injecting grout, under pressure, directly into the soil matrix (permeation grouting) or in conjunction with drilling (jet grouting) at regularly spaced intervals to form a continuous low-permeability wall. Using directional drilling techniques, angled grout walls can be formed beneath a waste site. This type of angled barrier is limited (more so than vertical slurry walls) by difficulties in verifying barrier continuity and by the materials used. New innovative materials have the potential for limiting radionuclide mobility through chemical reactions.

Slurry walls and grout walls have potential application in the vadose zone to limit the horizontal movement of moisture into contaminated materials or to limit the horizontal migration of contaminants. Vertical barriers can be used as a supplemental element in the design of surface barriers to improve containment performance; both slurry walls and grout walls are suitable technologies for this application.

While the need for horizontal control of contaminant migration has not been identified based on the RI Report (DOE/RL-2004-25), use of vertical slurry walls and grout walls has application in this FS as a means of limiting horizontal movement of contamination and water, in particular as part of a surface barrier alternative. Consequently, the vertical slurry and grout wall options are retained for use in the development of remedial alternatives discussed in Chapter 5.0, and for potential future use following the collection and evaluation of confirmatory data to confirm the appropriate remedial action specified for the analogous waste sites.

Suitability of this technology to limit vertical migration of contaminants is less certain. The geometry of representative sites in this FS (i.e., large surface areas, long narrow ditches, or contamination at considerable depth) presents significant difficulties for installation of a horizontal grout barrier beneath these sites. For these reasons, the use of slurry walls and grout walls to prevent vertical migration of contaminants is not retained in this FS.

4.2.1.4 Removal, Treatment, and Disposal

The Implementation Plan identified excavation of contaminated soils, with treatment as needed to meet disposal criteria, and transportation and disposal to the appropriate disposal facility, as an applicable technology for the waste sites. Excavation of material generally is accomplished using standard earth-moving equipment such as backhoes and front-end loaders. This technology is retained for use at sites as a standalone remedial alternative and in combination with other remedial technologies such as surface barriers. A number of sites in the 200-PW-2 and 200-PW-4 OUs have significant contamination in the depth range below 7.6 m

(25 ft). Excavation is more difficult at depths greater than 7.6 m (25 ft), which is a normal reach for conventional excavation equipment. While excavation to greater depths is possible, additional engineering controls such as shoring or more gradual slopes would be needed. Terracing would be required to reach greater depths, which could interfere with nearby buildings or facilities such as other waste sites, active facilities, or active process pipelines. Risks to workers increase with the depth of excavation because of increased construction duration and exposure time to the workers.

Levels of contamination in many waste sites in the 200-PW-2 and 200-PW-4 OUs might pose a significant dose threat to workers. Levels of radionuclides might result in excavation and disposal activities being identified as nuclear activities. In addition, the levels might result in implementing remote-handled removal techniques. Whether remote handled or contact handled, special safety controls will be required to address the contaminant concentrations. Shoring might be needed at cut intervals to reach these depths safely. Large excavations would significantly increase the time that workers are associated with the highly contaminated zones, resulting in increased doses. In addition, large excavations to these depths would put a large amount of contaminated material at risk for spread via airborne pathways. Costs would increase because of these increased safety techniques.

Waste disposal is divided into (1) onsite disposal of soils without transuranic (TRU)[1] constituents and (2) temporary onsite storage of soils with TRU constituents, followed by offsite disposal.

- **Waste Disposal of Soils without TRU Constituents.** Soils and debris not contaminated with TRU constituents will be disposed of in an approved location or facility.

- **Retrieval, Treatment, and Disposal of Soils with TRU Constituents.** Significant volumes of soil with TRU constituents might be generated from remediation of waste sites in the 200-PW-2 and 200-PW-4 OUs. If repackaged soil were determined to exceed 100 nCi/g (100,000 pCi/g), soil would be transported to the Waste Receiving and Processing Facility for waste certification and shipment to the Waste Isolation Pilot Plant (WIPP) in New Mexico.

Because the WIPP is exempt from RCRA land-disposal restrictions, specific ex situ treatment of mixed TRU waste for organic and inorganic contaminants may not be necessary.

4.2.1.5 Ex Situ Treatment

Based on results of the RI, treatment is not required to meet the disposal facility or WIPP waste acceptance criteria. Ex situ treatment processes retained in the Implementation Plan (DOE/RL-98-28) include thermal desorption, vapor extraction, mechanical separation, soil washing, ex situ vitrification, solidification/stabilization, and soil mixing.

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[1]Waste materials contaminated with 100 nCi/g of transuranic materials having half-lives longer than 20 years.

Thermal desorption and vapor extraction technologies typically are applied to soils contaminated with light- to medium-range hydrocarbons and other organics. Thermal desorption also is effective on heavier range hydrocarbons (e.g., diesel, oil). Based on data contained in the RI Report (DOE/RL-2004-25) and the results of the risk assessment, remediation for hydrocarbons or organics is not necessary. These ex situ technologies are ineffective for radionuclides and inorganic compounds and, therefore, were rejected for this FS.

The primary separation technique for solid media using mechanical separation is sieving to segregate material according to size, but other physical properties also might be used as a basis for segregation (e.g., local discoloration of soil). The main disadvantage of this technology is that increased waste handling carries potential of increased worker risk and the production of fugitive dust. This process was used as a component of removal and disposal actions on the Hanford Site. Experience in the 300 Area burial grounds shows that clogging of the sieving device might be a problem. There is no apparent technical advantage to using mechanical separation for waste sites in this FS. Therefore, the technology is not retained in this FS.

Soil washing has limited effectiveness on many radionuclides, with risk of higher exposures to workers and potentially high costs associated with soil washing, especially if chemicals are needed to remove contaminants. Therefore, soil washing is not retained in this FS.

Ex situ vitrification is costly and is deemed unnecessary to dispose of waste at the waste disposal facility or the WIPP. Therefore, ex situ vitrification is not retained in this FS.

Solidification/stabilization technologies generally are used to immobilize soil contaminants; this is assumed to be unnecessary for disposal to the waste disposal facility or to the WIPP. Therefore, solidification/stabilization technologies are not retained in this FS.

Some soil mixing (blending) might be required to meet worker health and safety standards. However, intended mixing of contaminated soil with cleaner soils is purposeful dilution and generally prohibited by regulations. Therefore, soil mixing as a treatment technology is not retained in this limited application in this FS.

4.2.1.6 In Situ Treatment

In situ treatment technologies were retained in the Implementation Plan to mitigate contaminant mobility or to treat organics in situ. Technologies are vitrification, grout injection, soil mixing, dynamic compaction, and natural attenuation.

In situ vitrification (ISV) applies an electrical current to melt contaminated soil and/or debris and forms a stable, vitrified mass when cooled. Stable mass chemically incorporates most inorganics (including heavy metals and radionuclides) and destroys or removes organic contaminants. Experience with ISV indicates convective mixing occurs during vitrification, which causes contaminants to be mixed throughout the melt matrix. Air emissions are collected and treated locally. In practice, vapors generated during vitrification are directed from the melt to an offgas hood, then to the offgas treatment system, where vapors are treated using a combination of scrubbers, filtration, and thermal oxidation (if required) before discharge to the environment.

The ISV technology has been refined during the past several years to target contamination deep below the surface. The planer-ISV technology has been used to depths of 8.8 m (29 ft) but possibly could be deployed deeper. Individual melting events typically have a diameter of 12 m (40 ft), but these can be overlapped to treat an area of much greater areal extent. One project produced a contiguous vitrified monolith with surface dimensions of 60 by 60 m (200 by 200 ft) by overlapping nearly 40 individual melting events.

ISV has been shown to be effective at waste sites containing high concentrations of radionuclides (including TRU) and hazardous constituents. The temperature of the subsurface is monitored during the process to ensure a homogeneous melt. The vitrified monolith has been shown to have chemical, physical, and weathering properties expected to result in a life expectancy measured in geologic time (tens of thousands of years).

Dose reduction factors are addressed in PNL-4800 SUPP 1, *In Situ Vitrification of Transuranic Waste: An Updated Systems Evaluation and Applications Assessment*. PNL-4800 SUPP 1 indicates dose reduction is expected because of self-shielding of the vitrified mass. Data collected from a number of projects demonstrate that dose is reduced as a result of the ISV process.

Well documented are ISV limitations on depth and configuration of application, high cost, extensive services and infrastructure required for implementation (significant electrical power generation), and the uncertainties associated with how well ISV mitigates direct radiation dose for constituents (e.g., Cs-137) that are bound in the matrix but still remain at the site after treatment. Given these limitations, ISV generally only is considered for use at sites where small areas of TRU contamination exist in shallow soils and where significant electrical power is available. However, at such sites removal generally is always the preferred alternative due to cost and implementability unless limiting factors make removal impossible. Although the 200-PW-2 and 200-PW-4 OU waste sites do not contain a high level of TRU constituents, a potential exists for TRU constituents to exist in 216-A-36B Crib soil (Section 2.4.2) at concentrations that could cause the soil to be designated as TRU waste, if removed. However, because the potential TRU concentrations at the 216-A-36B Crib are deep (7.6 to 8.5 m [25 to 28 ft] belowground surface [bgs]) and the site is large and unusually configured (i.e., very long and narrow, approximately 152 by 3.4 m (500 by 11 ft) at the crib bottom, ISV is not considered suitable for application at the 216-A-36B Crib.

Grout injection, commonly referred to as jet grouting or in situ grouting, is a process that entails injecting a slurry-like mixture of cements, chemical polymers, or petroleum-based waxes into contaminated media. Grouts are specially formulated to encapsulate contaminants, isolating these from the surrounding environment. As summarized in INEEL-01-00281, *Engineering Design File, Operable Unit 7-13/14 Evaluation of Soil and Buried Waste Retrieval Technologies*, in situ grouting has been approved by regulating agencies and implemented at several small-scale sites. However, in situ grouting has not been applied to large-scale sites with many radiological and chemical hazards, such as the 200-PW-2 and 200-PW-4 OU waste sites. Grout injection, as a standalone action, is rejected for this FS because of the size and depth of the waste sites and unproven effectiveness on large-scale sites having radiological and chemical hazards. However, the technology is applicable to remedial alternatives to fill voids in pipelines, voids in cribs, and voids in tanks remaining in place after contamination is removed.

Dynamic compaction is used to increase soil density, compact buried solid waste, and/or reduce void spaces by dropping a heavy weight onto the ground surface. The compaction process can reduce the hydraulic conductivity of subsurface soils and, correspondingly, the mobility of contaminants. Because the compactive energy attenuates with depth, dynamic compaction is limited to shallow applications typically less than 3 m (10 ft). Chemicals and radionuclides at the sites in this FS generally are deeper than 3 m (10 ft). For this reason, dynamic compaction is rejected in this FS as a standalone action. Dynamic compaction is retained in the FS as a sub-element of surface barriers; this technology frequently is used to prepare a waste site for barrier construction.

Deep-soil mixing uses large augers (mixers) and injector head systems to inject and mix solidifying agents (cement-based or chemical fixatives) into contaminated soil in place. The process reduces the mobility of contaminants by entraining these in the solidifying agent. Soil mixing at depth is difficult to implement in rocky soils, and the effectiveness of solidification of the contaminated soil is difficult to monitor and ensure. Soil mixing is rejected for this FS because of the size and depth of the waste sites to be treated.

Phytoremediation is the use of vegetation for in situ treatment of contaminated soils, sediments, and water and best applied at sites with shallow contamination of organic, nutrient, or metal pollutants. Phytoremediation is used at a number of pilot and full-scale field demonstration tests. It is best employed at very large field sites where other methods of remediation are not cost-effective or practicable, at sites with low concentrations of contaminants where only "polishing treatment" is required over long periods of time, and in conjunction with other technologies where vegetation is used as a final cap and closure of the site. Limitations to technology need to be considered carefully before selection for site remediation. These include limited regulatory acceptance, long amount of time typically required for clean-up to below action levels, potential contamination of vegetation and food chain, and difficulty establishing and maintaining vegetation at some toxic waste sites.

Plants have shown the capacity to withstand relatively high concentrations of organic chemicals without toxic effects, and can uptake and convert chemicals quickly to less toxic metabolites in some cases. In addition, plants stimulate degradation of organic chemicals in the rhizosphere by release of root exudates, enzymes, and the build-up of organic carbon in soil. For metal contaminants, plants show the potential for phytoextraction (uptake and recovery of contaminants into aboveground biomass), filtering metals from water onto root systems (rhizofiltration), or stabilizing waste sites by erosion control and ET of large quantities of water (phytostabilization). Phytoremediation is rejected for this FS because contaminants in waste sites typically are too deep to be effectively influenced by the roots of plants. In addition, establishment of plants on a waste site would require supplemental watering, which has the potential to mobilize subsurface contamination. Long-term management of contaminated plant residue (falling leaves, branches, etc.) also would be required to prevent the potential spread of contamination.

Natural attenuation is retained for this FS, because this is a natural component of all potential alternatives. Natural attenuation is most effective on sites with nonradionuclides readily degrading in the environment and on sites with radionuclides having short half-lives, such as Cs-137. However, natural attenuation is a slow process at sites having radionuclides with long half-lives (e.g., plutonium and uranium) or nonradionuclides not degrading naturally in the environment. It might be the only feasible and cost-effective technology for sites having deep contamination, because other technologies (e.g., retrieval and in situ treatment) are difficult to implement, ineffective, and potentially cost prohibitive.

4.2.2 Summary of Remedial Technologies and Process Options Retained for 200-PW-2 and 200-PW-4 Operable Units Alternative Development

Based on screening presented in Section 4.2, Table 4-1 shows remedial technologies and process options retained for development of remedial alternatives specific to 200-PW-2 and 200-PW-4 OUs.

Table 4-1. Technology Types and Process Options for Soil. (2 Pages)

General Response Action	Technology Type	Process Option	Retained in Implementation Plan (DOE/RL-98-28)	Retained in Feasibility Study for 200-PW-2 and 200-W-4 Operable Units
No action	None	Not applicable	Yes	Yes
Institutional controls	Land-use restrictions	Deed restrictions	Yes	Yes
	Access controls	Signs/fences	Yes	Yes
		Entry control	Yes	Yes
	Monitoring	Groundwater	Yes	Yes
		Vadose zone	Yes	Yes
		Air	Yes	Yes
	Surface barriers	Existing soil cover	No	Yes
Containment, including ET barriers	Engineered surface barriers	Hanford Barrier	Yes	Yes
		Modified RCRA and other ET caps	Yes	Yes
		Standard RCRA caps	No	No
		Asphalt, concrete, or cement-type cap	No	No
	Vertical barriers	Slurry walls	Yes	Yes
		Grout curtains	Yes	Yes
Removal	Excavation	Conventional	Yes	Yes
		High contamination	No	Yes
Disposal	Landfill disposal	Onsite landfill	Yes	Yes
		Offsite landfill/ repository	Yes	Yes
Ex situ treatment	Thermal treatment	Thermal desorption	Yes	No
		Vitrification	Yes	No

Table 4-1. Technology Types and Process Options for Soil. (2 Pages)

General Response Action	Technology Type	Process Option	Retained in Implementation Plan (DOE/RL-98-28)	Retained in Feasibility Study for 200-PW-2 and 200-W-4 Operable Units
	Physical/chemical treatment	Vapor extraction	Yes	No
		Soil washing	Yes	No
		Mechanical separation	Yes	No
		Solidification/ stabilization	Yes	No
		Soil mixing	Yes	No
In situ treatment	Thermal treatment	Vitrification	Yes	No
	Chemical/physical treatment	Vapor extraction	Yes	No
		Grout injection (pipelines and tanks)	Yes	Yes
		Deep-soil mixing	Yes	No
		Dynamic compaction (component of surface barriers)	Yes	Yes
		Phytoremediation	N/A (not included in Plan)	No
	Natural attenuation	Natural attenuation	Yes	Yes

DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program.*
Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

ET = evapotranspiration.
N/A = not applicable.
RCRA = *Resource Conservation and Recovery Act of 1976.*

5.0 DEVELOPMENT OF ALTERNATIVES

The EPA guidance for conducting an FS under CERCLA recommends that a limited number of technologies be carried forward from the technology identification and screening activity; these technologies then are grouped into remedial alternatives to address the site-specific conditions. In Chapter 4.0, technologies are identified and screened based on site-specific characteristics and contaminants of concern. In this chapter, these technologies are grouped in remedial alternatives to address site contamination problems. Several remedial alternatives are developed and described in this chapter for the waste sites in the 200-PW-2 and 200-PW-4 OUs. The applicability of these alternatives to the individual waste sites also is considered.

5.1 DEVELOPMENT OF ALTERNATIVES

Significant activities and evaluations have contributed to defining applicable technologies and process options addressing the 200-PW-2 and 200-PW-4 OUs representative and analogous waste sites. The Implementation Plan (DOE/RL-98-28), Appendix D, provides initial information on identification and screening of remedial technologies for 200 Areas waste sites. The Implementation Plan, in conjunction with Chapter 4.0 of this FS, forms the basis for the development of remedial alternatives. The Implementation Plan also preliminarily develops remedial alternatives based on the results of the technology screening for the waste sites. Remedial alternatives identified in the Implementation Plan for the 200-PW-2 and 200-PW-4 OUs include the following:

- No action
- Monitored natural attenuation/institutional controls
- Removal and disposal with or without ex situ treatment
- Engineered multimedia surface barriers.

Table 5-1 illustrates the process of identifying technology types, combining process options, and presenting the elements of alternatives considered as remedy options for this FS. Evaluation of the no-action alternative is a requirement under CERCLA. The monitored natural attenuation/institutional controls alternative is retained and further developed in this FS for sites where other remedial actions are expected or where contamination is expected to meet RAOs within a reasonable institutional controls period. The removal, treatment, and disposal alternative and the surface barriers alternative also are retained and further developed in this FS. The in situ vitrification alternative and in situ grouting or stabilization alternatives, as standalone alternatives, are screened out of this FS because of implementation problems associated with the size and depth of the waste sites and unproven effectiveness on large-scale sites having radiological and chemical hazards. In situ grouting or stabilization technologies, however, are retained for inclusion as elements of other remedial actions. This FS develops one additional alternative not identified in the Implementation Plan, but considered by recent Hanford Site FSs. This alternative is a combination alternative including partial removal, treatment, and disposal with a subsequent engineered surface barrier. The following sections further develop and describe the alternatives.

One important factor in the development of site-specific remedial alternatives is that radionuclides, heavy metals, and some inorganic compounds cannot be destroyed. As such, these compounds must be physically immobilized, contained, or chemically converted to a less mobile or less toxic form to meet the RAOs.

5.2 DESCRIPTION OF ALTERNATIVES

This section provides a description of the selected alternatives considered for evaluation in this FS:

- Alternative 1 – No Action
- Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls
- Alternative 3 – Removal, Treatment, and Disposal
- Alternative 4 – Engineered Surface Barrier
- Alternative 5 – Partial Removal, Treatment, and Disposal with Engineered Surface Barrier.

5.2.1 Alternative 1 – No Action

A no-action alternative is required to be evaluated as a baseline for comparison with other remedial alternatives (40 CFR 300). The no-action alternative represents a situation where no legal restrictions, access controls, or active remedial measures are applied to the site. No action implies "walking away from the waste site" and allowing the wastes to remain in their current configuration, affected only by natural processes. No maintenance or other activities are instituted or continued. Selecting the no-action alternative requires that a waste site pose no unacceptable threat to human health or the environment.

Based on the waste site evaluations and the results of the risk assessment, only one of the representative sites in this FS, the 207-A South Retention Basin, might meet the RAOs using the no-action alternative. The no-action alternative is carried forward in this FS for comparison purposes and to address analogous waste sites expected to meet the RAOs and preliminary remediation goals (PRG) without any action.

5.2.2 Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls

This alternative takes advantage of existing soil covers and the nature of the contaminants (such as the natural attenuation of Cs-137 and Sr-90, which have relatively short half-lives), in combination with institutional controls, to provide protection of human health and the environment. Monitoring also is an element of this alternative. For most of the waste sites in these OUs, an existing soil cover is present that is associated with the actual construction of the waste site (i.e., the waste site was constructed at depth and clean backfill placed in the excavation to the surface) and with surveillance and maintenance activities, where additional soil was added to stabilize the waste sites. Under this alternative, these existing soil covers are maintained and/or augmented as needed to provide protection from intrusion by human and/or biological receptors. Institutional controls, including legal and physical barriers, also are used to prevent human access to the site. The existing soil covers break the pathway between human and ecological receptors and the contaminants. *Washington Administrative Code* (WAC) 173-340-745(7), "Soil Cleanup Standards for Industrial Properties, Point of Compliance," identifies the points of compliance for different pathways as follows.

- "For soil cleanup levels based on protection of groundwater, the point of compliance shall be established in the soils throughout the site."
- "For soil cleanup levels based on human exposure via direct contact or other exposure pathways where direct contact with the soil is required to complete the pathway, the point of compliance shall be established in the soils throughout the site from the ground surface to fifteen feet below the ground surface."

WAC 173-340-7490, "Terrestrial Ecological Evaluation Procedures," specifies a standard point of compliance at 4.6 m (15 ft) bgs for ecological receptors; institutional controls are not required under this option. WAC 173-340-7490 also specifies a conditional point of compliance at the biologically active soil zone, with a requirement for institutional controls. The regulation assumes a 1.8 m (6 ft) bgs biologically active zone, but a site-specific zone could be established.

Based on literature searches regarding the root and burrowing depths of vegetation and animals present on the Hanford Site, a sufficient soil thickness to prevent biological intrusion generally would be 2.4 to 3.0 m (8 to 10 ft) bgs. The 200-PW-2 and 200-PW-4 OUs evaporative waste sites are disposal sites that have a soil cover (i.e., surface stabilization, backfill) over the contaminated zone of generally at least 11 ft (216-A-37-1 Crib) and typically much deeper (15 to 45 ft bgs). Soil covers at the analogous sites could be different from the soil covers at associated representative sites.

Institutional controls involve the use of physical barriers (fences) and access restrictions (deed restrictions) to reduce or eliminate exposure to contaminants of concern. Institutional controls also can include groundwater, vadose zone, surface soil, biotic, and/or air monitoring. Institutional controls for this alternative include periodic surveillance of the waste sites for evidence of contamination and biologic intrusion; emplacement of vegetation, herbicide application, manual removal, or other activities to control deep-rooted plants; control of deep-burrowing animals; maintenance of signs and/or fencing; maintenance of the existing soil cover (including an assumed periodic addition of soil); administrative controls; land-use restrictions, and site reviews.

Contaminants remaining beneath the clean soil cover are allowed to naturally attenuate until remediation goals are met. Natural attenuation relies on natural processes to lower contaminant concentrations until cleanup levels are met. Monitored natural attenuation includes sampling and/or environmental monitoring, consistent with EPA guidance (EPA/540/R-99/009, *Use of*

Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites November 1997, Draft Interim Final, OSWER Directive No. 9200.4-17P), to verify that contaminants are attenuating as expected. Attenuation monitoring activities could include monitoring of the vadose zone using geophysical logging methods or groundwater monitoring to verify that natural attenuation processes are effective.

The existing network of groundwater monitoring wells in the Central Plateau is adequate for monitoring most sites, in coordination with the groundwater OUs (200-BP-5, 200-PO-1, 200-UP-1, and 200-ZP-1). Where the existing network is unsatisfactory, additional monitoring wells are planned. If remediation activities result in the decommissioning of groundwater monitoring wells in the area of remediation, an evaluation of future monitoring needs is conducted.

5.2.3 Alternative 3 – Removal, Treatment, and Disposal

Under this alternative, contaminated soil is removed, treated if required to meet waste acceptance criteria, and disposed of to an appropriate facility. Based on characterization data, no treatment will be required. However, some soil blending might be required to meet health and safety standards. A generalized cross-section for this alternative is shown in Figure 5-1. The disposal facility chosen depends on the type of waste to be disposed. The majority of the waste generated under this alternative is disposed of at an approved location or facility for non-TRU waste. For waste sites with transuranic constituents above levels of concern (i.e., 100 nCi/g), disposal to a geologic repository is required. As reported in the RI Report (DOE/RL-2004-25), americium and plutonium levels in the 216-A-36B Crib, when summed, potentially could exceed 100 nCi/g.

For waste sites requiring deep excavations of more than approximately 30 m (100 ft) to reach the required remediation depth, special excavation techniques are necessary. These excavation sites will require terraced side slopes and access roads to the bottom of the excavation, and will have the potential for increased work crews and larger, and more numerous, equipment for removal of contaminated soil, and removal and replacement of overburden and clean soil. In addition, these sites likely will require the building of large stockpiles of overburden and clean soil located near the excavation site and potentially could impact neighboring facilities.

5.2.3.1 Sites Without Concentrations of Transuranic Constituents at Levels of Concern

Soil and associated structures (such as cribs) with contaminant concentrations above the PRGs are removed using conventional excavation techniques where appropriate, or specialized excavation techniques where required due to excavation depths. Excavated materials would be disposed of at an approved disposal facility. Precautions are used to minimize the generation of onsite fugitive dust. Depending on the configuration and depth of the area excavated, terraced side slopes and access roads might be required to comply with safety requirements and to reduce the quantity of excavated soil. The depth, and therefore the volume, of soil removed largely depend on the categories of PRGs (e.g., direct contact groundwater protection) exceeded. For example, if human health direct contact or ecological PRGs are exceeded, removals generally are conducted to a maximum of 4.6 m (15 ft) in line with the points of compliance identified in WAC 173-340-745 and WAC 173-340-7490. If groundwater protection is required, soils are removed to meet groundwater protection PRGs. Table 5-2 shows the excavation depths required for this alternative at each representative site. Risk assessment to support the data in Table 5-2 is contained in Chapter 2.0. Subgrade structures extending below 4.6 m (15 ft) are removed, if practicable, or stabilized in place. Figure 5-1 illustrates how excavation generally proceeds under this alternative. Implementability, short-term risk to workers, and cost are evaluated to determine decisions between removal and other remedial actions, such as engineered surface barriers.

The remediation of soil and associated structures for this alternative is guided by the observational approach. The observational approach is a method of planning, designing, and implementing a remedial action rely on information (e.g., samples, field screening) collected during remediation to guide the direction and scope of the activity. Data are collected to assess the extent of contamination and to make "real-time" decisions in the field. Targeted (or hot spot) removals could be considered under this alternative if contamination were localized in only a portion of a waste site.

Based on existing information, soil and/or debris removed from the waste sites should not require treatment to meet the waste disposal facility waste acceptance criteria. However, additional activities are required to meet health and safety requirements during excavation, handling, transportation, and disposal. Highly contaminated soil is blended with less contaminated soil to achieve as low as reasonably achievable goals and to reduce worker risks at all points in the removal and disposal process. Contaminated soil and structures are containerized (e.g., containers, bulk shipment) on site and transported to the waste disposal facility.

After the PRGs are met, uncontaminated soil is used to backfill the excavation. The backfill material could be found at a variety of sources, including local borrow pits and any remaining excavated material determined to be clean (verified as clean by meeting the PRGs). Following remediation, the site will be recontoured, resurfaced, and/or revegetated to establish natural site conditions or conditions consistent with industrial use of the location. Maintenance of the site is required until the vegetation is sufficiently established to prevent intrusion by noxious, non-native plants such as cheatgrass or Russian thistle.

5.2.3.2 Sites Potentially Contaminated with Transuranic Constituents at Levels of Concern

As described in the previous section, soil and associated structures (such as cribs) with contaminant concentrations above the PRGs are removed. However, the 216-A-36B Crib soil potentially contain americium and plutonium at levels that when summed could exceed TRU waste designation levels causing removed soil to be designated as TRU waste. This contamination is confined to a relatively thin layer at the bottom of the crib, between a depth of approximately 7.6 and 8.5 m (25 and 28 ft) bgs.

Under this alternative, contaminated soil is retrieved, verified as non-TRU waste or TRU waste by sampling and analysis, treated if necessary, temporarily stored, and disposed of at the WIPP, if TRU, or at another waste disposal facility, if low-level waste. Excavation of soil and waste containing transuranic constituents at levels of concern is performed at many DOE sites, including the Hanford Site, Idaho National Engineering and Environmental Laboratory, Rocky

Flats, and Savannah River. For soil sites, standard or modified excavation equipment is used to retrieve the soil and waste until PRGs are met. Equipment for removal of soil with transuranic constituents above 100 nCi/g is proven and available. Any clean overburden soil removed is stockpiled in an adjacent onsite area. Excavation of TRU waste is performed inside a portable greenhouse structure. Depending on the configuration of the area to be excavated, terraced side slopes and access roads might be required to comply with safety requirements. Characterization is required to confirm that TRU levels exist at the waste site and to minimize the amount of soil and waste classified as TRU. TRU and non-TRU soils and waste are segregated during retrieval and further tested to minimize the amount disposed at the WIPP. Packaging of the soil and waste for disposal at the WIPP most likely occurs at the site during excavation, but also could be performed in a separate storage facility. Details are determined during design, once more precise information on the location, volume, and concentration of TRU contamination is determined.

Following retrieval of the waste, the site is backfilled with clean soil and recontoured, resurfaced, and/or revegetated to establish natural site conditions or conditions consistent with industrial use of the location. Maintenance of the site is required until the vegetation is sufficiently established to prevent intrusion by noxious, non-native plants, such as cheatgrass or Russian thistle.

5.2.4 Alternative 4 – Engineered Surface Barrier

The engineered surface barrier alternative consists of constructing surface barriers over contaminated waste sites to control the amount of water infiltrating into contaminated media, to reduce or eliminate leaching of contamination to groundwater. These barriers might include vertical slurry or grout walls to limit horizontal movement of moisture into the waste site or to limit horizontal migration of contaminants. In addition to hydrological performance, barriers also can function as physical barriers to prevent intrusion by human and ecological receptors, limit wind and water erosion, and attenuate radiation. Additional elements to the barrier alternative include institutional controls, discussed earlier, and monitored natural attenuation, where contamination undergoes radioactive decay.

Where groundwater protection is of concern, the preferred barrier technology for the Hanford Site is an ET barrier, as shown in Figure 5-2. The ET surface barriers rely on the water-holding capacity of a soil, evaporation from the near-surface, and plant transpiration to control water movement through the barrier. Non-TRU-containing waste sites could have a variety of ET barriers; the most appropriate barrier is determined during design. The Modified RCRA Subtitle C Barrier design (Figure 5-3) is used as the basis for evaluating this alternative; this does not preclude the use of other ET designs (e.g., monolithic barrier). Monolithic and capillary barriers are shown to be equivalent to, or exceed the performance of, the standard RCRA Subtitle C Barrier design, and both are approved or planned for use in several western states (EPA 2003, *Remediation Technology Descriptions,* "Alternative Landfill Cover Project Profiles"; and DOE/RL-93-33. The TRU-containing waste sites might require barrier performance similar to the Hanford Barrier (Figure 5-4). These barriers are described in detail in Chapter 4.0.

If an engineered surface barrier is identified as the preferred alternative, finalization of site-specific designs occurs as part of the remedial design process and considers the RAOs and requirements defined in the record of decision, regulatory design and performance standards, material availability, cost effectiveness, current surface barrier technology information, and site-specific hydrologic and physical performance requirements to ensure waste containment. Different waste sites likely have varying barrier performance requirements, and more than one barrier design (e.g., monolithic and capillary barrier) might be deployed to address waste site barrier needs.

When groundwater protection is required, the barrier is designed to limit the infiltration of precipitation. When the prevention of ecological and human intrusion is a performance requirement, the physical obstruction components to the barrier become more important. When prevention of wind erosion to allow for natural attenuation of short-lived contaminants (e.g., at sites with only speck contamination) is required, the barrier design (e.g., Figure 5-5) is simplified to address these minimal requirements. The barrier alternative includes provisions for groundwater monitoring for those waste sites with contamination predicted to threaten groundwater maximum concentration levels.

Performance monitoring of the Hanford Barrier, installed at the 216-B-57 Crib in 1994, shows essentially no water infiltration through the barrier (CP-14873). The effectiveness of the barrier is related to the design, which must be specific to the conditions at the waste site, and to continued monitoring activities. Some recent preliminary fate and transport modeling for the BC Cribs and Trenches area shows that reducing the infiltration rate to 0.1 mm/yr by use of a barrier would cause a five-fold reduction in the resulting groundwater concentration versus that for sites without barriers.

Use of a barrier alternative requires an assessment of the lateral extent of contamination during the confirmatory and/or remedial design sampling phases to properly size and design the barrier to ensure containment. The site-specific extent of contamination can be assessed using a variety of approaches including, but not limited to, process knowledge, previous site investigations, geophysical logging, and/or soil sampling. Some degree of oversizing the barrier beyond the footprint of the waste zone (referred to as overlap) is expected and depends on the barrier design used and the depth of contamination. For the purposes of this FS, an overlap of 6.1 m (20 ft) is assumed based on the performance of the Hanford Barrier. The type and availability of barrier construction materials also are design considerations. The results of the most recent investigation (BHI-01551, *Alternative Fine-Grained Soil Borrow Source Study Final Report*) are considered during remedial design for selection of the barrier construction materials.

Engineered surface barriers require surveillance and maintenance throughout their life to ensure continued protection. To ensure the barrier is performing as designed, performance monitoring is conducted. Performance monitoring for this alternative is twofold. The first component is groundwater monitoring. The second component is vadose zone monitoring, if practical. The effectiveness of institutional controls to maintain the barrier becomes uncertain past 150 years. For the majority of the sites in this FS, a design life of 500 years is considered sufficient, because the contaminants decay to protective levels at the surface within 500 years. For barriers using naturally stable geologic materials, the key factor establishing life expectancy is projected wind-erosion rates, which are minimized by maintaining the vegetation cover, adding gravel to the upper portion of the surface layer, or by using other armoring methods.

5.2.5 Alternative 5 – Partial Removal, Treatment, and Disposal with Engineered Surface Barrier

Figure 5-4 depicts a generalized remedial action that combines excavation of near-surface contamination with capping. This alternative would remove high-activity, near-surface contaminants from affected waste sites that may require significant soil mixing to achieve the waste disposal facility's waste acceptance criteria. If the near-surface contamination is present as localized "hot spots" rather than being uniformly distributed along the trench footprint, the mixing would be employed only as necessary. Excavation would be to the maximum depths listed in Table 5-3, which are approximately 1 m (3 ft) below the depth corresponding to the maximum activity. Following excavation, the waste site would be backfilled with suitable material and capped as discussed above, except that the cap would not require intrusion-deterrent features. These activities would remove a majority of the near-surface contaminant load. The removal, treatment, disposal, and capping activities would be the same as or similar to those described in Chapter 4.0 and in the preceding subsections except that removal activities would be focused at reducing the mass of contaminants associated with the bottom of the waste site, which would, in turn, reduce the potential intruder risk. The disposal options would be the same. The required cap would be less rigorous than if these contaminants were left in place, because the inadvertent intruder risk is significantly reduced. For example, a simple monofill or capillary soil barrier, without any intrusion deterrent features, may be appropriate. The actual design of the barrier would be determined through the detailed design activities. Table 5-3 lists the contamination zone for each representative site. If contaminants are not in the 0 to 4.6 m (0 to 15-ft) zone, then the resulting risk reduction to humans and ecological receptors from direct contact to shallow-zone contamination would be zero. The point of compliance for direct exposure is the 0 to 4.6 m (0 to 15-ft) zone, so contaminants deeper than this only would reduce the risk to intruders. Contaminants that impact the groundwater are located much deeper in the vadose zone than 6.1 m (20 ft). Therefore, the removal of contaminants from the 0 to 6.1 m (0 to 20-ft) zone would not significantly change the risk to groundwater. The capping activity provided in this alternative would address protection of groundwater from the remaining contaminants in the vadose zone. Similar to Alternative 4, institutional controls would be an additional requirement for this alternative, because contamination above PRGs is left on site.

Under Alternative 5, contaminants generally are removed to depths of 4.5 m (15 ft) or slightly deeper. The exceptions to this could be sites with potential TRU contaminants that can be readily removed (e.g., removal depth is 9 m [30 ft] for the 216-A-36B waste site) or at sites where contaminant removal significantly mitigates overall site risk. These are depths considered protective of human health from direct contact and intruder scenarios and protective to ecological receptors. Risk assessment information to support these depths is contained in Chapter 2.0. Following excavation, the waste site is backfilled with suitable material and an engineered surface barrier is installed as discussed previously. These activities remove a fraction of the near-surface contamination load. The removal, treatment, disposal, and barrier activities are similar to those described in the preceding sections. However, removal activities are not aimed at removing all contaminants in the vadose zone. Activities are aimed at reducing the mass of contamination associated with the bottom of the waste site, which in turn reduces the potential intruder risk. The disposal option is the same. The required barrier is less rigorous if these contaminants are left in place because the inadvertent intruder risk is significantly reduced. For example, instead of a Hanford Barrier, a monofill soil barrier might be appropriate. The actual design of the barrier is determined through the remedial design process.

If contaminants are not in the 0 to 4.6 m (0 to 15-ft) zone (the point of compliance for direct exposure), the resulting risk to humans and ecological receptors from direct contact to shallow-zone contamination is zero. However, contaminants impacting the groundwater might be located deeper in the vadose zone. Therefore, the removal of contaminants to mitigate the direct contact and intruder human health risk might not significantly change the risk to groundwater. The barrier activity provided in this alternative addresses protection of groundwater from the remaining contaminants in the vadose zone. Institutional controls are an additional requirement for this alternative, because contamination above PRGs is left on site.

It is possible in some cases, that the level of contamination in the vadose zone below the level of excavation is not a threat to groundwater, in which case a barrier is not required (i.e., Alternatives 3 and 5 are identical).

Figure 5-2. Evapotranspiration Barrier.

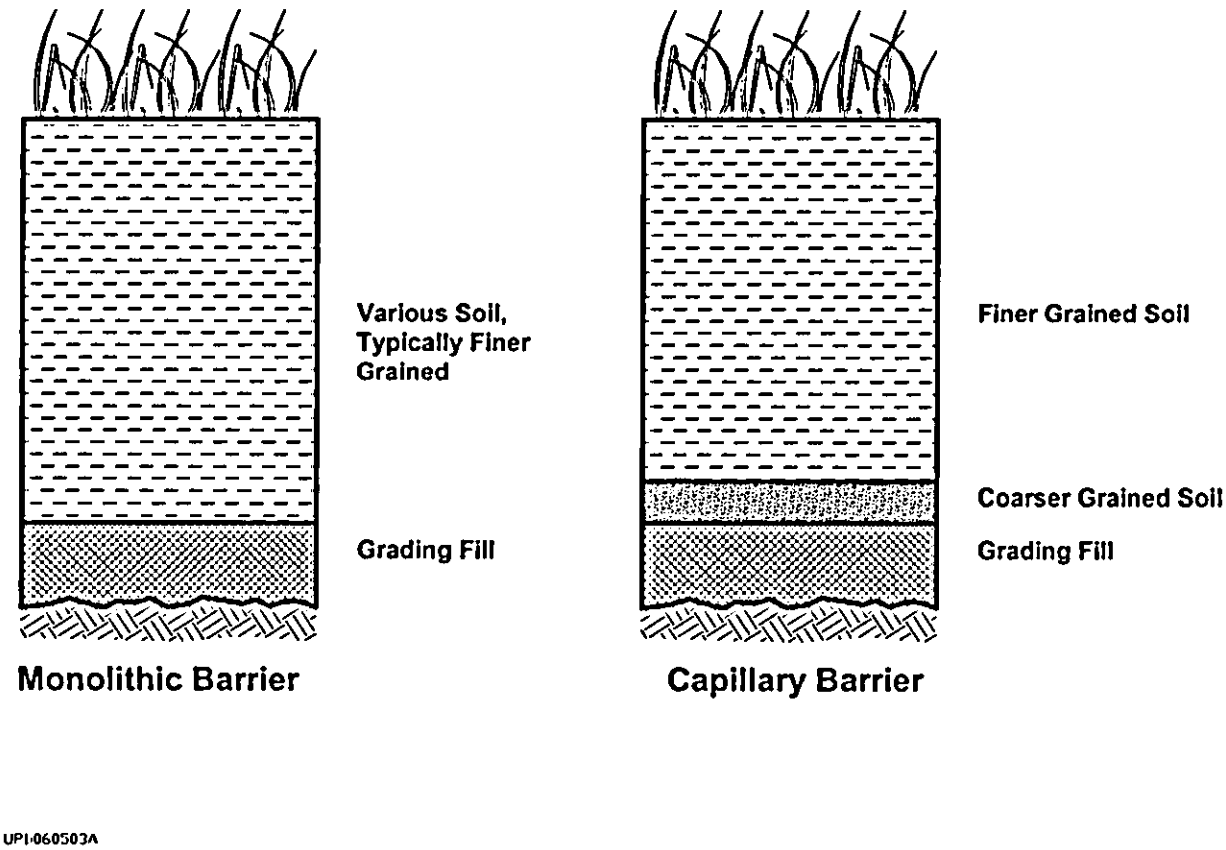


Figure 5-3. Modified RCRA C Barrier.

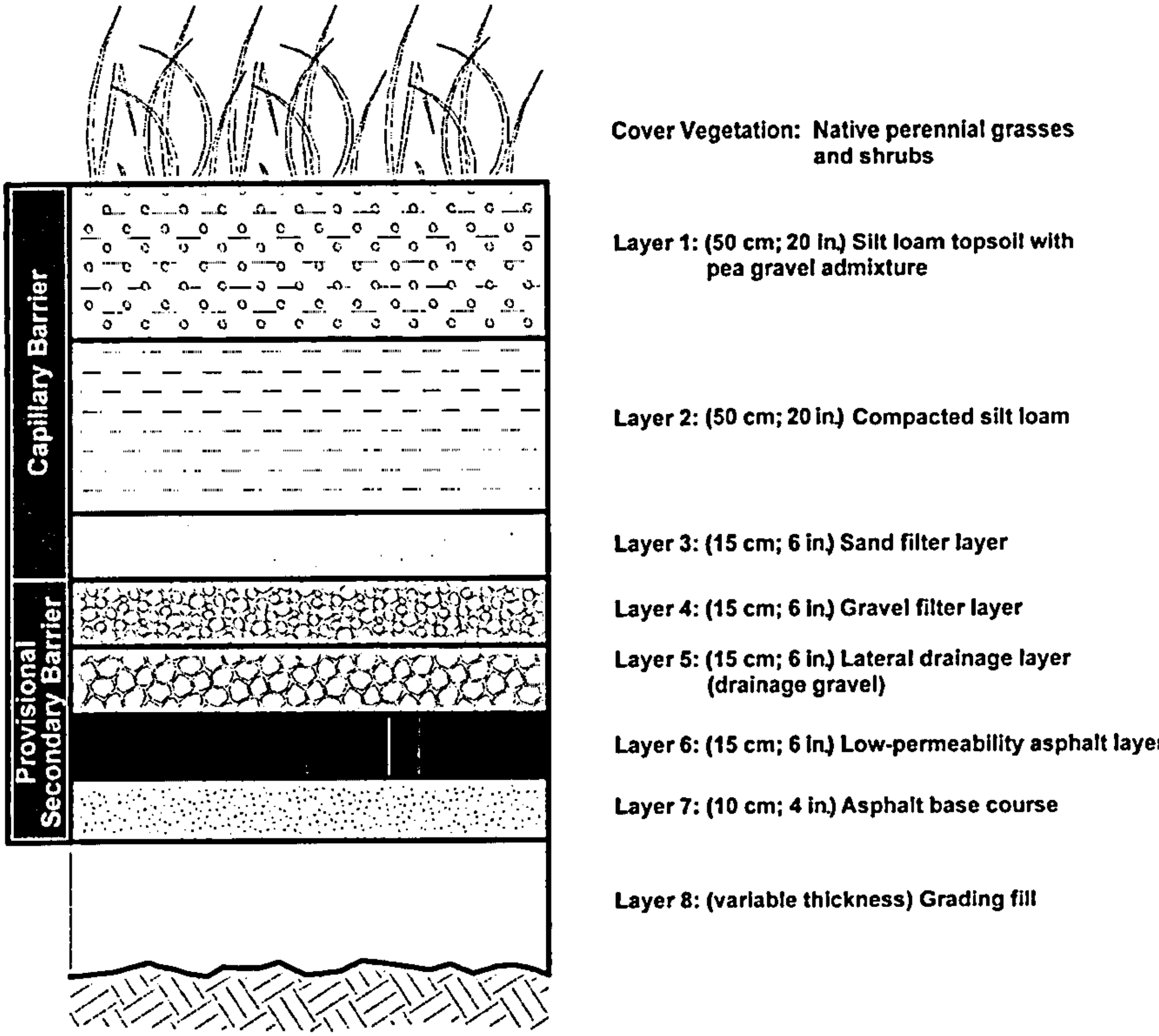


Figure 5-4. Hanford Barrier.

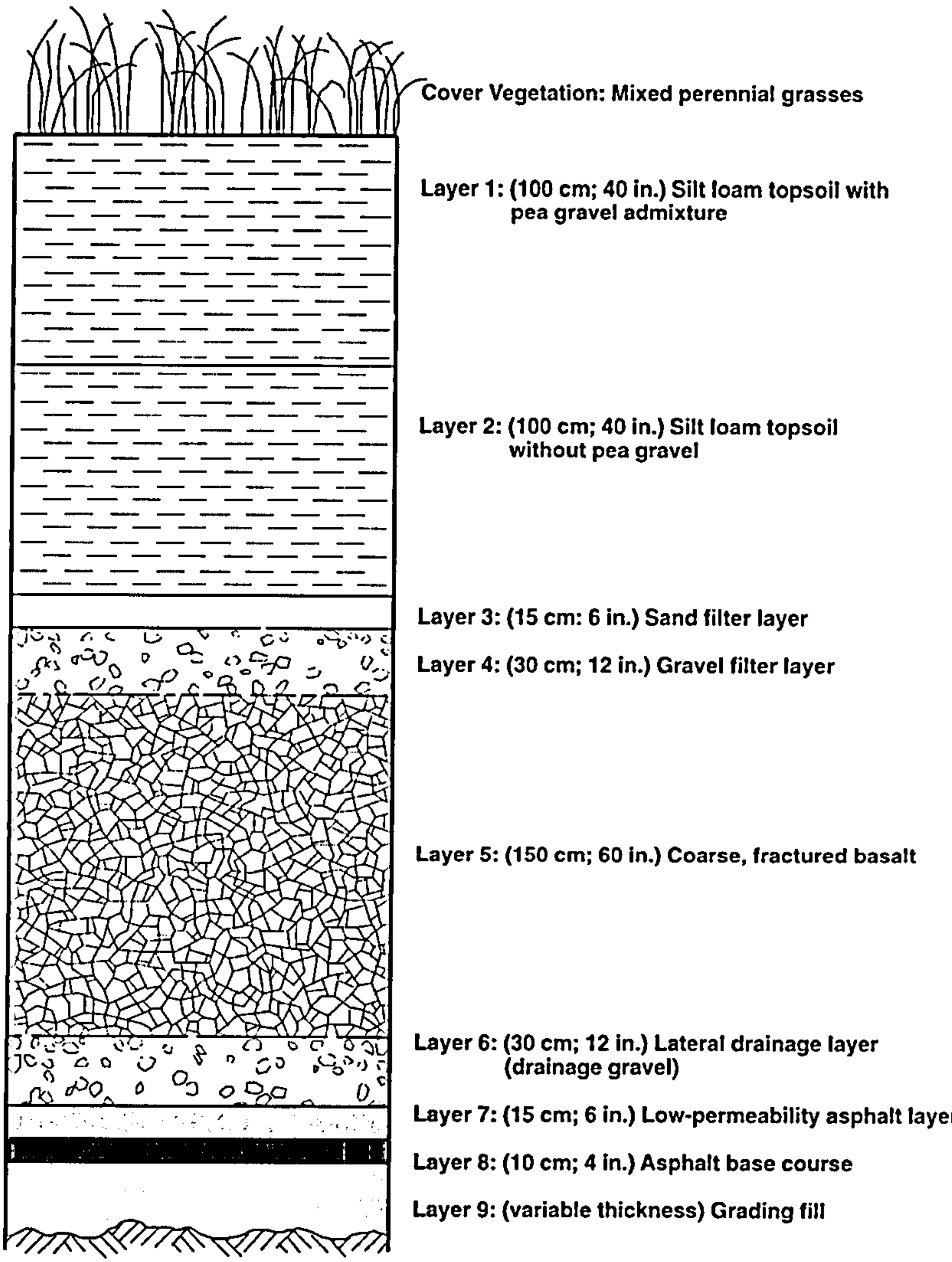


Figure 5-5. Monitored Natural Attenuation Barrier.

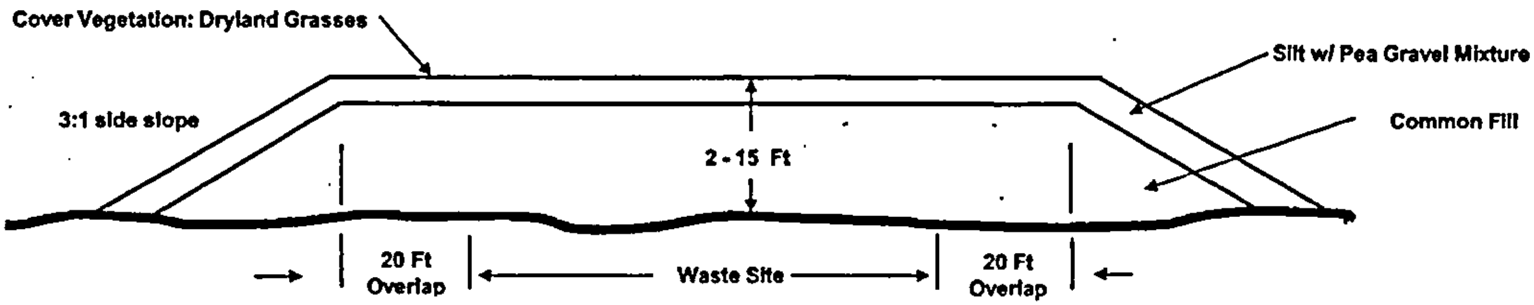


Table 5-1. Summary of Remedial Alternatives and Associated Components.

Technology Type	Process Option	Alternative 1 – No Action	Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls	Alternative 3 – Removal, Treatment, and Disposal	Alternative 4 – Engineered Surface Barrier	Alternative 5 – Partial Removal, Treatment, and Disposal with Engineered Surface Barrier
No action	No action	X				
Land-use restrictions	Deed restrictions		X		X	X
Access controls	Signs/fences		X		X	X
	Entry control		X		X	X
Monitoring	Groundwater		X		X	X
	Vadose zone		X		X	X
	Air		X		X	X
Barriers	Existing soil cover		X		X	
	Engineered surface barriers				X	X
In situ physical treatment	Dynamic compaction				X	X
	Grout injection				X[a]	
In situ thermal treatment	In situ vitrification					
Ex situ physical treatment	Soil mixing			X[b]		X[b]
Removal	Conventional excavation			X		X
	Excavation in high concentration areas			X		X
Landfill disposal	Onsite landfill			X		X
Monitored natural attenuation	Offsite landfill/ repository			X[c]		X[c]
	Monitored natural attenuation	X	X	X	X	X

[a]For filling pipelines or tanks and for stabilizing cribs or other subsurface structures to prepare for placement of a barrier or for removal.
[b]Applicable only to meet disposal facility requirements.
[c]Disposal of soils from waste sites with TRU constituents at concentration of concern (i.e., greater than 100 nCi/g).

TRU = waste materials contaminated with more than 100 nCi/g of transuranic materials having half-lives longer than 20 years).

Table 5-2. Depth of Excavation for Alternative 3 – Removal, Treatment, and Disposal.

Representative Site	Excavation Depth[a] of Chemical Contamination to Meet Groundwater PRG (ft)	Excavation Depth[a] to Remove Direct Contact Risk (ft)	Excavation Depth[a] to Remove Ecological Risk (ft)	Excavation Depth[a] of Radiological Contamination to Meet Groundwater PRG (ft)	Excavation Depth[a] to Remove Intruder Risk (ft) at 150 years	Alternative 3 Excavation Depth[a] (ft)
207-A South Retention Basin	N/A	N/A	N/A	N/A	N/A	8
216-A-10 Crib	N/A	N/A	N/A	62.5	62.5[b]	62.5
216-A-19 Trench	47	N/A	N/A	N/A	N/A	47
216-A-36B Crib	303	N/A	N/A	25	30[c]	303
216-A-37-1 Crib	25	N/A	13	N/A	N/A	25
216-B-12 Crib	191.5	N/A	N/A	N/A	63[c]	191.5
216-S-7 Crib	225.5	N/A	N/A	192	27[c]	225.5

[a]Depth is measured in feet below ground surface.

[b]The maximum concentrations of Cs-137 and Pu-239, which are the constituents that exceeded intruder risk levels, are 2,950 pCi/g at 62.5 ft and 3,120 pCi/g at 54 ft, respectively. The Cs-137 concentrations appear to drop immediately and are undetected at 10 ft lower elevation and the Pu-239 is less than 1 pCi/g at 62.5 ft, making this an appropriate depth of excavation to remove intruder risk at this site.

[c]Intruder scenario exposure generally identifies the applicable zone of contributing contamination as 5 ft deeper than the point of maximum concentration of Cs-137 or Pu. For 216-A-36B, the SGL maximum occurred at 27 ft bgs; for 216-B-12, the SGL maximum occurred at 35 ft bgs; for 216-S-7, the SGL maximum was observed at 25 ft bgs.

bgs = below ground surface.
N/A = not applicable as a risk scenario to this site.
PRG = preliminary remediation goal.
SGL = spectral gamma logging.

6.0 DETAILED ANALYSIS OF ALTERNATIVES

This chapter presents the detailed analysis of the remedial alternatives described in Chapter 5.0 for the 200-PW-2 and 200-PW-4 OU waste sites included in this FS. The remedial alternatives are evaluated relative to seven of the nine CERCLA criteria, described in the next section. The remedial alternatives are evaluated for each representative site to determine if the CERCLA evaluation criteria are met.

Analogous waste sites were assigned to representative sites based primarily on the similarity of waste streams received, on physical similarities (where appropriate), and similarities in the expected distribution of contamination using available information and process knowledge. For this reason, analogous sites are assumed to have contaminant distributions and risks similar to, or less than, the representative site. Therefore, the detailed analysis for the representative site is assumed to be appropriate for the analogous sites. The assignments of analogous sites to representative sites are explained in detail in Chapter 2.0.

The detailed analysis is presented by alternative. Within each alternative, each representative site is compared with each CERCLA evaluation criterion. Tables 6-1 through 6-4 provide a summary of the detailed analyses for the representative sites and their respective analogous sites.

The representative sites analyzed are as follows:

- 207-A South Retention Basin (located within the 200-PW-4 OU)
- 216-A-10 Crib (located within the 200-PW-2 OU)
- 216-A-19 Trench (located within the 200-PW-2 OU)
- 216-A-37-1 Crib (located within the 200-PW-4 OU)
- 216-A-36B Crib (located within the 200-PW-2 OU)
- 216-B-12 Crib (located within the 200-PW-2 OU)
- 216-S-7 Crib (located within the 200-PW-2 OU).

The analysis of the alternatives takes into account the nature of the contaminants at each site and the assumed land use. Currently, the land use for the 200 Areas is industrial in nature, associated with the management of waste. This land use can be reasonably predicted to be the same for the next 50 years, given the DOE's current commitment to vitrify waste in the tank farms, and is assumed for the foreseeable future.

6.1 DESCRIPTION OF EVALUATION CRITERIA

The EPA has developed nine CERCLA evaluation criteria, defined in EPA/540/G-89/004, to address the statutory requirements and the technical and policy considerations important for selecting remedial alternatives. These criteria serve as the basis for conducting detailed and comparative analyses and for the subsequent selection of appropriate remedial actions.

The nine CERCLA evaluation criteria are as follows:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance.

The first two criteria, overall protection of human health and the environment and compliance with ARARs, are threshold criteria. Alternatives that do not protect human health and the environment or those that do not comply with ARARs (or do not justify a waiver) do not meet statutory requirements and are eliminated from further consideration in this FS.

The next five criteria (long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost) are balancing criteria on which the remedy selection is based. The CERCLA guidance for conducting an FS lists appropriate questions to be answered when evaluating an alternative against the balancing criteria (EPA/540/G-89/004). The detailed analysis process in this chapter addresses these questions, providing a consistent basis for the evaluation of each alternative.

The final two criteria, state and community acceptance, are modifying criteria. The criterion of state acceptance will be addressed in DOE/RL-2005-86, *Proposed Plan for the 200-PW-2 Uranium-Rich Process Waste Group, and 200-PW-4 General Process Condensate and Process Waste Group Operable Units* (Proposed Plan), prepared by the DOE, EPA, and Ecology (Tri-Parties). The Proposed Plan will identify the preferred remedy (or remedies) accepted by the Tri-Parties. The criterion of community acceptance will be evaluated following the issuance of the Proposed Plan for public review and comment.

In addition to the CERCLA criteria, NEPA values have been incorporated into this document. Assessment of these considerations is important for the integration of NEPA values into CERCLA documents, as called for by the *Secretarial Policy on the National Environmental Policy Act* (DOE 1994) and DOE O 451.1A, *National Environmental Policy Act Compliance Program*. Potential effects on NEPA values also are discussed in this chapter.

6.1.1 Overall Protection of Human Health and the Environment

This criterion determines whether adequate protection of human health and the environment, including preservation of natural systems and biological diversity, is achieved through implementation of the remedial alternative. Protection includes reducing risk to acceptable levels, either by reducing contaminant concentrations or by eliminating potential routes for exposure, and minimizing exposure threats introduced by actions during remediation. Environmental protection includes avoiding or minimizing impacts to natural, cultural, and historical resources. This criterion also evaluates the potential for human health risks, the extent of those risks, and whether a net environmental benefit will result from implementing the remedial alternative.

This first criterion is a threshold requirement and is the primary objective of the remedial action program. As indicated in EPA guidance, this criterion, and the criteria for compliance with ARARs, long-term effectiveness and permanence, and short-term effectiveness, overlap (EPA/540/G-89/004). This FS used the CERCLA risk range of 1×10^{-4} to 1×10^{-6} ELCR for human health as the range of protectiveness. Alternatives were measured against this standard to determine if the alternative meets this criterion. Protection of groundwater was measured against groundwater protection standards derived from the maximum contaminant levels identified in 40 CFR 141, reported in the RI Report (DOE/RL-2004-25) and Appendix D of this FS. Ecological compliance was judged using WAC 173-340-900 and DOE/STD-1153-2002.

6.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

The ARARs are any appropriate standards, criteria, or limitations under any Federal environmental law or more stringent state requirement that must be either met or waived for any hazardous substance, pollutant, or contaminant that will remain on site during or after completion of a remedial action. The ARAR identification process is based on CERCLA guidance (EPA/540/2-88/002, *Technological Approaches to Cleanup of Radiologically Contaminated Superfund Sites*; EPA/540/G-89/004). Potential Federal and state chemical-, location-, and action-specific ARARs associated with remediation of the waste sites addressed in this FS are presented in Appendix C, and each alternative is assessed for compliance against these ARARs. When an ARAR cannot be met, the lead agency can request a waiver if there is a solid basis for justifying the waiver. Several of these ARARs address the protection, restoration, or enhancement of fish and wildlife habitat and other natural, cultural, and historical resources.

6.1.3 Long-Term Effectiveness and Permanence

This criterion addresses the results of a remedial action in terms of risks that remain at the site after RAOs are met. The primary focus of this evaluation is the extent and effectiveness of the controls that could be required to manage the risk posed by treatment residuals and/or untreated wastes. The following components of the criterion are considered for each alternative:

- Magnitude of residual risk to human and ecological receptors. This factor assesses the residual risk from untreated waste or treatment residue after remedial activities are completed. The characteristics of the residual waste are considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bioaccumulate.

- Adequacy and reliability of controls. This factor assesses the adequacy and suitability of controls used to manage treatment residues or untreated wastes that remain at the site. It also assesses the long-term reliability of management controls for providing continued protection from residues, and it includes an assessment of the potential need to replace the alternative's technical components.

A related consideration is the restoration time required to reestablish sustainable environmental conditions, including fish and wildlife habitat and cultural resources, where appropriate. Residual risk to natural and cultural resources after conclusion of remedial activities also is evaluated. Current environmental conditions are assessed against the alternative's long-term and permanent solutions. The assessment considerations are based on whether lasting environmental losses would be incurred for the sake of short-term cleanup gains, including whether environmental restoration and/or mitigation options would be precluded if a remedial alternative were implemented.

6.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

This criterion addresses the degree to which a remedial alternative reduces the toxicity, mobility, or volume of a hazardous substance through treatment. Significant overall reduction can be achieved by destroying toxic contaminants or by reducing total mass, contaminant mobility, or total volume of contaminated media.

This criterion focuses on the following factors for each alternative:

- The treatment processes used and the materials treated
- Whether recycling, reuse, and/or waste minimization are used in the treatment process
- The type and quantity of treatment residuals that remain following treatment, and whether any special treatment actions will be needed
- Whether the alternative satisfies the statutory preference for treatment as a principal element.

6.1.5 Short-Term Effectiveness

This criterion evaluates the potential effects on human health and the environment during the construction and implementation phases of a remedial action. This criterion also considers the speed with which an alternative achieves protection. The following factors are considered for each alternative:

- Health and safety of remediation workers and reliability of protective measures taken. Specifically, this involves any risk resulting from implementation, such as fugitive dust, transportation of hazardous materials, or air quality impacts from offgas emissions.

- Physical, biological, and cultural impacts that might result from the construction and implementation of the remedial action, and whether the impacts can be controlled or mitigated.
- The amount of time for the RAOs to be met.

Short-term human health impacts are closely related to the duration of exposure to hazardous waste and the risks associated with waste removal. The greater the exposure time, the greater the risk. Guidelines will be followed during implementation of the remedial action to minimize worker risks and maintain radiation exposures as low as reasonably achievable.

Short-term environmental impacts are related primarily to the extent of physical disturbance of a site and its associated habitat. Risks also can be associated with the potential disturbance of sensitive species (e.g., bald eagles) because of increased human activity in the area.

6.1.6 Implementability

This criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of the required services and materials.

The following factors are considered for each alternative:

- Technical feasibility
  - The likelihood of technical difficulties in constructing and operating the alternative
  - The likelihood of delays because of technical problems
  - Uncertainties related to innovative technologies (e.g., failures).
- Administrative feasibility
  - Ability to coordinate activities with other offices and agencies
  - Potential for regulatory constraints to develop (e.g., as a result of uncovering buried cultural resources or encountering endangered species).
- Availability of services and materials
  - Availability of adequate onsite or offsite treatment storage capacity, and disposal services, if necessary
  - Availability of necessary equipment, specialists, and provisions to ensure obtaining any additional resources, if necessary.

6.1.7 Cost

This criterion considers the cost of implementing a remedial alternative, including capital costs, operation and maintenance costs, and monitoring costs. The cost evaluation also includes monitoring of any restoration or mitigation measures for natural, cultural, and historical resources.

The cost estimates for the purposes of this study are presented in either 2004 constant dollars or present-value terms. The cost estimates were prepared from information available at the time of this study. The actual cost of the project will depend on additional information gained during the remedial design phase, the final scope and design of the selected remedial action, the schedule of implementation, the competitive market conditions, and other variables. However, most of these factors are not expected to significantly affect the relative cost differences of alternatives.

6.1.8 State Acceptance

This criterion evaluates the technical issues and concerns that the EPA and Ecology could have regarding a remedial alternative. The regulatory acceptance process would involve a review and concurrence by the EPA and the Ecology. This criterion will be addressed at the time that the Proposed Plan is published.

6.1.9 Community Acceptance

This criterion evaluates the issues and concerns that the public may have regarding a remedial alternative. This criterion will be addressed following public review of the Proposed Plan.

6.2 DETAILED ANALYSIS OF ALTERNATIVES

In this section, each of the five alternatives (Chapter 5.0) is evaluated against the first seven CERCLA evaluation criteria. This section presents the detailed analysis of the alternatives evaluated under an industrial (exclusive) land-use scenario. This section is followed by a NEPA evaluation. Detailed evaluations were performed on all representative sites. Data obtained at the representative sites were used to evaluate analogous sites.

The following detailed evaluations are applicable to the representative waste sites and their respective analogous sites. Unless noted, when a site name is used, it means the representative site plus any associated analogous site(s).

6.2.1 Detailed Analysis of Alternative 1 – No Action

Alternative 1 is retained for detailed analysis as a baseline description of the effects of taking no action and is required by CERCLA regulations.

6.2.1.1 Overall Protection of Human Health and the Environment

For six of the seven representative waste sites (all except the 207-A South Retention Basin) addressed by this FS, the no-action alternative would fail to provide overall protection of human health and the environment because contaminants at concentrations above the PRGs would remain on site with no measures performed to prevent intrusion to the contaminants or to monitor their migration. Therefore, for the six remaining representative sites, this alternative fails to meet this criterion under CERCLA. None of the analogous sites are expected to meet this criterion, because all are expected to possess excessive contamination.

6.2.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

Because no action would be taken to control the exposure pathway, this alternative would not meet the ARARs for the representative waste sites, except for representative site 207-A South Retention Basin. For this site, all ARARs are anticipated to be met under Alternative 1 because the retention basin contains no contaminants above action levels. Because of expected contamination at the analogous sites, none of these sites are expected to comply with ARARs. ARARs include RBCs for soil cleanup that, if exceeded, would result in a radiological dose of 15 mrem/yr or greater under an industrial scenario. As shown in Table 2-2, the dose rates for all of the seven representative sites do not exceed 15 mrem/yr, assuming that no credit is taken for protectiveness of the existing cover. The appropriateness of the 15 mrem/yr end dose is discussed in *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination*, OSWER 9200.4-18 (EPA 1997), and clarified in EPA/540/R-99/006.

Appendix D contains an analysis of risk to an inadvertent intruder and indicates that an inadvertent intruder would not receive a dose in excess of 15 mrem/yr at the following 200-PW-2 or 200-PW-4 OU representative waste sites:

- 207-A South Retention Basin
- 216-A-19 Trench
- 216-A-37-1 Crib.

Thus, ARARs relating to intrusion at the above waste sites are satisfied for the no-action alternative.

Human health risk assessment and RESRAD dose modeling indicates that six of the seven representative sites (all except the 207-A South Retention Basin) are predicted to require groundwater protection. Human health risk assessment and the RESRAD model were used to predict whether existing nonradiological and radiological concentrations in soil would migrate to groundwater and result in groundwater concentrations that exceed Federal maximum contaminant levels as defined by 40 CFR 141.

As summarized in Table 2-2, only uranium at the 216-A-19 Trench exceeds wildlife-screening values presented in WAC 173-340-900, Table 749-3. Similarly, no concentrations of radiological constituents at the seven representative sites exceed BCG values (DOE-STD-1153-2002). Because no remedial activities would take place under this alternative, action-specific ARARs would not be triggered. No location-specific ARARs have been identified for the waste sites.

6.2.1.3 Long-Term Effectiveness and Permanence

Long-Term Effectiveness and Permanence for Human Health. For the representative sites and their associated analogous waste sites, except the 207-A South Retention Basin, the no-action alternative fails to provide long-term effectiveness and permanence for human health, because contaminants would remain on site at concentrations that are above the PRGs. For this reason, this alternative fails to meet this criterion under CERCLA for these sites.

Long-Term Effectiveness and Permanence for Groundwater. Contaminants are predicted to reach the groundwater at six of the seven representative sites (all except the 207-A South Retention Basin). Therefore, Alternative 1 does not provide long-term effectiveness for groundwater protection for those sites or for their analogous sites.

Long-Term Effectiveness and Permanence for the Environment. All of the representative sites, except the 216-A-19 Trench, are expected to meet the standard for protection of the environment in the 0 to 4.6 m (0 to 15 ft) bgs zone (see Table 2-8). However, many of the analogous sites are not expected to meet the standard for protection of the environment, because the depth of contamination is less than 4.6 m (15 ft).

6.2.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume would occur at all the waste sites in the form of natural attenuation. Natural attenuation is a process that results in a reduction of toxicity, mobility, or volume through the natural radioactive decay process. Radioactive decay is the only process currently available to eliminate nuclear particle emissions. Radionuclides identified during characterization would be influenced by the radioactive decay process; however, some (e.g., U and Pu isotopes, Am-241) have such long half-lives that radioactive decay is not significant.

In EPA/540/R-99/009, *Use of Monitored Natural Attenuation at Superfund RCRA Corrective Action and Underground Storage Tank Sites November 1997*, OSWER 9200.4-17P, the EPA acknowledges that natural attenuation can be an appropriate treatment for contaminated soil. Because of uncertainties in the science of natural attenuation processes, the EPA considers source control and performance monitoring to be fundamental components of the remedy. The no-action alternative does not use any source control or monitoring. Because of the concentrations of contaminants and the substantial length of time required for natural attenuation processes to meet RAOs, this alternative fails to meet this criterion under CERCLA.

6.2.1.5 Short-Term Effectiveness

No short-term risks to humans would be associated with the no-action alternative because remedial activities would not be conducted. Current risks to workers are not an issue because of protective soil covers and appropriate safety measures for work activities. No ecological risks currently exist at the seven representative sites; therefore, this alternative meets the criterion for short-term effectiveness at the representative sites.

6.2.1.6 Implementability

The no-action alternative could be implemented immediately and would not present any technical problems.

6.2.1.7 Cost

The no-action alternative for the representative sites would involve no cost.

6.2.2 Detailed Analysis of Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls

Under this alternative, existing soil covers would be maintained to provide protection from intrusion by human and/or biological receptors. Legal and physical barriers also would be used to prevent human access to the waste sites. The existing soil covers would break the pathway between human and ecological receptors and the contaminants. Groundwater monitoring also is included in this alternative, as needed.

The following sections present a detailed analysis of Alternative 2 against the evaluation criteria. This analysis is summarized in Table 6-1.

6.2.2.1 Overall Protection of Human Health and the Environment

Alternative 2 would provide overall protection of human health and the environment for sites that show protection of groundwater and achieve human health and environmental protection within 150 years. Because the viability of institutional controls cannot be assured past 150 years, this alternative fails to meet this criterion for sites with long-lived contaminants such as technetium and uranium, because the waste sites would have contamination that would not attenuate to acceptable levels within 150 years. Risk assessment details are contained in Chapter 2.0 and in Appendix D and are summarized in this section.

207-A South Retention Basin and Analogous Waste Site – The 207-A South Retention Basin has no contaminants present in the 4.6 m (15-ft) bgs zone and no record of leaks. Therefore, this alternative is expected to be protective of human health and the environment.

Although its analogous site (200-W-22) is relatively shallow and therefore is expected to have contaminants in the 4.6 m (15-ft) bgs zone, contamination levels are believed to be low. Also, contaminant levels are not expected to exceed groundwater protection PRGs. Therefore, this alternative is expected to be protective of human health and the environment.

216-A-10 Crib and Analogous Waste Sites – Based on the evaluation of the 216-A-10 Crib representative site, Alternative 2 is not expected to be protective of human health and the environment for the 216-A-10 Crib and all of its analogous waste sites, with the possible exception of the 200-E-58 Neutralization Tank, because RAOs will be exceeded beyond 150 years. Even the nearly empty 200-E-58 Neutralization Tank may contain sufficient residual contamination to exceed RAOs.

216-A-19 Trench and Analogous Waste Sites – Based on the evaluation of the 216-A-19 Trench representative site, Alternative 2 is not protective of the 216-A-19 Trench and its analogous sites, because contamination will exceed PRGs beyond 150 years, except the

216-A-34 Ditch, which has no reportable contaminant inventory, and the 216-S-8 Trench, which has minimal inventory.

216-A-36B Crib and Analogous Waste Sites – Based on the evaluation of the 216-A-36B Crib representative site, Alternative 2 is not protective of the 216-A-36B Crib and its analogous waste site, the 216-A-36A Crib, because adverse groundwater impact is predicted.

The remaining analogous site (UPR-200-E-39) is not expected to exceed groundwater protection PRGs, but is expected to contain contaminants in the 4.6 m (15-ft) bgs zone. Because the site consists of a one-time contaminant release at the surface, this alternative may be protective of human health and the environment.

216-A-37-1 Crib – Based on the evaluation of the 216-A-37-1 Crib waste site, Alternative 2 is protective of human health and the environment, provided potential nitrate concentrations in groundwater can be accepted. Otherwise, this alternative is not protective of human health or the environment for the 216-A-37-1 Crib. No contamination was present in the 4.6 m (15-ft) bgs zone above RAOs for this site.

216-B-12 Crib and Analogous Waste Sites – Based on the evaluation of the 216-B-12 Crib representative site, Alternative 2 is not protective of human health and the environment, because unacceptable groundwater and intruder risk is predicted.

None of the analogous sites in this group are expected to exceed groundwater protection PRGs, because of their lesser inventories of mobile contaminants. Several sites (216-C-3 Crib, 216-C-5 Crib, 216-C-7 Crib, and the 216-C-10 Crib) are relatively shallow and could represent a potential human health and/or ecological threat (Section 2.6.7). Thus, Alternative 2 may not be protective for these sites. Alternative 2 may be protective of human health and the environment for the 216-B-60 Crib, because of uncertainty in its expected uranium inventory (see Table 2-2), which, if minor, would not impact groundwater. The 209-E-WS-3 Valve Pit and Hold-Up Tank and 270-E-1 Neutralization Tank are deeper, but intrusion into residual waste within these tanks past the duration of institutional controls (150 years) could result in excessive exposure, which results in Alternative 2 not being protective. The UPR-200-E-64 site may be adequately protected by Alternative 2, because its contamination level is expected to attenuate to acceptable levels by 150 years.

216-S-7 Crib and Analogous Waste Sites – Based on the evaluation of the 216-S-7 Crib representative site, Alternative 2 would not be protective because of unacceptable intruder and groundwater risk beyond 150 years.

Considering analogous sites, Alternative 2 would not be protective of human health and the environment for the 216-S-1&2 Cribs, because of expected groundwater impact. This alternative also would not be protective for the UPR-200-W-36 site, which is a contaminated well casing associated with the 216-S-1&2 Cribs and is expected to be contaminated along its length to groundwater. The 216-S-4 French Drain, 216-S-22 Crib, and 216-T-20 Trench would not be protective of human health and the environment, because of the significant inventory. The 216-S-23 Crib should be adequately protected by Alternative 2, because of its minor inventory.

6.2.2.2 Compliance with Applicable or Relevant and Appropriate Requirements

Under Alternative 2, ARARs would not be met at any of the seven representative sites, with the exception of the 207-A South Retention Basin. Risk analysis (Chapter 2.0) shows that groundwater protection standards will be exceeded at all of the representative sites, with the exception of the 207-A South Retention Basin. Ecological protection standards are exceeded at only the 216-A-19 Trench. No human-health direct-contact PRGs are expected to be exceeded past the 150-year active institutional control period. However, because of the groundwater protection issues, each representative site (except the 207-A South Retention Basin) fails to comply with ARARs.

Alternative 2 may provide ARAR compliance for several analogous sites, because their minor inventories would be expected to decay to less than PRGs by 150 years from the present, and groundwater impact should be negligible. These sites are the 200-W-22 Site Group, UPR-200-E-39, UPR-200-E-64, 216-S-4 French Drain, 216-S-22 Crib, 216-S-23 Crib, and 216-T-20 Trench.

For the 207-A South Retention Basin, Alternative 2 will comply with all ARARs, as discussed in the previous section.

6.2.2.3 Long-Term Effectiveness and Permanence

Human Health

Alternative 2 would rely on natural attenuation (e.g., radioactive decay) to decrease contaminants until concentrations reached levels that would be protective of human health and the environment. This alternative would incorporate the use of institutional controls to prevent inadvertent human and biological intrusion into the waste until contaminant concentrations reached acceptable levels. Institutional controls (e.g., deed restrictions, fencing, signage, monitoring of groundwater) would be required components of this alternative. Institutional control and monitoring would be required for the entire time that contaminants exceed RAOs to be effective. Institutional controls are assumed to be lost after 150 years.

Table 2-5 summarizes risk assessments for the seven representative sites and shows that in all cases, except at the 207-A South Retention Basin, human health risks remain past the period of effective institutional control (150 years). At the 216-A-10 Crib, 216-A-36B Crib, and 216-S-7 Crib, groundwater protection standards are exceeded for long-lived radionuclides, which will out-live the institutional control period. No representative sites are shown to have ecological PRGs that are an issue after 150 years. While the radionuclides contributing to ecological risk (Cs-137 and Sr-90) will decay substantially during this time frame, chemical contaminants that pose ecological risk (nitrate, nitrite, and uranium) will not decay, and after the institutional control period it may be expected that the existing cover will erode, exposing fauna to these contaminants.

207-A South Retention Basin and Analogous Waste Site – Under Alternative 2, chemicals and radionuclides are not expected to remain in the vadose zone beneath the representative site or its analogous waste site 200-W-22 at concentrations above PRGs. Therefore, this alternative is expected to be protective of human health in the long term, due to a lack of contaminants above

PRGs for the 207-A South Retention Basin, and to the low contaminant inventory at analogous waste site 200-W-22.

216-A-10 Crib and Analogous Waste Sites – Under Alternative 2, chemicals and radionuclides would not remain in the vadose zone beneath the waste sites in the 0 to 4.6 m (0 to 15-ft) zone at concentrations above PRGs, but would remain in the deep zone and thus would result in a potential threat to intruders and groundwater. Therefore, this alternative is not protective of human health in the long term. As such, this alternative is not protective of human health in the long term at the 216-A-10 Crib and is not expected to be protective at its analogous sites, with the possible exception of the 200-E-58 Neutralization Tank. Based on this site containing a drained underground tank with no documented history of leaks, this alternative may be protective of human health in the long term.

216-A-19 Trench and Analogous Waste Sites – Under Alternative 2, chemicals and radionuclides representing a potential groundwater threat would remain in the vadose zone beneath the representative site at concentrations above RAOs beyond 150 years. Therefore, this alternative is not protective of human health in the long term, even though intruder risk is acceptable. Similarly, the 216-A-1 Crib, 216-A-3 Crib, 216-A-18 Trench, 216-A-20 Trench, 216-A-22 French Drain and associated UPR-200-E-17, 216-A-28 Crib and 216-A-18 Trench are expected to possess contaminant concentrations exceeding PRGs at 150 years. However, the UPR-200-E-145 and 216-A-34 Ditch waste sites are believed to possess minor inventory that may attenuate to acceptable levels by 150 years.

216-A-36B Crib and Analogous Waste Sites – Under Alternative 2, chemicals and radionuclides would not remain in the vadose zone beneath the representative site, 216-A-36B, in the 0 to 4.6 m (0 to 15-ft) zone at concentrations above PRGs, but would remain in the deep zone and thus would result in a potential threat to groundwater and to intruders. Based on the evaluation of the representative site, the 216-A-36B Crib and its analogous waste site, 216-A-36A Crib, this alternative is not expected to be protective of human health in the long term. The remaining analogous site (UPR-200-E-39) is not expected to exceed groundwater protection PRGs, but is expected to contain contaminants in the 4.6 m (15-ft) bgs zone. Because the site consists of a one-time contaminant release at the surface, this alternative may be protective of human health at 150 years.

216-A-37-1 Crib – Under Alternative 2, chemicals and radionuclides would not remain in the vadose zone beneath the waste sites in the 0 to 4.6 m (0 to 15-ft) zone at concentrations above PRGs, but would remain in the deep zone and thus would result in a potential threat to groundwater and intruders. Therefore, this alternative is not protective of human health in the long term.

216-B-12 Crib and Analogous Waste Sites – Under Alternative 2, chemicals and radionuclides would remain in the deep zone and thus would result in a potential threat to groundwater and intruders. Therefore, this alternative is not protective of human health in the long term for the 216-B-12 Crib. This alternative also is not expected to be effective in the long term for the 216-C-3 Crib. Alternative 2 may be effective in the long term for the 216-B-60 Crib, because of uncertainty in its expected uranium inventory (see Table 2-2), which, if minor, would not impact groundwater. However, based on the shallowness of the analogous sites, the low effluent volume received, and/or the low ratio of effluent volume to soil pore volume, this alternative may be protective of human health in the long term. In addition, two of the analogous sites contain underground tanks (209-E-WS-3 Valve Pit and Hold-Up Tank and 270-E-1 Neutralization Tank), and neither has documented history of leakage.

Based on the shallow site evaluation methodology described in Section 2.6.7.2, analogous waste sites 216-C-3 Crib, 216-C-5 Crib, and 216-C-10 Crib potentially present an ecological risk.

216-S-7 Crib and Analogous Waste Sites – Under Alternative 2, chemicals and radionuclides would not remain in the vadose zone beneath the representative site in the 0 to 4.6 m (0 to 15-ft) zone at concentrations above PRGs, but would remain in the deep zone and thus would result in a potential threat to groundwater and intruders. As such, this alternative is not protective of human health in the long term at the 216-S-7 Crib and three of its analogous sites (216-S-1&2 Cribs, UPR-200-W-36, and 216-S-23 Crib). However, for the remaining analogous sites in this group (216-S-4 French Drain, 216-S-22 Crib, 216-T-20 Trench), based on the low effluent volume received at these sites, this alternative may be protective of human health in the long term.

Protection of Groundwater

207-A South Retention Basin and Analogous Waste Site – Risk analysis shows no long-term risk to groundwater from the 207-A South Retention Basin. Therefore, Alternative 2 would be protective of groundwater at this site. Analogous site 200-W-22 is a relatively shallow site and is not expected to exceed groundwater protection PRGs. Based on the lower effluent volume received at this analogous site, this alternative is expected to be protective of groundwater.

216-A-10 Crib and Analogous Waste Sites – As demonstrated by the risk analysis, reported in Chapter 2.0, and summarized in Table 2-5, the 216-A-10 Crib exceeds groundwater protection PRGs for I-129. This alternative is not protective of the groundwater for the 216-A-10 Crib. Based on the evaluation of the representative site, the 216-A-10 Crib and all of its analogous waste sites, with the exception of the 200-E-58 Neutralization Tank, are not expected to be protective of groundwater. The remaining analogous site (200-E-58) is not expected to exceed groundwater protection PRGs based on the site containing an underground tank with no documented history of leaks.

216-A-19 Trench and Analogous Waste Sites – As demonstrated by the risk analysis, reported in Chapter 2.0, and summarized in Table 2-5, the 216-A-19 Trench exceeds groundwater protection PRGs for nitrate (as N), nitrate/nitrite (as N), and total uranium. Thus, Alternative 2 is not protective of the groundwater for the 216-A-19 Trench. Analogous sites 216-A-1 Crib, 216-A-3 Crib, 216-A-18 Trench, 216-A-20 Trench, 216-A-28 Crib, and 216-S-8 Trench also may impact groundwater, because of their significant uranium inventories. Analogous sites 216-A-22 French Drain, 216-A-34 Ditch, UPR-200-E-17, and UPR-200-E-145 are not expected to exceed groundwater protection PRGs due to the lower effluent volumes received at these analogous sites, and lower inventories of mobile contaminants.

216-A-36B Crib and Analogous Waste Sites – As demonstrated by the risk analysis, reported in Chapter 2.0 and summarized in Table 2-5, the 216-A-36B Crib exceeds groundwater protection PRGs for nitrate (as N), nitrate/nitrite (as N), nitrite (as N), total uranium, and Tc-99 and is expected to exceed these PRGs for analogous site 216-A-36A Crib. Thus, Alternative 2 is not protective of the groundwater for the 216-A-36B and 216-A-36A Cribs. The remaining analogous site (UPR-200-E-39) is not expected to exceed groundwater protection PRGs, because the site consists of a one-time contaminant release at the surface.

216-A-37-1 Crib – As demonstrated by the risk analysis, reported in Chapter 2.0 and summarized in Table 2-5, the 216-A-37-1 Crib exceeds groundwater protection PRGs for nitrate (as N), and nitrate/nitrite (as N). As such, this alternative is not protective of the groundwater for the 216-A-37-1 Crib.

216-B-12 Crib and Analogous Waste Sites – As demonstrated by the risk analysis, reported in Chapter 2.0, and summarized in Table 2-5, the 216-B-12 Crib exceeds groundwater protection PRGs for nitrate (as N), nitrate/nitrite (as N), and total uranium. Thus, Alternative 2 is not protective of the groundwater for the 216-B-12 Crib. Analogous sites 216-B-60 Crib and 216-C-3 Crib also may impact groundwater, because of their significant uranium and/or nitrate inventories. However, for the 216-C-5 Crib, the 216-C-7 Crib, the 216-C-10 Crib, the 209-E-WS-3 Valve Pit and Hold-Up Tank, the 270-E-1 Tank, and the UPR-200-E-64 analogous waste sites, groundwater is not expected to be impacted because of the minor inventories associated with these waste sites. Also, two of these analogous sites contain underground tanks (209-E-WS-3 Valve Pit and Hold-Up Tank and the 270-E-1 Neutralization Tank), and neither has documented history of leakage.

Based on the shallow site evaluation methodology described in Section 2.6.7.2, analogous waste sites 216-C-3 Crib, 216-C-5 Crib, and 216-C-10 Crib potentially present an ecological risk.

216-S-7 Crib and Analogous Waste Sites – As demonstrated by the risk analysis, reported in Chapter 2.0, and summarized in Table 2-5, the 216-S-7 Crib exceeds groundwater protection PRGs for nitrate (as N), nitrate/nitrite (as N), total uranium, and tritium, and is expected to exceed these PRGs for three of its analogous sites. Thus, Alternative 2 is not protective of groundwater at the 216-S-7 Crib and analogous sites 216-S-1&2 Cribs, UPR-200-W-36, and 216-S-23 Crib. The remaining analogous sites in this group (216-S-4 French Drain, 216-S-22 Crib, and 216-T-20 Trench) are not expected to exceed groundwater protection PRGs based on the low effluent volume received.

The Environment

None of the representative sites have contaminants located in the shallow soils (0 to 4.6 m [0 to 15-ft] bgs) that present potential risks to burrowing animals. Therefore, this alternative provides long-term protection to the environment for the representative sites. Only the 216-T-20 Trench, which is approximately 1.2 m (4 ft) deep, represents potential ecological risk.

6.2.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 2 does not provide any engineered treatment to reduce toxicity, mobility, or volume. However, natural attenuation will occur through radioactive decay.

In EPA/540/R-99/009, the EPA acknowledges that natural attenuation can be an appropriate treatment for contaminated soil. Because of uncertainties in the science of natural attenuation process, the EPA considers source control and performance monitoring to be fundamental components of the alternative.

This alternative provides a reduction in the mass of radioactive contaminants at each site, but only through radioactive decay.

6.2.2.5 Short-Term Effectiveness

6.2.2.5.1 Remediation Worker Risk

For Alternative 2, only minimal short-term worker risks are expected, which are associated with monitoring and maintenance activities. Experienced workers using appropriate safety precautions would conduct these activities. Risks would decrease over time as the radionuclides decay. As such, the risk to workers is qualitatively identified as low. Additionally, DOE control of the Central Plateau is assumed for the next 50 years given DOE's commitment to vitrify the waste in the tank farms. Therefore, failure of this alternative in the short term is considered unlikely.

6.2.2.5.2 Impact to Environment During Remediation

This alternative reduces the risk to human and ecological receptors through the use of existing soil covers and the implementation of institutional controls. Currently, no representative sites have contamination within the shallow soils 0 to 4.6 m (0 to 15 ft) above PRGs. Some analogous sites do have contamination within the shallow soils, but Alternative 2 would ensure, through periodic monitoring and maintenance of existing soil cover, the contamination spread did not occur. As such, short-term impacts to vegetation and wildlife are not likely to occur at these sites during the implementation of this alternative. The waste sites have been highly disturbed, and the existing soil cover provides protection for all but the deep-rooted plants or deep-burrowing animals. The short-term impacts to the environment are expected to be low.

6.2.2.5.3 Time to Meet the Remedial Action Objectives

In this alternative, RAOs can only be fully met through natural radiological decay of contaminants, which can take hundreds to thousands of years to achieve. Therefore, for the representative sites, this alternative does not meet RAOs in a reasonable time frame except for the representative site (207-A South Retention Basin), discussed earlier.

6.2.2.5.4 Implementability

Alternative 2 could be readily implemented and would not present technical problems. This alternative currently is being implemented through Hanford Site access controls, surface and subsurface radiation area work and access controls, and the waste site/radiation area surveillance and maintenance program.

6.2.2.6 Cost

Cost estimates for Alternative 2 were developed based on existing costs for similar activities currently conducted on the Hanford Site. Details of the cost estimates are presented in

Appendix F. Summarized costs for the representative and analogous sites are presented in Table 6-1. The input parameters used in these estimates are the best available at this time, but in many cases the data on COCs, site locations, and site dimensions are limited. The uncertainties identified above are similar for all the sites evaluated in this FS. Despite these uncertainties, the cost estimates are of sufficient quality to fulfill the primary objective, which is to aid in selecting preferred remedial alternatives.

Costs are estimated for periodic surveillance of the waste sites for evidence of contamination and biologic intrusion; emplacement of vegetation, herbicide application, or other activities to control deep-rooted plants; control of deep-burrowing animals; maintenance of signs and/or fencing; maintenance of the existing soil cover (including an assumed periodic addition of soil); administrative controls; and site reviews. The present-worth costs assume a 3.1 percent discount rate (based on 2004 Office of Management and Budget information) and assume an operation and maintenance period of 150 years.

6.2.3 Detailed Analysis of Alternative 3 – Removal, Treatment, and Disposal

Under Alternative 3, contaminated soil and debris (such as concrete or wood associated with cribs) would be removed, treated as necessary to meet disposal facility waste acceptance criteria, and transported for disposal at an approved waste disposal facility. Soils would be removed to meet PRGs. Alternative 3 has two disposal paths: one for disposal of soils contaminated with transuranic constituents above 100 nCi/g and one for disposal of soils that are not contaminated above these levels. These latter soils could be disposed of on-site at the existing waste disposal facility. Soils are not anticipated to require treatment before disposal, based on the data collected for the representative waste sites. Alternative 3 would remove contaminated waste and soil from waste sites to a depth to meet the RAOs.

One of the representative sites, the 216-A-36B Crib, was found to have concentrations of transuranics above 100 nCi/g. The maximum concentration of transuranics found at this site was 138 nCi/g. Excavated soil that is determined to contain more than 100 nCi/g of transuranic constituents would be handled, packaged, stored, and ultimately disposed of in accordance with ARARs. Disposal likely would occur at the Waste Isolation Pilot Plant (WIPP).

This alternative generally provides a high degree of overall protection of human health and the environment, because contaminants are removed to meet PRGs. Removal of the contaminants provides for the most flexibility for future land use.

This alternative would provide future protection to humans and the environment because the contaminants are removed from the waste site. The groundwater would be protected. Potential intruders would be protected. Because contaminants above PRGs would be removed from a waste site and placed in an approved disposal facility, failure of this alternative is not likely. Residual risks would be at acceptable levels for protection of human health, the environment, and groundwater. Verification sampling would be conducted to determine that PRGs are met by the removal activities. Risks associated with the failure of the disposal facility are not evaluated here, but are evaluated as part of the permitting process for the facility.

Some of the representative sites have contamination greater than PRGs to depths near the water table. Excavation to these depths and levels of contamination is difficult, requires workers to be exposed to the high contaminant concentrations as well as risks associated with deep excavations, and has the potential to impact neighboring facilities, such as the tank farms. This type of excavation is expensive and creates considerable waste that requires disposal. Special excavation techniques, such as terraced side slopes and access roads to the bottom of the excavation, likely would be necessary to support this alternative, which would significantly increase costs and disposal capacity requirements.

6.2.3.1 Overall Protection of Human Health and the Environment

Because this alternative removes contaminants that are above PRGs, it provides overall protection (human health and the environment) in all cases. It does, however, potentially expose remediation workers to contamination and industrial risks.

207-A South Retention Basin and Analogous Waste Site – Although the 207-A South Retention Basin exceeds no PRGs and excavation of the site is not necessary to provide overall protection of human health and the environment, excavation would provide overall protection of human health and the environment for this site. The analogous site 200-W-22 Site Group also is believed to possess only minor contamination. Because these waste sites are shallow and possess relatively low contamination levels (if any), worker risk during remediation would be low.

216-A-10 Crib and Analogous Waste Sites – As shown in the risk analysis, the 216-A-10 Crib exceeds groundwater protection PRGs for I-129 to the 19 m (62.5 ft) bgs level. Therefore, excavation of the site to 19 m (62.5 ft) would provide overall protection of human health and the environment. Similarly, excavation of the analogous waste sites to remove contaminants in excess of the PRGs would provide overall protection of human health and the environment. Worker risk during excavation is estimated as moderate, primarily because of industrial hazards associated with excavation to this depth.

216-A-19 Trench and Analogous Waste Sites – Risk analysis showed chemical and radiological contaminants in excess of the PRGs extend to a depth of at least 14 m (47 ft). The 216-A-19 Trench exceeds groundwater protection PRGs for nitrate (as N), nitrate/nitrite (as N), and total uranium. Excavating the site to this depth will provide overall protection of human health and the environment. Similarly, excavation of the analogous waste sites to remove contaminants in excess of the PRGs would provide overall protection of human health and the environment. Worker risk during excavation is estimated as moderate, primarily because of industrial hazards associated with excavation to this depth.

216-A-36B Crib and Analogous Waste Sites – As shown in the risk analysis, the 216-A-36B Crib exceeds groundwater protection PRGs for nitrate (as N), nitrate/nitrite (as N), nitrite (as N), and total uranium to the 92 m (303 ft) bgs level. Therefore, excavation of the site to 92 m (303 ft) would provide overall protection of human health and the environment. Similarly, excavation of the analogous waste sites to remove contaminants in excess of the PRGs would provide overall protection of human health and the environment. Worker risk during

216-A-37-1 Crib – As shown in the risk analysis, the 216-A-37-1 Crib exceeds groundwater protection PRGs for nitrate (as N) and nitrate/nitrite (as N) to the 7.6 m (25 ft) bgs level. Therefore, excavation of the site to 7.6 m (25 ft) would provide overall protection of human health and the environment. Worker risk during remediation would be low, because the site is shallow and possesses relatively low contamination levels.

216-B-12 Crib and Analogous Waste Sites – As shown in the risk analysis, the 216-B-12 Crib exceeds groundwater protection PRGs for nitrate (as N), nitrate/nitrite (as N), and total uranium to the 58 m (191.5 ft) bgs level. Therefore, excavation of the site to 58 m (191.5 ft) would provide overall protection of human health and the environment. Similarly, excavation of the analogous waste sites to remove contaminants in excess of the PRGs, if any, would provide overall protection of human health and the environment. Worker risk during excavation is estimated as moderate, primarily because of industrial hazards associated with excavation to this depth.

216-S-7 Crib and Analogous Waste Sites – As shown in the risk analysis, the 216-S-7 Crib exceeds groundwater protection PRGs for nitrate (as N), nitrate/nitrite (as N), total uranium, and tritium to the 69 m (225.5 ft) bgs level. Therefore, excavation of the site to 69 m (225.5 ft) would provide overall protection of human health and the environment. Similarly, excavation of the analogous waste sites to remove contaminants in excess of the PRGs, if any, would provide overall protection of human health and the environment. Worker risk during excavation is estimated as high, because of the high radionuclide concentrations that would be encountered and industrial hazards associated with excavation to this depth.

6.2.3.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 3 would comply with contaminant-specific ARARs by removing soil that exceeds the PRGs and by removing structures. Removal of all contaminants would achieve the contaminant-specific ARARs discussed in Section 6.2.1.2 for protection of human health, ecological receptors, and groundwater protection. Action-specific ARARs, such as worker, public, and environmental exposure standards, may be exceeded under this alternative during implementation unless proper precautions are taken. Other action-specific ARARs that could be pertinent to Alternative 3 are Washington State solid and dangerous waste regulations (for management of characterization and remediation wastes and performance standards for waste left in place), *Atomic Energy Act of 1954* regulations (for performance standards for radioactive waste sites), and Federal and state regulations related to air emissions. It is anticipated that these ARARs could be met. No location-specific ARARs have been identified for the waste sites addressed in this FS.

6.2.3.3 Long-Term Effectiveness and Permanence

Human Health

With regard to human health, this alternative would be effective and permanent in the long term for all sites because excavation activities under Alternative 3 would remove contaminants to meet human health RAOs. EPA and Ecology cleanup authorities prescribe remedies that use permanent solutions to the maximum extent practicable and where cost effective. Removal of contaminants would be a permanent solution at the waste sites; however, much of the waste would remain on site at the onsite low-level waste disposal facility or be disposed of at the WIPP.

The removal of buried materials from the Central Plateau, for disposal in the approved onsite waste disposal facility, transfers the long-term impact of buried waste from individual waste sites to one consolidated disposal facility. The onsite waste disposal facility is designed for long-term management of buried waste.

Protection of Groundwater

Contaminants are removed to meet the RAOs. Therefore, Alternative 3 meets this criterion.

The Environment

All contaminated soil above PRGs is removed in this alternative. Therefore, this alternative would be effective and permanent for all representative and analogous sites with respect to the environment. Excavation and transportation of waste and structures would disturb areas beyond the waste site boundaries during the implementation period. These areas would need to be revegetated after disturbance and would require activities to control intrusion by non-native, noxious plants. This should not adversely affect the alternative in the long term or permanently. Because of the large volumes of backfill material that would be needed to fill excavations in excess of 60 m (200 ft) deep, borrow areas would be impacted.

6.2.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

In general, the removal, treatment, and disposal alternative would include treatment to reduce toxicity, mobility, or volume. However, with the availability of the onsite waste disposal facility, treatment is not anticipated, nor is treatment anticipated for any waste planned for shipment to the WIPP. Radiological decay ultimately results in reduction of toxicity and volume. Movement of the waste to the onsite waste disposal facility or to the WIPP would result in reduction of mobility. Both facilities would provide additional protection against remobilization of contaminants over their current location.

6.2.3.5 Short-Term Effectiveness

6.2.3.5.1 Remediation Worker Risk

The levels of contamination in some of the waste sites may pose a dose threat to workers. In addition, the levels may result in implementing remote-handled removal techniques. Whether remote handled or contact handled, special safety controls may be required to address the contaminant concentrations. Shielded excavation equipment for these wastes may be required to reduce worker dose. Additional measures may be needed to limit the quantity of exposed soil during excavation, such as a rolling excavation, where only a small portion of the waste site is excavated at a time. The excavation is backfilled before the next small section of the waste site is exposed. Worker protection also may include providing filtered breathing air and dust suppression. These activities limit the worker risk, but also have a direct impact on schedule and cost. Based on the effectiveness of such controls, construction of a containment structure to further limit airborne releases may be needed. Nonetheless, excavation with dust suppression and health and safety controls has been proven to be effective in excavating large soil sites.

6.2.3.5.2 Impact to Environment During Remediation

Physical disruption of the waste sites during excavation, increased human activity, and noise, in addition to the generation of fugitive dust, affect local biological resources. However, the waste sites are located within historically disturbed industrial areas. Potential animal intrusion and biological uptake also are issues that will require control of open excavations and exposed contaminated soils at the end of each day. This control could be accomplished through placement of covers or fixatives. Not only are digging animals a concern, but in open trenches where cellulose was used to control dust and other airborne releases, insects such as fruit flies represent a further pathway to spread contamination. These are documented pathways at the Hanford Site. Areas of disturbed surface are documented in Appendix F and reported below. Waste site groups making up less than 0.4 ha (1 a) are rounded up to a minimum of 0.4 ha (1 a) for cost estimating purposes. Additional disturbed area was estimated to average 20 percent of the site area.

207-A South Retention Basin and Waste Analogous Site – The surface area disturbed during excavation of the analogous waste site will be 1.0 ha (2.4 a). A slightly larger area will be impacted due to activities such as staging construction activities and stockpiling clean soil.

216-A-10 Crib and Analogous Waste Sites – The surface area disturbed during excavation of this representative site and its analogous waste sites will be 3.4 ha (8.3 a). A slightly larger area will be impacted due to activities such as staging construction activities and stockpiling clean soil.

216-A-19 Trench and Analogous Waste Sites – The surface area disturbed during excavation of this representative site and its analogous waste sites will be 3.8 ha (9.4 a). A slightly larger area will be impacted due to activities such as staging construction activities and stockpiling clean soil.

216-A-36B Crib and Analogous Waste Sites – The surface area disturbed during excavation of this representative site and its analogous waste sites will be 37.9 ha (93.7 a). A slightly larger area will be impacted due to activities such as staging construction activities and stockpiling clean soil.

216-A-37-1 Crib – The surface area disturbed during excavation of this representative site will be 0.7 ha (1.8 a). A slightly larger area will be impacted due to activities such as staging construction activities and stockpiling clean soil.

216-B-12 Crib and Analogous Waste Sites – The surface area disturbed during excavation of this representative site and its analogous waste sites will be 10.6 ha (26.2 a). A slightly larger area will be impacted due to activities such as staging construction activities and stockpiling clean soil.

216-S-7 Crib and Analogous Waste Sites – The surface area disturbed during excavation of this representative site and its analogous waste sites will be 21.6 ha (53.4 a). A slightly larger

216-S-7 Crib and Analogous Waste Sites – The surface area disturbed during excavation of this representative site and its analogous waste sites will be 21.6 ha (53.4 a). A slightly larger area will be impacted due to activities such as staging construction activities and stockpiling clean soil.

Alternative 3 may pose a significant short-term impact on the environment by disturbing areas of recovering habitat where grasses are becoming more prevalent. While the deeper-rooted plants currently are controlled, the grasses do provide more habitat than unvegetated areas. Additionally, the disruptive nature of the removal process can have impacts on neighboring habitats and visiting wildlife, such as birds.

Transportation activities on the Central Plateau would increase as a result of bringing construction equipment to the site, transporting contaminated soils to the onsite waste disposal facility and WIPP, and bringing clean fill to the excavated sites. Minimal uncertainties are associated with the transport of waste to the onsite waste disposal facility. Excavated soils with transuranic constituents above 100 nCi/g would be analyzed; treated, if necessary; and transported to the WIPP. The only waste currently identified in this FS as potentially requiring disposal to the WIPP (e.g., greater than 100 nCi/g) is 532 m^3 (696 yd^3) of soil beneath the 216-A-36B and 216-A-36A Cribs. When excavated, this soil must be placed in containers, certified, and transported to the WIPP. These actions would cause short-term impacts, generating approximately 2,558, 55-gal drums requiring transport to and disposal at the WIPP. Air monitoring around the waste sites would be used to monitor potential air releases (e.g., waste or fill-material particulates) that could affect the public and the environment.

6.2.3.5.3 Time to Achieve the Remedial Action Objectives

This alternative prevents the risk to human or ecological receptors by moving the source to an engineered disposal facility. Construction and waste excavation activities would be expected to require several months to many years to complete. Once completed, all long-term RAOs will be met (reducing risk to human health and ecological receptors, protection of groundwater, and reduction of exposure to industrial workers). The only RAOs not met are short-term concerns: preventing or reducing occupational health risks and minimizing the general disruption of wildlife habitat. The issue of disruption of wildlife habitat is mitigated due to current and future land use. These waste sites are located in an industrial setting providing little habitation for vegetation and wildlife. The following estimates of time to complete remediation activities under Alternative 3 are from Appendix F.

207-A South Retention Basin and Analogous Waste Site – While excavation of the 207-A South Retention Basin is not necessary to provide overall protection of human health and the environment because it contains no COCs above PRG levels, its removal would take approximately 26 days. Construction of the removal, treatment, and disposal alternative for its analogous waste site (200-W-22) would take approximately 91 days.

216-A-10 Crib and Analogous Waste Sites – Implementation of the removal, treatment, and disposal alternative for this representative site would take approximately 291 days. If the four analogous sites were to be remediated consecutively (one after the other) rather than concurrently with the representative site, and using the conservative assumptions discussed

216-A-19 Trench and Analogous Waste Sites – Remediation of this representative site using Alternative 3 would take approximately 61 days. If the ten analogous sites were to be remediated consecutively (one after the other) rather than concurrently with the representative site, and using the conservative assumptions discussed above, the time to remediate the analogous sites would be an additional 789 days, for a total of 850 days.

216-A-36B Crib and Analogous Waste Sites – Implementation of Alternative 3 for this representative site would take approximately 1,316 days. If the two analogous sites were to be remediated consecutively (one after the other) rather than concurrently with the representative site, and using the conservative assumptions discussed above, the time to remediate the analogous sites would be an additional 1,050 days, for a total of 2,366 days.

216-A-37-1 Crib – Implementation of Alternative 3 for this representative site would take approximately 113 days.

216-B-12 Crib and Analogous Waste Sites – Implementation of the removal, treatment, and disposal alternative for this representative site would take approximately 481 days. If the eight analogous sites were to be remediated consecutively (one after the other) rather than concurrently with the representative site, and using the conservative assumptions discussed above, the time to remediate the analogous sites would be an additional 438 days, for a total of 919 days.

216-S-7 Crib and Analogous Waste Sites – Implementation of the removal, treatment, and disposal alternative for this representative site would take approximately 613 days. If the six analogous sites were to be remediated consecutively (one after the other) rather than concurrently with the representative site, and using the conservative assumptions discussed above, the time to remediate the analogous sites would be an additional 936 days, for a total of 1,549 days.

6.2.3.6 Implementability

Excavation is a proven and implementable technology used to remove wastes. Deeper excavations will require the use of more sophisticated digging equipment and techniques, the use of approach ramps and shoring, extensive removal of clean material to obtain adequately safe side slopes, etc. The aboveground structures (e.g., vent pipes, valve pit, and concrete structures) would be removed along with the waste site soil covers and contaminated soils. Every 0.3 m (1 ft) of excavation would require 0.46 to 0.61 m (1.5 to 2.0 ft) (see Appendix F) of side slope for a 1:1.5 or 1:2 vertical to horizontal ratio. This safety measure significantly increases the amount of material excavated, but is considered implementable.

Depending on the location and excavation depth, the size of excavation for some sites may interfere with unrelated buildings, roads, utilities, other waste sites, and tank farms.

The total disposal volume, should Alternative 3 be chosen for all sites addressed by this FS, is 489,904 m^3 (641,236 yd^3), which does not exceed the current capacity of the ERDF. The remaining capacity of the onsite waste disposal facility in February 2004 was 5.9 million m^3 (7.7 million yd^3), so implementing this alternative would not significantly impact the remaining disposal volume there. The majority of the volume would result from excavation of the 216-A-36B Crib, 216-B-12 Crib, 216-S-7 Crib, and the 216-S-1&2 Cribs (with UPR-200-W-36).

Following excavation, the hole would be filled with clean soil from onsite source(s).

Coordination with other agencies and local governments would be necessary after approval of the alternative. Excavation and disposal would require coordination with state agencies to assess matters relative to storm water control and the potential for radioactive air emissions.

207-A South Retention Basin and Analogous Waste Site – To remove the 207-A South Retention Basin, 1,507 m^3 (1,971 yd^3) of debris would be removed and sent to the onsite waste disposal facility. To remove subgrade structures from the analogous site, 200-W-22, an additional 3,456 m^3 (4,520 yd^3) of soil and debris would be removed and sent to that facility. To remove soil and remnants of structures at the analogous site, the excavation would be advanced to a depth of 3.6 m (12 ft) bgs. To remove the COCs at this group, 4,963 m^3 (3,792 yd^3) of soil and debris would be removed and sent to the onsite waste disposal facility.

216-A-10 Crib and Analogous Waste Sites – To remove soils above the PRGs, the excavation would be advanced to a depth of 19 m (62.5 ft) bgs at the 216-A-10 Crib. To remove the COCs at this representative site and its analogous sites, 81,231 m^3 (106,323 yd^3) of soil and debris would be removed and sent to the onsite waste disposal facility. All but one of the analogous waste sites are anticipated to be significantly shallower than the representative site. Therefore, for estimating purposes, it was assumed that the sites were excavated to the depths listed in Appendix F.

216-A-19 Trench and Analogous Waste Sites – To remove soils above the PRGs, the excavation at the 216-A-19 Trench would be advanced to a depth of 14 m (47 ft) bgs. To remove the COCs for this representative site and its analogous sites, 126,673 m^3 (165,802 yd^3) of soil and debris would be removed and sent to the onsite waste disposal facility. All but one of the analogous waste sites are anticipated to be significantly shallower than the representative site. Therefore, for estimating purposes, it was assumed that the sites were excavated to the depths listed in Appendix F. Two of the 216-A-19 Trench analogous sites are unplanned releases near the surface, and for estimating purposes, it was assumed that one of these sites is excavated to a depth of 1 m (3 ft), while the other is excavated to a depth of 2 m (6 ft) (because it was a release from a buried pipe approximately 1 m [3 ft] bgs).

216-A-37-1 Crib – To remove soils above the PRGs, the excavation would be advanced to a depth of 7.6 m (25 ft) bgs. To remove the COCs at this site, 18,859 m^3 (24,652 yd^3) of soil and debris would be removed and sent to the onsite waste disposal facility.

216-A-36B Crib and Analogous Waste Sites – To remove soils above the PRGs, the excavation would be advanced to a depth of 92 m (303 ft) bgs. To remove the COCs for this representative site and its analogous sites, 49,839 m^3 (65,234 yd^3) of soil and debris would be removed and sent to the onsite waste disposal facility and WIPP. The volume that would go to the WIPP would be determined by onsite sampling and assay during the excavation and packaging process. The estimated quantity of potential contaminated soil is 2,558, 55-gal drums.

One of the 216-A-36B Crib analogous sites is an unplanned release near the surface, and for estimating purposes, it was assumed that this site was excavated to a depth of 1 m (3 ft).

216-B-12 Crib and Analogous Waste Sites – To remove soils above the PRGs, excavation of the 216-B-12 Crib would be advanced to a depth of 58 m (191.5 ft) bgs. To remove the COCs for this representative site and its analogous sites, 81,421 m^3 (106,572 yd^3) of soil and debris would be removed and sent to the onsite waste disposal facility. The analogous waste sites are anticipated to be significantly shallower than the representative site. Therefore, for estimating purposes, it was assumed that the sites were excavated to the depths listed in Appendix F. One of the 216-B-12 Crib analogous sites (UPR-200-E-64) is an unplanned release on the surface, and for estimating purposes, it was assumed that this site was excavated to a depth of 0.9 m (3 ft) (because the contamination at this site was spread by ants and wind).

216-S-7 Crib and Analogous Waste Sites – To remove soils above the PRGs at the 216-S-7 Crib, the excavation would be advanced to a depth of 69 m (225.5 ft) bgs. To remove the COCs for this representative site and its analogous sites, 72,710 m^3 (95,170 yd^3) of soil and debris would be removed and sent to the onsite waste disposal facility.

6.2.3.7 Cost

Costs include mobilizing personnel and equipment; monitoring, sampling, and analysis; excavating; disposing of the waste at the onsite waste disposal facility and WIPP; backfilling with onsite resources and additional backfilling from a local stockpile; revegetating; and performing prime contractor oversight.

Costs are based on the use of standard excavation equipment (e.g., hydraulic excavators, front-end loaders, tractor-trailers). The costs are based on the assumption that a subcontractor would do the work, with oversight performed by prime contractor personnel. Details of the cost estimates are presented in Appendix F. Summarized costs for the representative and analogous sites are presented in Table 6-2.

6.2.4 Detailed Analysis of Alternative 4 – Engineered Surface Barrier

The following sections present a detailed analysis of Alternative 4 against the evaluation criteria. This analysis is summarized in Table 6-3. Three types of engineered barriers were analyzed for this alternative. An evapotranspiration (ET) barrier was analyzed for all of the waste sites except the 216-A-36B and 216-A-36A Cribs. Because concentrations of transuranics are present at these sites, the Hanford Barrier was analyzed. In addition, a monitored natural attenuation barrier was analyzed for the UPR-200-E-64 waste site.

6.2.4.1 Overall Protection of Human Health and the Environment

For all representative and analogous sites, this alternative would break potential exposure pathways to receptors through placement of an engineered surface barrier and institutional controls, which would be maintained at these sites until the RAOs are achieved through natural attenuation. Institutional controls would provide additional protection against access. The site would incorporate monitoring and inspections of barrier performance and natural attenuation to aid in the evaluation of engineered barrier performance. The engineered barrier would provide additional intrusion protection and would provide infiltration control to protect groundwater. The area will be maintained for industrial land use. These monitoring activities would be coordinated at those waste sites that have uncertainty associated with mobile contaminants (e.g., nitrates, Tc-99).

6.2.4.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 4 would comply with all ARARs for representative and analogous waste sites by breaking the pathways for exposure and emplacing engineered barriers that meet the intent of the regulations. In addition to the engineered barrier, institutional controls such as additional land-use restrictions and groundwater monitoring are elements of this alternative.

6.2.4.3 Long-Term Effectiveness and Permanence

Human Health

The engineered barrier alternative would be protective of human health and the environment by breaking exposure pathways. Chemicals and radionuclides left in place at the waste sites would be physically separated from receptors by the thickness of the engineered barrier and by the additional thickness of the existing soil covers. Intrusion-deterrent layers in the engineered barriers, along with institutional controls such as markers and use restrictions, would help protect against inadvertent intruders. Because contaminants at many of the waste sites have the potential to impact groundwater, engineered barriers would be designed to limit and control infiltration.

The long-term effectiveness depends on the proper construction and maintenance of the barrier and associated institutional controls throughout the natural attenuation time frame to prevent exposure to potential receptors. Maintenance activities would include erosion repairs and possible vegetation maintenance. Subsidence is not considered a major factor in maintenance activities for these waste sites. Failure of the engineered barrier is unlikely if maintenance and institutional control activities continue. Engineered barriers would be designed and constructed to account for the necessary time frame to reach RAOs and to minimize maintenance requirements and impacts from potential institutional controls failure. Complete failure of institutional controls could result in unacceptable intruder risk for some waste sites.

Because a significant amount of risk attenuates within the active institutional controls period for sites with significant risk contribution from short-lived radioisotopes, failure of the engineered barriers in later years would be associated with lower risks than at present. Additionally, the 5-year reviews required for sites with contaminants above RAOs would serve to monitor the effectiveness and reliability of the engineered barriers; adjustments and maintenance activities could be instituted to help prevent failure, based on the 5-year review results.

In addition, management controls (e.g., deed restrictions, fencing, signage, monitoring of groundwater) would be required components of this alternative. Once remediated, the barrier and surrounding disturbed area would be revegetated to further enhance ET, limit erosion, and blend the site area into the surrounding landscape.

The results of the fate and transport modeling and added evaluation indicate that most COCs are effectively attenuated in the vadose zone and do not pose a substantial threat to future groundwater quality during the 1,000-year simulation. Contaminants that affect groundwater in the future in significant concentrations are Tc-99, nitrate, nitrite, uranium, tritium, and I-129. Tritium is the only contaminant that is predicted to reach groundwater within the 1,000 years. Short-lived radionuclides, such as Cs-137 and Sr-90, were shown to decay before reaching groundwater.

207-A South Retention Basin and Analogous Waste Site – While an engineered barrier will not be required for this waste site because contaminants do not exceed PRG levels, an ET barrier was used in estimating the cost of a barrier for this site. An ET barrier also is proposed for the analogous waste site, 200-W-22, based on the shallow nature of the site.

216-A-10 Crib and Analogous Waste Sites – Only groundwater protection risks are associated with this site and its analogous sites, with the exception of the 200-E-58 Neutralization Tank. Therefore, a groundwater protection engineered barrier likely will be needed to address chemical and radiological contaminants listed in Table 2-8 for these sites. For the representative site and its analogous sites, with the exception of the 200-E-58 Neutralization Tank, RAOs are expected to be met within the life of an ET barrier. For estimating purposes, though a barrier will not be required, an ET barrier also was used for the 200-E-58 site.

216-A-19 Trench and Analogous Waste Sites – Groundwater and ecological protection risks are associated with this representative site. Therefore, an ET barrier likely will be needed to address chemical and radiological contaminants listed in Table 2-8. An ET barrier also was considered for the analogous waste sites.

216-A-36B Crib and Analogous Waste Sites – Only groundwater protection risks are associated with this site and its analogous sites, with the exception of UPR-200-E-39. Therefore, a groundwater protection engineered barrier likely will be needed to address chemical and radiological contaminants listed in Table 2-8 for these sites, with the exception of UPR-200-E-39. Contaminants for this representative site also include TRU constituents at 138 nCi/g. Therefore, a barrier type such as a Hanford Barrier, may be required for the 216-B-36B and 216-A-36A Cribs.

Based on the UPR-200-E-39 analogous site consisting of a one-time release to the surface, shallow zone RAOs are expected to be met within the life of an ET barrier.

216-A-37-1 Crib – Only groundwater protection risks are associated with this site. Therefore, a groundwater protection engineered ET barrier likely will be needed to address chemical and radiological contaminants listed in Table 2-8. For this site, RAOs are expected to be met within the life of an ET barrier.

216-B-12 Crib and Analogous Waste Sites – Only groundwater protection risks are associated with this site. Therefore, a groundwater protection engineered barrier likely will be needed to address chemical and radiological contaminants listed in Table 2-8. RAOs are expected to be met within the life of an ET barrier for the representative site. Based on the lower effluent volumes received and lower inventories of mobile contaminants at the analogous sites, RAOs are expected to be met at all analogous waste sites of this group within the life of an ET barrier.

216-S-7 Crib and Analogous Waste Sites – Only groundwater protection risks are associated with this site and analogous sites, 216-S-1&2 Cribs, UPR-200-W-36, 216-S-22 Crib, and 216-S-23 Crib. Therefore, a groundwater protection engineered barrier likely will be needed to address chemical and radiological contaminants listed in Table 2-8 for these sites. For the above-mentioned sites and remaining analogous sites (based on the lower effluent volumes received and lower inventories of mobile contaminants), RAOs are expected to be met within the life of an ET barrier.

Protection of Groundwater

This alternative is protective of the groundwater because it limits infiltration of precipitation, thereby reducing the driving force for contaminant transport toward groundwater. Additionally, the 5-year review would focus on groundwater protection monitoring and effectiveness of the engineered barrier in addressing the mobile contaminants at depth (e.g., Tc-99, nitrates).

The Environment

This alternative would provide protection to the environment by placing a barrier between the waste and the surface flora and fauna. Although no representative sites fail the protection of the environment from an ecological perspective, specific analogous sites that are shallow could require an environmental barrier element in the design.

6.2.4.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume would occur in the form of natural attenuation. The engineered barrier alternative would rely on natural attenuation processes (most importantly radioactive decay) to reduce radioactivity to levels that would not present a risk to human health or the environment. Natural attenuation is a process that results in a reduction of toxicity, mobility, or volume through the natural radioactive decay process. Radioactive decay is the only process currently available to eliminate nuclear particle emissions. Most of the contaminants identified during characterization would be influenced by the radioactive decay process; however, concentrations are high enough to require extended periods for radionuclides to decay to PRG levels.

The engineered barrier alternative would address the mobility of contaminants by limiting infiltration to the vadose zone, thereby limiting the driving force to move contaminants to the groundwater.

6.2.4.5 Short-Term Effectiveness

6.2.4.5.1 Remediation Worker Risk

Experienced workers using appropriate safety precautions would conduct these activities. Risks to workers for this alternative were compared to the baseline no-action alternative. For Alternative 4, only low short-term risks are expected. The engineered barrier alternative would not require excavation of contaminated soils, so the risks to workers primarily would be associated with general construction activities at the borrow sites and placement of the engineered barrier. Worker risk would be controlled through adherence to site health and safety procedures. Air monitoring would address potential air releases (e.g., barrier-material particulates) that could affect the public during construction of the engineered barriers.

6.2.4.5.2 Impact to Environment During Remediation

Physical disruption of the waste sites during engineered barrier construction, increased human activity and noise, and the generation of fugitive dust affect local biological resources. However, the waste sites are located within historically disturbed industrial areas. As such, short-term impacts to vegetation and animals at these sites would be low because these sites currently are poor wildlife habitats; however, exposure during remediation could be at unacceptable levels if controls were not in place to limit access.

Construction activities at the waste sites could disrupt wildlife in the area because of increased noise and human activity. However, most of the waste sites are located in areas already disturbed by earlier facility operations and in areas adjacent to ongoing facility operations, so impacts on biological resources would be low. Collection of borrow soil for barrier construction does have potential to disrupt wildlife and plant life within the Area C Borrow Site.

6.2.4.5.3 Time to Meet the Remedial Action Objectives

The following estimates of time to complete remedial activities under Alternative 4 are from Appendix F.

207-A South Retention Basin and Analogous Waste Site – Construction of the engineered barrier for the analogous waste site only would take approximately 69 days.

216-A-10 Crib and Analogous Waste Sites – Construction of the engineered barriers for this waste group would take approximately 170 days.

216-A-19 Trench and Analogous Waste Sites – Construction of the engineered barriers for this waste group would take approximately 329 days.

216-A-36B Crib and Analogous Waste Sites – Construction of the engineered barriers for this waste group would take approximately 213 days.

216-A-37-1 Crib – Construction of the engineered barrier for this waste site would take approximately 52 days.

216-B-12 Crib and Analogous Waste Sites – Construction of the engineered barriers for this waste group would take approximately 252 days.

216-S-7 Crib and Analogous Waste Sites – Construction of the engineered barriers for this waste group would take approximately 191 days.

6.2.4.6 Implementability

The engineered barrier alternative is considered implementable at all waste sites. A prototype Hanford Barrier has been implemented at the Hanford Site at the 216-B-57 Crib (CP-14873, *200-BP-1 Prototype Hanford Barrier Annual Monitoring Report for Fiscal Year 2002).* Other types of barriers (including the modified RCRA C engineered barrier) have not been used at the Hanford Site, but have been implemented at other sites and are easy to construct and maintain. The existing soil covers over the waste sites would be considered a part of the overall design to minimize the cost of materials and to minimize the impact to visual aesthetics.

Construction of the engineered barriers would follow standard procedures that have been thoroughly field-tested. The engineered barriers likely would require minor repair during the restoration time frame. Monitoring the continued integrity of the engineered barriers would be accomplished through visual inspection and would be supplemented with groundwater sampling. Implementation of the engineered barrier alternative may require additional design data based on confirmatory sampling to define the lateral extent of deep contamination.

Gravel, sand, and silt/loam soil used for the engineered barriers would be transported from borrow areas located on or near the Hanford Site. Anticipated volumes of these materials are identified in Appendix F. Area C currently is planned as a silt borrow location, which has a large volume of fine-grained material. Other locations have not yet been determined. Soil most likely would come from near the waste sites or from Pit 30, which is located between the 200 East and 200 West Areas. Analyses of an appropriate borrow area for silt/loam soil would be the subject of a future NEPA evaluation to determine a location with the least impacts to natural and cultural resources. Borrow material may occur in environmentally sensitive areas and obtaining sufficient engineered barrier material, especially for a multilayered engineered barrier, may affect areas of ecological significance and is a consideration in evaluating the relative risk reduction gained by installing the engineered barrier. Materials such as rip-rap that may be used in the engineered barrier construction could be obtained on the Hanford Site or could be purchased from local dealers.

Engineered barrier materials hauled to the Central Plateau from borrow areas and gravel pits within the Hanford Site would increase heavy equipment use and transportation activities at the sites. However, radioactive or hazardous waste would not have to be hauled from the Site.

Barrier construction at the 216-B-60 Crib waste site is not currently implementable, because it is located beneath the 225-B Building (WESF).

6.2.4.7 Cost

Costs, shown in Table 6-3, include stabilization of the existing site; excavation or import, transportation, and placement of engineered barrier material; compaction of the engineered barrier; prime contractor oversight; and confirmatory sampling. Costs are based on the use of standard equipment (e.g., hydraulic excavators, front-end loaders, dozers) and assume that a subcontractor would do the work, with oversight performed by the prime contractor. The subcontractor personnel are assumed to be wearing Level D personal protective equipment (e.g., blues and no respirators) during construction. The present-worth costs assume a 3.1 percent discount rate (based on 2004 Office of Management and Budget information) and assume operations and maintenance for 150 years. The operations and maintenance costs include site inspection/surveillance, periodic radiation site surveys of surface soil, biotic control, maintenance of signs and markers, cover maintenance, and site reviews.

6.2.5 Detailed Analysis of Alternative 5 – Partial Removal, Treatment, and Disposal with Engineered Surface Barrier

This alternative includes the removal of contaminants extending to depths shown in Table 5-2. The excavation would be filled with borrow material obtained on the Hanford Site. When the backfilling operation is finished, a barrier will be placed over the site. These activities remove a significant fraction of the near-surface contaminant load and still provide protection to the groundwater from deeper contaminants. The removal, treatment, disposal, and engineered barrier activities would be the same as those described earlier, except not as deep as for Alternative 3. This alternative is not applicable to sites where contamination is shallow with no deep component or where contamination is very deep with no shallow component. Consequently, this alternative is eliminated from consideration for many of the waste sites.

6.2.5.1 Overall Protection of Human Health and the Environment

This alternative would break potential exposure pathways to receptors through placement of a barrier to limit infiltration. The engineered barrier would provide additional distance between potential human and ecological receptors. The partial removal activity would remove the high contamination zone at the bottom of the waste site, leaving only the lower concentration, deeper contaminants that mainly pose a risk to groundwater. Partial removal of the more shallow contamination would reduce human health and ecological risk for those sites where contamination is in the 0 to 4.6 m (0 to 15-ft) bgs zone and intruder risk associated with the high concentrations at the bottom of the waste site (see Appendix D). While, in the long term, this alternative is protective of human health and the environment, the radiological risk to workers during the excavation essentially is the same as for Alternative 3, because the material being removed under Alternative 5 is the same material that causes most of the dose for the full-excavation alternative.

Institutional controls, including maintenance of the engineered barrier, land-use restrictions, and monitoring, would be instituted at sites where Alternative 5 is applied until the RAOs are achieved through natural attenuation. The engineered barrier would be designed to maximally limit infiltration. Institutional controls would provide additional protection for groundwater monitoring by providing a means to identify potential impacts to groundwater.

207-A South Retention Basin and Analogous Site – The 207-A South Retention Basin contains no COCs that present a risk to human health or intruders and does not contain contamination in deeper zones that are a threat to groundwater. Therefore, the 207-A South Retention Basin is not a candidate for this alternative. The analogous site (200-W-22) to the 207-A South Retention Basin is not a candidate for this alternative due to the expected depth of contamination being in the shallow zone only.

216-A-10 Crib and Analogous Waste Sites – The 216-A-10 Crib and all of its analogous sites, with the exception of the 200-E-58 Neutralization Tank, are candidates for this alternative. Although no human health direct-contact PRGs are exceeded in the shallow zone (0 to 4.6 m [0 to 15 ft]), intrusion into deeper contamination could exceed guidelines. Also, groundwater protection PRGs are exceeded in the deeper zone. Thus, Alternative 5 is protective of human health and the environment. Because of the high level of Cs-137 contamination at the 216-A-10 site, worker risk is elevated during the excavation portion of the remedy for this site and perhaps the analogous sites. Alternative 5 is not applicable to the 200-E-58 Neutralization Tank, because there are no known leaks from the tank.

216-A-19 Trench Representing Ecological Risk and Analogous Waste Sites – The 216-A-19 Trench possesses relatively shallow contamination combined with deeper contamination representing a groundwater threat. The 216-A-19 Trench showed acceptable risk from the intruder scenario. Although analogous waste sites in this group are not expected to contain contamination that presents a risk to intruders and not to contain contamination in deeper zones that is a threat to groundwater, Alternative 5 would provide overall protection of human health and the environment. At analogous site 216-A-20 Trench, the crib would be excavated to the depth of 6.1 m (20 ft), according to Table 5-2, but in addition for this site only, the area associated with the 216-A-20 Trench overflow would be excavated to 1 m (3 ft) but not covered with a barrier. Alternative 5 costs for this crib reflect these combined activities. This alternative is applicable for the 216-A-34 Ditch, because the potential for deeper contamination exists. Alternative 5 is not applicable for the UPR-200-E-145 waste site, because shallow excavation would completely eliminate the need for a cap.

216-A-36B Crib and Analogous Waste Sites – The 216-A-36B Crib and its analogous site 216-A-36A Crib are candidates for this alternative. Excavation to approximately 9.1 m (30 ft) would eliminate human health and intruder risk. Subsequent capping would provide groundwater protection. Thus, Alternative 5 would provide overall protection of human health and the environment. Because of the high levels of Cs-137, plutonium, and Am-241 contamination in these sites, worker risk is elevated during the excavation portion of the remedy.

The analogous site UPR-200-E-39 is not anticipated to have deep zone contamination and is not a candidate for this alternative. This site consists of a one-time accidental surface release and is therefore not anticipated to contain deep zone contamination.

216-A-37-1 Crib – The 216-A-37-1 Crib contains contaminants to a depth of 7.6 m (25 ft) that present a threat to groundwater. Removal of contaminants to the 4.9 m (16 ft) level and placement of an engineered barrier would be protective of human health and the environment and groundwater. Alternative 5 would provide overall protection of human health and the environment.

216-B-12 Crib and Analogous Waste Sites – Risk analysis for the 216-B-12 Crib showed that while no human health direct-contact PRGs are exceeded in the shallow zone (0 to 4.6 m [0 to 15 ft]), contaminants exist to 19.2 m (63 ft) that present excessive intruder risk. Also, groundwater protection PRGs are exceeded in the deeper zone. For the analogous site 216-C-7 Crib, no COCs that present a risk to intruders are expected. In addition, it is expected not to contain contamination in deeper zones that are a threat to groundwater. Because of the high level of Cs-137 contamination at the 216-B-12 site, worker risk is elevated during the excavation portion of the remedy for this site and perhaps the analogous sites. Alternative 5 would provide overall protection of human health and the environment for this site and the analogous sites by removing human health, ecological, and potential intruder risks by excavating near-surface contamination and by providing groundwater protection with a cap. This alternative is not applicable for the 209-E-WS-3 Valve Pit and Hold-Up Tank, the 270-E-1 Neutralization Tank, and the UPR-200-E-64 waste site, because removal of near-surface contamination would eliminate the need for potential groundwater protection.

216-S-7 Crib and Analogous Waste Sites – Risk analysis for the 216-S-7 Crib showed that while no human health direct-contact PRGs are exceeded in the shallow zone (0 to 4.6 m [0 to 15 ft]), contaminants exist to 9.1 m (30 ft) that present excessive intruder risk. Also, groundwater protection PRGs are exceeded in the deeper zone. Thus, Alternative 5 would be protective of human health and the environment. Similarly, by adjustment of excavation depth, this alternative would be protective of human health and the environment for the analogous waste sites. Because of the high level of Cs-137 contamination at the 216-S-7 site, worker risk is elevated during the excavation portion of the remedy for this site and perhaps the analogous sites.

6.2.5.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 5 would comply with ARARs for the waste sites by breaking the pathways for exposure and emplacing engineered barriers that meet the intent of the groundwater protection regulations. In addition to the engineered barrier, institutional controls such as additional land-use restrictions and groundwater monitoring, are elements of this alternative.

6.2.5.3 Long-Term Effectiveness and Permanence

Human Health

With regard to human health, Alternative 5 would be effective and permanent in the long term, because excavation activities would remove contaminants to meet direct-exposure human health and intruder RAOs, and placement of an engineered barrier would limit infiltration of water to the vadose zone. EPA and Ecology cleanup authorities prescribe remedies that use permanent solutions to the maximum extent practicable and where cost effective. Removal of contaminants would be a permanent solution. This action would remove any potential human, including intruder, and ecological direct-contact exposure.

Under this alternative, the most highly contaminated soils would be removed and disposed of at either an approved location or facility for low-level waste, or the WIPP. The removal of buried materials from the Central Plateau, for disposal on the Hanford Site, transfers the long-term impact of buried waste from individual waste sites to one consolidated disposal facility. The on-site waste disposal facility is designed for long-term management of buried waste.

Protection of Groundwater

Alternative 5 would protect groundwater through placement of an engineered barrier that would limit infiltration. In addition to the engineered barrier, institutional controls such as additional land-use restrictions and groundwater monitoring are protective elements of this alternative.

The Environment

All contaminated soil in the near-surface region capable of being intercepted by biota is removed in this alternative. Therefore, this alternative provides long-term protection to the environment following implementation.

6.2.5.4 Reduction of Toxicity, Mobility, or Volume through Treatment

The partial removal, treatment, and disposal with engineered barrier alternative would address the mobility of contaminants by removing a portion of the contaminants and limiting infiltration to the vadose zone, thereby limiting the mass and driving force to move contaminants to the groundwater. Natural attenuation is an important treatment component of this alternative that results in the reduction of toxicity, mobility, and volume of the radionuclides.

6.2.5.5 Short-Term Effectiveness

6.2.5.5.1 Remediation Worker Risk

Experienced workers using appropriate safety precautions would conduct these activities. Risks to workers for this alternative were compared to the baseline no-action alternative. Short-term effects of this alternative would be associated primarily with worker safety during waste excavation (soil and structures), transportation, and disposal. Risk to unprotected workers would be unacceptable, because of the concentrations and nature of the contaminants at the waste sites. The major contaminants in most of the waste sites are short-lived radionuclides (Cs-137 and Sr-90) that emit relatively high radiation. Excavation workers, truck drivers, and waste management workers may be exposed to dose rates that require special protections. These protections may include shielding, high-efficiency particulate air filtration for breathing air, and equipment modification to provide additional shielding from the source. These precautions significantly increase costs; however, excavation with dust suppression and health and safety controls has been proven to handle potential problems with excavating large soil sites.

6.2.5.5.2 Impact to Environment During Remediation

Most of the short-term impacts to the environment from this alternative will be from the excavation phase of the work. Physical disruption of the waste sites during excavation, increased human activity and noise, in addition to the generation of fugitive dust, affect local biological resources. However, the waste sites are located within historically disturbed industrial areas.

Areas of capping and disturbed surface are documented in Appendix F and reported below. Additional disturbed area was estimated to average 20 percent of the site area.

207-A South Retention Basin and Analogous Waste Site – As described earlier, neither the representative site nor its analogous site are candidates for this alternative.

216-A-10 Crib and Analogous Waste Sites – As described earlier, the 216-A-10 Crib and all analogous sites, except the 200-E-58 Neutralization Tank, are candidates for this alternative (Table 6-4) and were analyzed to determine impacts to the environment. The surface area disturbed during excavation and placement of a barrier at these sites will be 1.3 ha (3.2 a).

216-A-19 Trench and Analogous Waste Sites – As described earlier, the representative and analogous waste sites within this group (except for UPR-200-E-145) are candidates for this alternative (Table 6-4) and are analyzed to determine impacts to the environment. The surface area disturbed during excavation and placement of a barrier at the representative site and its analogous waste sites (except for UPR-200-E-145) will be 2.2 ha (5.4 a).

216-A-36B Crib and Analogous Waste Sites – As described earlier, only the 216-A-36B and 216-A-36A Cribs are candidates for Alternative 5. The surface area disturbed during excavation and placement of a barrier at these waste sites will be 1.7 ha (4.2 a).

216-A-37-1 Crib – As described earlier, this waste site is a candidate for this alternative and as such, was analyzed to determine impacts to the environment. The surface area disturbed during excavation and placement of a barrier at this waste site will be 0.69 ha (1.7 a).

216-B-12 Crib and Analogous Waste Sites – As described earlier, the 216-B-12 Crib and all analogous waste sites, except the 209-E-WS-3 Valve Pit and Hold-Up Tank, the 270-E-1 Neutralization Tank, and UPR-200-E-64, were analyzed to determine impacts to the environment. The surface area disturbed during excavation and placement of a barrier at these waste sites will be 1.8 ha (4.3 a).

216-S-7 Crib and Analogous Waste Sites – As described earlier, the 216-S-7 Crib and all analogous waste sites were analyzed to determine impacts to the environment. The surface area disturbed during excavation and placement of a barrier at these waste sites will be 1.5 ha (4.3 a).

Transportation activities on the Central Plateau would increase as a result of bringing construction equipment to the site, transporting contaminated soils to the onsite waste disposal facility and WIPP (if necessary), and bringing clean fill to the excavated sites. Minimal uncertainties are associated with the transport of waste to the onsite waste disposal facility. Excavated soils with transuranic constituents above 100 nCi/g would be analyzed; treated, if necessary; and transported to the WIPP. The only waste currently identified in this FS as potentially requiring disposal to the WIPP (e.g., greater than 100 nCi/g) is 532 m^3 (696 yd^3) of soil beneath the 216-A-36B and 216-A-36A Cribs. Because these sites are candidates for Alternative 5, the handling, transportation, and disposal of transuranic soils is an issue for Alternative 5. Air monitoring around the waste sites would be used to monitor potential air releases (e.g., waste or fill-material particulates) that could affect the public and the environment.

Alternative 5 may pose a significant short-term impact to the environment by disturbing areas of recovering habitat where grasses are becoming more prevalent. While the deeper-rooted plants are currently controlled, the grasses do provide more habitat than unvegetated areas. Additionally, the disruptive nature of the removal process can have impacts on neighboring habitats and visiting wildlife, such as birds.

6.2.5.5.3 Time to Meet the Remedial Action Objectives

Once contaminants at the waste sites are removed and the engineered barrier is installed, four of the five RAOs are met. The only RAO potentially not met is minimizing the general disruption of wildlife habitat. However, these waste sites are located in an industrial setting, providing little habitat for vegetation and wildlife.

207-A South Retention Basin and Analogous Waste Site – As described earlier, neither the representative site nor its analogous site are candidates for Alternative 5.

216-A-10 Crib and Analogous Waste Sites – Construction of the partial removal, treatment, disposal, and engineered barrier alternative for the 216-A-10 Crib and its analogous sites, except for the 200-E-58 Neutralization Tank, would take approximately 562 days, based on the conservative assumptions used in Appendix F, and assuming sites were to be remediated consecutively.

216-A-19 Trench and Analogous Waste Sites – Construction of the partial removal, treatment, disposal, and engineered barrier alternative for the representative waste site would take approximately 37 days, based on the conservative assumptions used in Appendix F. If all candidate sites were to be remediated consecutively (one after the other) rather than concurrently with the representative site, the time to remediate the candidate sites in this waste group would be an additional 405 days, for a total of 442 days.

216-A-36B Crib and Analogous Waste Sites – Construction of the partial removal, treatment, disposal, and engineered barrier alternative for the two waste sites within this group that are candidates for this alternative (Table 6-4) would take approximately 209 days. Because there are only two sites in this group considered for this alternative, as well as their proximity to each other, it is assumed that remediation will take place concurrently.

216-A-37-1 Crib – Construction of the partial removal, treatment, disposal, and engineered barrier alternative for this waste site would take approximately 79 days, based on the conservative assumptions used in Appendix F.

216-B-12 Crib and Analogous Waste Sites – Construction of the partial removal, treatment, disposal, and engineered barrier alternative for analogous waste sites within this group that are candidates for this alternative (Table 6-4) would take approximately 483 days, based on the conservative assumptions used in Appendix F, and assuming sites were to be remediated consecutively.

216-S-7 Crib and Analogous Waste Sites – Construction of the partial removal, treatment, disposal, and engineered barrier alternative for waste sites within this group that are candidates for this alternative (Table 6-4) would take approximately 321 days, based on the conservative assumptions used in Appendix F.

6.2.5.6 Implementability

The implementability of this alternative is similar to that for Alternatives 3 and 4. The excavation of contaminated soils is technically implementable, although the use of more sophisticated excavation equipment and techniques would be required for the high-dose areas. Construction of the engineered barriers would follow standard procedures that have been thoroughly field-tested. Every 0.3 m (1 ft) of excavation would require 0.5 m (1.5 ft) of side slope for a 1:1.5 vertical to horizontal ratio. This safety measure significantly increases the amount of material excavated, but is considered implementable. All excavated material would be disposed of at the onsite waste disposal facility or, if needed, at the WIPP. The current remaining capacity of the onsite waste disposal facility is approximately 5.9 million m^3

(7.7 million yd^3) as of February 2004 compared to the total disposal volume of 489,904 m^3 (641,236 yd^3).

The engineered barriers likely would require repair during the restoration time frame. Monitoring the continued integrity of the engineered barriers would be accomplished through visual inspection and would be supplemented with groundwater sampling. Designing the barrier associated with this alternative would require additional design data (e.g., ground-penetrating radar) and confirmatory sampling, because existing data are not adequate for determining the lateral extent of deep contamination.

Gravel, sand, and silt/loam soil used for the engineered barriers would be transported from borrow areas located on or near the Hanford Site. Anticipated volumes of these materials are identified in Appendix F. Area C currently is planned as a silt borrow location; the area has a large volume of fine-grained material. Other locations have not yet been determined. Soil most likely would come from near the waste sites or from Pit 30, which is located between the 200 East and 200 West Areas. Analyses of an appropriate borrow area for silt/loam soil would be the subject of a future NEPA evaluation to determine a location with the least impacts to natural and cultural resources. Borrow material may occur in environmentally sensitive areas and obtaining sufficient engineered barrier material may affect areas of ecological significance and is a consideration in evaluating the relative risk reduction gained by installing the engineered barrier.

Limited coordination with other agencies and local governments would be necessary after approval of the alternative. Excavation and disposal would require coordination with state agencies to assess matters relative to storm water control and the potential for radioactive air emissions.

Implementation of Alternative 5 is not feasible for the 216-B-60 Crib until the overlying 225-B Building (WESF) is removed.

207-A South Retention Basin and Analogous Waste Site – As described earlier, neither the representative site nor its analogous site are candidates for Alternative 5.

216-A-10 Crib and Analogous Sites – Excavation of the 216-A-10 representative site and analogous sites, except the 200-E-58 Neutralization Tank, to remove near-surface contamination, would remove 99,843 m^3 (130,685 yd^3) of contaminated soil (see Appendix F).

216-A-19 Trench and Analogous Sites – The sites in this group considered candidates for this alternative would remove 41,204 m^3 (53,932 yd^3) of soil (see Appendix F).

216-A-36B Crib and Analogous Sites – The two sites in this group considered candidates for this alternative would be excavated to a depth of 9.1 m (30 ft) to remove soil contaminated with TRU constituents. A total of 49,839 m^3 (65,234 yd^3) of soil will be removed from the sites in this group for this alternative (see Appendix F).

216-A-37-1 Crib – The 216-A-37-1 Crib is considered a candidate for this alternative and would be excavated to a depth of 4.6 m (19 ft). A total of 6,965 m^3 (9,117 yd^3) of soil will be removed from this site for this alternative (see Appendix F).

216-B-12 Crib and Analogous Sites – The sites in this group considered candidates Alternative 5 would remove 65,506 m^3 (89,668 yd^3) of soil (see Appendix F).

216-S-7 Crib and Analogous Sites – The sites in this group considered candidates for this alternative would remove 26,428 m^3 (34,591 yd^3) of soil (see Appendix F).

6.2.5.7 Cost

Costs, shown in Table 6-4, include stabilization of the existing site; excavation or import, transportation, and placement of material; compaction of the engineered barrier; prime contractor oversight; and confirmatory sampling. Costs are based on the use of standard equipment (e.g., hydraulic excavators, front-end loaders, dozers) and assume that a subcontractor would do the work, with oversight performed by the prime contractor. The subcontractor personnel are assumed to be wearing Level D personal protective equipment (e.g., blues and no respirators) during construction. The present-worth costs assume a 3.1 percent discount rate (based on 2004 Office of Management and Budget information) and assumes operation and maintenance for 150 years. The operation and maintenance costs include site inspection/surveillance, periodic radiation site surveys of surface soil, and biotic control; maintenance of signs and markers; cover maintenance; and site reviews.

6.3 NEPA VALUES EVALUATION

The NEPA process is intended to help Federal agencies make decisions that are based on understanding environmental consequences, then to take actions that protect, restore, and enhance the environment. Secretarial policies (DOE 1994) and DOE O 451.1A require that CERCLA documents incorporate NEPA values, such as analysis of cumulative, offsite, ecological, and socioeconomic impacts to the extent practicable, in lieu of preparing separate NEPA documentation for CERCLA activities.

6.3.1 Description of NEPA Values

Several of the CERCLA evaluation criteria involve consideration of environmental resources, but the emphasis frequently is directed at the potential effects of chemical contaminants on living organisms. The NEPA regulations (40 CFR 1502.16, "Environmental Impact Statement," "Environmental Consequences") specify evaluation of the environmental consequences of proposed alternatives. These consequences include potential effects on transportation resources, air quality, and cultural and historical resources; noise, visual, and aesthetic effects; environmental justice; and the socioeconomic aspects of implementation. The NEPA process also involves consideration of several issues such as cumulative impacts (direct and indirect), mitigation of adversely impacted resources, and the irreversible and irretrievable commitment of resources.

The NEPA-related resources and values that the DOE has considered in this evaluation include the following.

- Transportation impacts. This value considers impacts of the proposed remedial action on local traffic (e.g., traffic at the Hanford Site) and traffic in the surrounding region. Transportation impacts are considered in part under the CERCLA criteria of short-term effectiveness or implementability.

- Air quality. This value considers potential air quality concerns associated with emissions generated during the proposed remedial actions.

- Natural, cultural, and historical resources. This value considers impacts of the proposed remedial actions on wildlife, wildlife habitat, archeological sites and artifacts, and historically significant properties on the Central Plateau.

- Noise, visual, and aesthetic effects. This value considers increases in noise levels or impaired visual or aesthetic values during or after the proposed remedial actions.

- Socioeconomic impacts. This value considers impacts pertaining to employment, income, other services (e.g., water and power utilities), and the effect of implementation of the proposed remedial actions on the availability of services and materials.

- Environmental justice. Environmental justice, as mandated by Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, refers to fair treatment of humans of all races, cultures, and income levels with respect to laws, policies, and government actions. This value considers whether the proposed remedial actions would have inappropriately or disproportionately high and adverse human health or environmental effects on minority or low-income populations.

- Cumulative impacts (direct and indirect). This value considers whether the proposed remedial actions could have cumulative impacts on human health or the environment when considered together with other activities on the Central Plateau, at the Hanford Site, or in the region.

- Mitigation. If adverse impacts cannot be avoided, remedial action planning should minimize them to the extent practicable. This value identifies required mitigation activities.

- Irreversible and irretrievable commitment of resources. This value evaluates the use of nonrenewable resources for the proposed remedial actions and the effects that resource consumption would have on future generations. When a resource (e.g., energy, minerals, water, wetland) is used or destroyed and cannot be replaced within a reasonable amount of time, its use is considered irreversible.

6.3.2 Detailed Evaluation of NEPA

6.3.2.1 Transportation Impacts

Implementation of remedial action at the waste sites likely would have some short-term impacts on local traffic and traffic in the surrounding region. For Alternatives 4 and 5, impacts would result from hauling barrier material to the waste site areas. For Alternatives 3 and 5, transportation impacts would result from hauling waste to the approved waste disposal location or facility and hauling clean fill to the waste sites. For Alternatives 3, 4, and 5, impacts could be expected from increased traffic bringing supplies, equipment, and workers to the sites. To mitigate these potential impacts, a transportation safety analysis would be performed before any transport activities began. The analysis would identify the need for specific precautions (e.g., road closures, preferred hauling times, staggered work shifts) to be taken as necessary. Increases in the workforce traffic related to waste treatment would be expected to be minor. The impacts of transportation of TRU waste[1] to the WIPP and disposal of TRU waste at the WIPP were analyzed in DOE/EIS-0026-S-2, *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement.*

For Alternatives 3 and 5, there may be a need to ship approximately 2,558, 55-gal drums of TRU-contaminated soil to the WIPP, which would occur if excavated soil beneath the 216-A-36B and 216-A-36A Cribs is determined to have concentrations of TRU constituents greater than 100 nCi/g.

6.3.2.2 Air Quality

No current air quality impacts are associated with Alternative 1; however, potential impacts to air quality could be associated with plant or animal uptake of contaminants and wind dispersion. This also is true for Alternative 2. Potential near-term impacts to air quality associated with Alternatives 3, 4, and 5 are expected to be minor and could be mitigated through appropriate engineering controls.

Potential air quality impacts primarily would be associated with fugitive dust during site preparation, structure demolition, excavation, placement of backfill or barriers, and revegetation activities. Dust suppression (using water and water treated with soil fixatives) would be used to control visible fugitive dust, so neither local nor regional air quality is expected to be affected. Routine emissions from vehicles would occur.

6.3.2.3 Natural, Cultural, and Historical Resources

In all cases, remediation will be performed on sites that have been disturbed by industrial activities. Therefore, although cultural resources may be encountered with Alternatives 3, 4, and 5 during the excavation and construction of staging areas, the probability is low. A cultural resource mitigation plan would be established before remediation was begun. To ensure that

[1] Waste materials contaminated with more than 100 nCi/g of transuranic materials having half-lives longer than 20 years

impacts to cultural resources are avoided and/or mitigated, a cultural resource mitigation plan will be established before remediation begins. If cultural resources are encountered during excavation, work will be stopped in the area, and unanticipated- and inadvertent-discovery procedures will be followed pursuant to DOE/RL-98-10, *Hanford Cultural Resources Management Plan*. If cultural resources were encountered during excavation, the State Historic Preservation Office and Native American Tribes would be consulted about minimizing impacts and taking appropriate actions for resource documentation or recovery.

Some short-term adverse impacts to natural resources (e.g., local wildlife) may occur during the construction and implementation phases of remedial action. Ecological surveys would be performed to identify the species present and the special precautions that should be taken to minimize adverse impacts.

6.3.2.4 Noise, Visual, and Aesthetic Effects

Alternatives 1 and 2 would have little to no impact on current noise, visual, or aesthetic site characteristics. Alternatives 3 and 5 would increase noise levels and impair visual values, but the impacts would be short-term during remedial actions and ultimately would improve the aesthetics by removing any remaining site structures. Likewise, Alternative 4 would increase noise levels and impair visual values in the short term during construction of the engineered barrier. These alternatives also could have some long-term visual and aesthetic impacts, both positive and negative. Positive impacts would result from the removal of aboveground site structures. Negative impacts would be associated with the visibility and aesthetics of the engineered barriers over large distances if they are not contoured to blend in with the surrounding area. Aesthetically, given the past disturbance in the 200 Areas and on the Central Plateau, no impacts would be expected from the alternatives.

6.3.2.5 Socioeconomic Impacts

Alternative 1 would have no socioeconomic impacts. The other four alternatives would have some positive socioeconomic impacts related to the employment opportunities that would occur during the life of the remedial action project. The labor force required to implement remedial action would be drawn from current Hanford Site contractors and the local labor force, so the socioeconomic impacts would be expected to be minimal.

6.3.2.6 Environmental Justice

Under Alternative 3, environmental justice issues would not be a concern because future surface uses on the Central Plateau would not be restricted beyond the Central Plateau-wide restrictions. Under Alternatives 1, 2, 4, and 5, environmental justice impacts would be minimal because future-use restrictions would pertain to only a small percentage of the Central Plateau, and the Central Plateau still would be under active waste management industrial land use.

6.3.2.7 Irreversible and Irretrievable Commitment of Resources

Alternatives 3, 4, and 5 would require some irreversible or irretrievable commitment of natural resources. All of the alternatives, with the exception of Alternative 1, would result in some land-use loss, at least for the near future. Alternatives 3, 4, and 5 would require additional soil, including materials that may come from ecologically sensitive areas, and some energy resources. They would require a commitment of resources in the form of land-use loss in the waste site areas until remedial action objectives and goals were met. The amount of land-use loss would vary among alternatives. Alternative 2 generally would require land-use loss of the entire site surface and subsurface for the necessary attenuation period to meet remedial action objectives. Alternative 3 generally would allow land use from the ground surface to the depth of soil removed following the completion and regulatory acceptance of remedial activities. Alternatives 4 and 5 would allow surface use of the sites, but would not allow any subsurface site use until potential groundwater impact no longer exists. This use would be limited based on potential impacts to surface-barrier integrity.

For Alternatives 3 and 5, the low-level waste disposal facility may need to be expanded, depending on demand from other remediation activities, to accommodate the additional waste. Implementation of these alternatives also may require waste disposal to the WIPP. The waste volumes from the aboveground structure demolition in Alternatives 3, 4, and 5 are relatively small and are not anticipated to specifically require additional waste disposal facility capacity.

Alternatives 3, 4, and 5 would require an irretrievable and irreversible commitment of resources in the form of geologic materials and petroleum products (e.g., diesel fuel, gasoline). With Alternatives 3 and 5, excavated material would be replaced with a stockpile of clean soil cover removed from the site (such as from Pit 30), as well as clean sand and gravel fill from onsite borrow pits. The sand and gravel for the surface-barrier alternative would come from nearby borrow pits, but the silt would need to come either from the Area C Borrow Pit (the Fitzner-Eberhardt Arid Lands Ecology Reserve) or from off site. Sand, drainage gravel, gravel filter, crushed base course, fractured basalt, and asphalt pavement would be supplied by offsite vendors or from commercial gravel pits.

6.3.2.8 Cumulative Impacts

The proposed RAOs could have impacts when considered together with impacts from past and foreseeable future actions at and near the Hanford Site. Authorized current and future activities include soil and groundwater remediation; waste management and treatment (e.g., tank farms, the Waste Treatment Plant); and surveillance, maintenance, decontamination, and decommissioning of facilities. Other Hanford Site activities that might be ongoing during remedial action at the Central Plateau waste sites include deactivation and decontamination of reprocessing facilities and operation of the Energy Northwest reactor. Activities near the Hanford Site include a privately owned radioactive and mixed-waste treatment facility, a commercial fuel manufacturer, a commercial low-level radioactive waste disposal site, and a titanium reprocessing plant.

The proposed remediation alternatives would have minimal impacts on transportation; air quality; and natural, cultural, and historical resources. Noise, visual and aesthetic effects, and socioeconomic impacts also would be minimal. Therefore, cumulative impacts with respect to these values are expected to be insignificant. The most notable area for cumulative impacts is with respect to the irretrievable and irreversible commitment of resources. All of the proposed alternatives except Alternative 1 would require long-term land-use restrictions.

To varying levels, Alternatives 2, 3, 4, and 5 would result in the loss of some land use on the Central Plateau, but the cumulative impacts with respect to loss of land use are not expected to be significant. Alternatives 3 and 5 also may require a commitment of land use as a result of the waste-disposal facility expansion on the Central Plateau. This would be in addition to numerous other Hanford Site projects that would commit land use on the Central Plateau.

Under Alternatives 3, 4, and 5, cumulative impacts also would occur with respect to the irretrievable and irreversible commitment of geologic resources. The Central Plateau waste sites constitute only a portion of the total actions requiring material for barriers and backfill at the Hanford Site. The total quantity of geologic materials required for other Hanford Site actions currently is being identified (BHI-01551, *Alternative Fine-Grained Soil Borrow Source Study Final Report*) and may be subject to a separate NEPA evaluation.

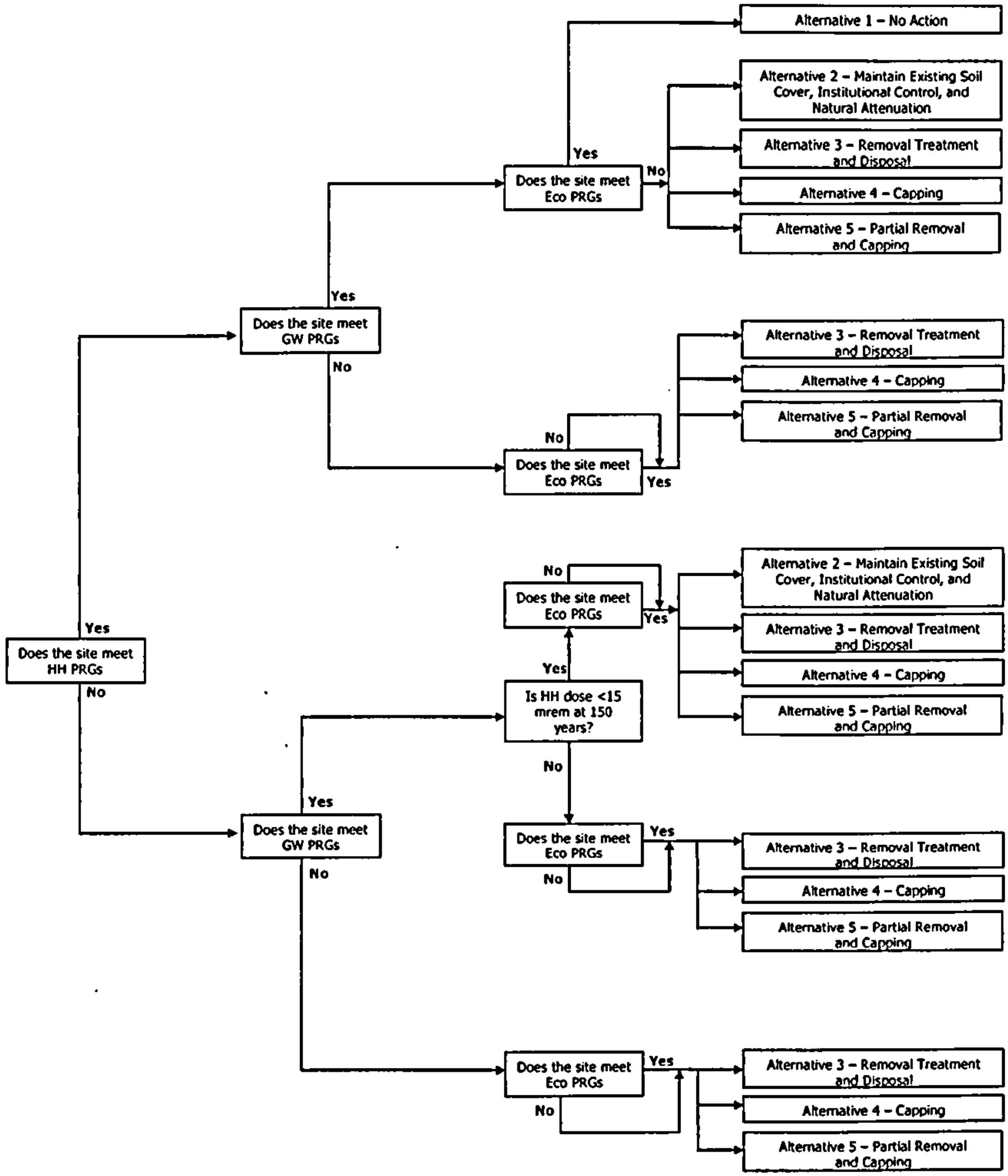
6.3.2.9 Mitigation

Alternative 1 would not include mitigation. Mitigation measures under Alternative 2 would include surveillance, physical controls, and potential interim remedies. Mitigation measures taken under Alternatives 3, 4, and 5 would include dust suppression, stockpiling clean topsoil for reuse, minimizing the size of construction areas, and planning activities to avoid nesting and breeding cycles of birds and mammals.

6.3.2.10 Summary of NEPA Evaluation

Remedial actions at the Central Plateau waste sites would result in some impacts to public health and the environment. However, the overall environmental impacts under normal operating conditions would not be very large, nor would they vary greatly among the remedial alternatives.

Figure 6-1. Logic Diagram for Selecting Applicable Alternatives.



Notes:
If human health PRGs are not met, then the ecological PRGs have little influence on the alternatives.
If human health PRGs are met, then the ecological PRGs have a significant influence on the alternatives.

ECO = Ecological GW= Groundwater HH = Human Health mrem = Millrem PRG = Preliminary Remediation Goals < = Less Than

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. (8 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Present-Worth Cost in Thousands
Representative Site							
207-A South Retention Basin	Protective. Samples collected from inside and below the basin did not exceed RAOs. In addition, no documented history of leaks from the basin exists.	Complies.	Effective, because no residual risk would exist.	N/A, because no residual radionuclide contamination exists.	No short-term risk to human receptors. The short-term impacts to the environment are expected to be low.	Readily implementable.	$868
Waste Site Analogous to 207-A South Retention Basin							
200-W-22 Site Group	Expected to be protective, based on the low anticipated inventory.	Based on 207-A South Retention Basin data, anticipated to comply.	Groundwater expected to be protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$1,057
Representative Site							
216-A-10 Crib	Not protective, because contaminants exceed RAOs after 150 years.	Not expected to comply, because groundwater standards are exceeded.	Groundwater is not protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$866
Waste Sites Analogous to 216-A-10 Crib							
216-A-5 Crib	Not protective, because contaminants likely to exceed RAOs after 150 years.	Not expected to comply, because groundwater standards are exceeded.	Groundwater not likely to be protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$866

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. (8 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Present-Worth Cost in Thousands
216-A-45 Crib	Not protective, because contaminants likely to exceed RAOs after 150 years.	Not expected to comply, because groundwater standards are exceeded.	Groundwater not likely to be protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$866
216-C-1 Crib	Not protective, because contaminants likely to exceed RAOs after 150 years.	Not expected to comply, because groundwater standards are exceeded.	Groundwater not likely to be protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$877
200-E-58 Neutralization Tank	Based on no history of leaks from the tank, this alternative is anticipated to be protective.	Based on no history of leaks from this tank and confirmation of minimal residual waste within the tank, this alternative is anticipated to comply.	Though there is no history of leaks, tank contents may remain.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$866
Representative Site							
216-A-19 Trench	Not protective, because contaminants exceed RAOs after 150 years.	Does not comply, because groundwater standards are exceeded.	Groundwater is not protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$868

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. (8 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Present-Worth Cost in Thousands
Waste Sites Analogous to 216-A-19 Trench							
216-A-1 Crib	Not protective, because contaminants expected to exceed RAOs after 150 years.	May not comply with groundwater protection requirements	Groundwater may not be protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$868
216-A-3 Crib	Not protective, because contaminants expected to exceed RAOs after 150 years.	May not comply with groundwater protection requirements.	Groundwater may not be protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$868
216-A-18 Trench	Not protective, because contaminants expected to exceed RAOs after 150 years.	May not comply with groundwater protection requirements.	Groundwater may not be protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$868
216-A-20 Trench	Not protective, because contaminants expected to exceed RAOs after 150 years.	May not comply with groundwater protection requirements.	Groundwater may not be protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$868
216-A-22 French Drain and UPR-200-E-17	Not protective, because contaminants expected to exceed RAOs after 150 years.	Based on site data and comparison to 216-A-19, this alternative may comply.	Excessive near-surface uranium contamination may exist.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$866

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. (8 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Present-Worth Cost in Thousands**
216-A-28 Crib	Not protective, because contaminants expected to exceed RAOs after 150 years.	May not comply with groundwater protection requirements.	Groundwater may not be protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$866
216-A-34 Ditch	Based on no reportable contaminant inventory, this alternative may be protective.	Based on site data and comparison to 216-A-19, this alternative should comply.	Groundwater expected to be protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$868
216-S-8 Trench	Not protective, because contaminants expected to exceed RAOs after 150 years.	May not comply with groundwater protection requirements.	Groundwater may not be protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$870
UPR-200-E-145	Not protective, because contaminants expected to exceed RAOs after 150 years.	Based on site data and comparison to 216-A-19, this alternative may comply.	Groundwater expected to be protected. Excessive near-surface uranium contamination may exist.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$868
Representative Site							
216-A-36B Crib	Not protective, because contaminants exceed RAOs after 150 years.	Does not comply, because groundwater standards are exceeded.	Groundwater is not protected. Contaminant concentrations, including TRU constituents, will remain elevated past 150 years.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$866

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. (8 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Present-Worth Cost in Thousands
Waste Sites Analogous to 216-A-36B Crib							
216-A-36A Crib	Based on 216-A-36B Crib data, not anticipated to be protective.	Based on 216-A-36B Crib data, not anticipated to comply.	Based on 216-A-36B Crib data, not anticipated to be effective.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$866
UPR-200-E-39	Because site consists of a one-time contaminant release to asphalt, this alternative is anticipated to be protective.	Expected to comply.	Expected to be protective if implemented in conjunction with future CDI engineered barrier over the Plutonium-Uranium Extraction Plant canyon building.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$866 (150 year) $421 (20 year)
Representative Site							
216-A-37-1 Crib	Not protective, because contaminants exceed RAOs after 150 years.	Does not comply, because groundwater standards are exceeded.	Groundwater is not protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$866
Representative Site							
216-B-12 Crib	Not protective, because contaminants exceed RAOs after 150 years.	Does not comply.	Groundwater is not protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$868

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. (8 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Present-Worth Cost in Thousands
Waste Sites Analogous to 216-B-12 Crib							
216-B-60 Crib	Based on the low inventory, this alternative may be protective.	Based on site data and comparison to 216-B-12, this alternative may comply.	Groundwater expected to be protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable, once 225-B Building (WESF) is removed.	$868
216-C-3 Crib	Based on the low inventory, this alternative may be protective.	Based on site data and comparison to 216-B-12, this alternative may comply.	Groundwater expected to be protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$877
216-C-5 Crib	Based on the low inventory, this alternative may be protective.	Based on site data and comparison to 216-B-12, this alternative may comply.	Groundwater expected to be protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$877
216-C-7 Crib	Based on the low inventory, this alternative may be protective.	Based on site data and comparison to 216-B-12, this alternative may comply.	Groundwater expected to be protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$877
216-C-10 Crib	Based on the low inventory, this alternative may be protective.	Based on site data and comparison to 216-B-12, this alternative may comply.	Groundwater expected to be protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$877

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. (8 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Present-Worth Cost in Thousands
209-E-WS-3 Valve Pit and Hold-Up Tank	Not protective, because contaminants exceed RAOs after 150 years.	Not expected to comply, because of potential contact with residual waste in tank.	Although there is no history of leaks, tank contents may remain.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$877
270-E-1 Neutralization Tank	Not protective, because contaminants exceed RAOs after 150 years.	Not expected to comply, because of potential contact with residual waste within tank.	Although there is no history of leaks, tank contents may remain.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$868
UPR-200-E-64	Based on the low effluent volume, this alternative may be protective.	Based on site data and comparison to 216-B-12, this alternative may comply.	Groundwater expected to be protected. Possible spread of speck contamination due to ants and wind, because site is very shallow.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$868
Representative Site							
216-S-7 Crib	Not protective, because contaminants exceed RAOs after 150 years.	Does not comply, because groundwater standards are exceeded.	Groundwater is not protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$870
Waste Sites Analogous to 216-S-7 Crib							
216-S-1&2 Cribs and UPR-200-W-36	Not protective, because contaminants likely to exceed RAOs after 150 years.	Not expected to comply with groundwater standards.	Groundwater not expected to be protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$870

Table 6-1. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls. (8 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Present-Worth Cost in Thousands
216-S-4 French Drain	Based on the predicted inventory, this alternative may be protective.	Based on site data and comparison to 216-S-7, this alternative may comply.	Groundwater expected to be protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$877
216-S-22 Crib	Based on the predicted inventory, this alternative may be protective.	Based on site data and comparison to 216-S-7, this alternative may comply.	Groundwater expected to be protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$870
216-S-23 Crib	Based on the predicted inventory, this alternative may be protective.	Based on site data and comparison to 216-S-7, this alternative may comply.	Groundwater expected to be protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$872
216-T-20 Trench	Based on the effluent volume, this alternative may be protective.	Based on site data and comparison to 216-S-7, this alternative may comply.	Groundwater expected to be protected.	Reduction through natural attenuation of radionuclides.	Human receptors would be exposed to minimal short-term risks. The short-term impacts to the environment are expected to be low.	Readily implementable.	$868

ARAR = applicable or relevant and appropriate requirement.
CDI = canyon disposition initiative.
RAO = remedial action objective.

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (12 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Present-Worth Cost in Thousands
Representative Site							
207-A South Retention Basin	Protective. Excavation would remove basin. Sampling of the basin resulted in finding no contaminants of concern above RAO standards.	Complies.	Effective and permanent in the long term, because excavation removes basin.	N/A, because no contamination above criteria observed.	Low short-term industrial risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$724
Waste Site Analogous to 207-A South Retention Basin							
200-W-22 Site Group	Protective, because expect all contaminants and subgrade structures would be excavated to meet RAOs.	Expected to comply.	Effective, because expect all contaminants and subgrade structures would be excavated to meet RAOs. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Low short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$1,424 (UPR) $2,070 (subgrade structures)
Representative Site							
216-A-10 Crib	Protective, because contaminants would be excavated to meet RAOs.	Complies.	Effective and permanent in the long term, because excavation removes contaminants to meet RAOs. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$11,215

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (12 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Present-Worth Cost in Thousands
216-A-5 Crib	Protective, because expect all contaminants would be excavated to meet RAOs.	Expected to comply.	Effective, because expect contaminants would be excavated to meet RAOs. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$2,714
216-A-45 Crib	Protective, because expect all contaminants would be excavated to meet RAOs.	Expected to comply.	Effective, because expect contaminants would be excavated to meet RAOs. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderated short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$15,810
216-C-1 Crib	Protective, because expect all contaminants would be excavated to meet RAOs.	Expected to comply.	Effective, because expect contaminants would be excavated to meet RAOs. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$1,677
200-E-58 Neutralization Tank	Protective, because tank and its contents would be removed to meet RAOs.	Expected to comply.	Effective, because expect removal of tank would meet RAOs. Excavation is a proven technology, with little chance of failure.	Tank is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$812

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (12 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Present-Worth Cost in Thousands**
Representative Site							
216-A-19 Trench	Protective, because expect all contaminants would be excavated to meet RAOs.	Complies.	Effective and permanent in the long term, because excavation removes contaminants to meet protection of groundwater RAOs. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$3,368
Waste Sites Analogous to 216-A-19 Trench							
216-A-1 Crib	Protective, because expect all contaminants would be excavated to meet RAOs.	Expected to comply.	Effective. Excavation is a proven technology, with little chance of failure.	Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$2,265
216-A-3 Crib	Protective, because expect all contaminants would be excavated to meet RAOs.	Expected to comply.	Effective. Excavation is a proven technology, with little chance of failure.	Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$2,394

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (12 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Present-Worth Cost in Thousands
216-A-18 Trench	Protective, because expect all contaminants would be excavated to meet RAOs.	Expected to comply.	Effective. Excavation is a proven technology, with little chance of failure.	Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$7,336
216-A-20 Trench (includes overflow area)	Protective, because expect all contaminants would be excavated to meet RAOs.	Expected to comply.	Effective. Excavation is a proven technology, with little chance of failure.	Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$2,719
216-A-22 Crib and UPR-200-E-17	Protective, because expect all contaminants would be excavated to meet RAOs.	Expected to comply.	Effective. Excavation is a proven technology, with little chance of failure.	Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$1,722
216-A-28 Crib	Protective, because expect all contaminants would be excavated to meet RAOs.	Expected to comply.	Effective. Excavation is a proven technology, with little chance of failure.	Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$1,365

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (12 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Present-Worth Cost in Thousands**
216-A-34 Ditch	Protective, because expect all contaminants would be excavated to meet RAOs.	Expected to comply.	Effective. Excavation is a proven technology, with little chance of failure.	Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$12,565
216-S-8 Trench	Protective, because expect all contaminants would be excavated to meet RAOs.	Expected to comply.	Effective. Excavation is a proven technology, with little chance of failure.	Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$8,431
UPR-200-E-145	Protective, because expect all contaminants would be excavated to meet RAOs.	Expected to comply.	Effective, because expect all contaminants would be excavated to meet RAOs. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Low short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$671

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (12 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Present-Worth Cost in Thousands
Representative Site							
216-A-36B Crib	Protective, because expect all contaminants would be excavated to meet RAOs.	Complies.	Effective and permanent in the long term, because excavation removes contaminants to meet protection of groundwater RAOs. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term industrial and radiological risks (due to possible transuranic concentrations) to workers.	Implementability questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue. Also, at deep excavations, interference with surrounding structures/roads may become an issue.	$100,070 (w/TRU) $87,383 (w/o TRU)
Waste Sites Analogous to 216-A-36B Crib							
216-A-36A Crib	Protective, because expect all contaminants would be excavated to meet RAOs.	Expected to comply.	Effective, because expect all contaminants would be excavated to meet RAOs. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term industrial and radiological risks (due to possible transuranic concentrations) to workers.	Implementability questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue. Also, at deep excavations, interference with surrounding structures/roads may become an issue.	$66,032 (w/TRU) $61,876 (w/o TRU)

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (12 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Present-Worth Cost in Thousands
UPR-200-E-39	Protective, because expect all contaminants would be excavated to meet RAOs.	Expected to comply.	Effective, because expect all contaminants would be excavated to meet RAOs. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Low short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$667
Representative Site							
216-A-37-1 Crib	Protective, because expect all contaminants would be excavated to meet RAOs.	Complies.	Effective and permanent in the long term, because excavation removes contaminants to meet protection of groundwater RAOs.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$6,355
Representative Site							
216-B-12 Crib	Protective, because expect all contaminants would be excavated to meet RAOs.	Complies.	Effective and permanent in the long term, because excavation removes contaminants to meet protection of groundwater RAOs. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term industrial and radiological risks to workers.	Implementability questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue. Also, at deep excavations, interference with surrounding structures/roads may become an issue.	$41,231

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (12 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Present-Worth Cost in Thousands
Waste Sites Analogous to 216-B-12 Crib							
216-B-60 Crib	Protective, because expect all contaminants would be excavated to meet RAOs.	Expected to comply.	Effective. Excavation is a proven technology, with little chance of failure.	Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$5,433
216-C-3 Crib	Protective, because expect all contaminants would be excavated to meet RAOs.	Expected to comply.	Effective. Excavation is a proven technology, with little chance of failure.	Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$2,718
216-C-5 Crib	Protective, because expect all contaminants would be excavated to meet RAOs.	Expected to comply.	Effective. Excavation is a proven technology, with little chance of failure.	Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$2,622
216-C-7 Crib	Protective, because expect all contaminants would be excavated to meet RAOs.	Expected to comply.	Effective. Excavation is a proven technology, with little chance of failure.	Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$2,681

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (12 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Present-Worth Cost in Thousands
216-C-10 Crib	Protective, because expect all contaminants would be excavated to meet RAOs.	Expected to comply.	Effective. Excavation is a proven technology, with little chance of failure.	Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$2,470
209-E-WS-3 Valve Pit and Hold-Up Tank	Protective, because expect removal of tank and valve pit to meet RAOs.	Expected to comply.	Effective, because expect removal of tank and valve pit would meet RAOs. Excavation is a proven technology, with little chance of failure.	Tank and valve pit are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Low short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$684
270-E-1 Neutralization Tank	Protective, because expect removal of tank to meet RAOs.	Expected to comply.	Effective, because expect removal of tank would meet RAOs. Excavation is a proven technology, with little chance of failure.	Tank and valve pit are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Low short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$824
UPR-200-E-64	Protective, because expect all contaminants would be excavated to meet RAOs.	Expected to comply.	Effective, because expect all contaminants would be excavated to meet RAOs. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Low short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$1,528

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (12 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Present-Worth Cost in Thousands
Representative Site							
216-S-7 Crib	Protective, because expect all contaminants would be excavated to meet RAOs.	Complies.	Effective and permanent in the long term, because excavation removes contaminants to meet protection of groundwater RAOs. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementability questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue. Also, at deep excavations, interference with surrounding structures/roads may become an issue.	$45,747
Waste Sites Analogous to 216-S-7 Crib							
216-S-1&2 Cribs and UPR-200-W-36	Protective, because expect all contaminants would be excavated to meet RAOs.	Expected to comply.	Effective, because expect contaminants would be excavated to meet RAOs. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementability questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue. Also, at deep excavations, interference with surrounding structures/roads may become an issue.	$46,708

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (12 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Present-Worth Cost in Thousands**
216-S-4 French Drain	Protective, because expect all contaminants would be excavated to meet RAOs.	Expected to comply.	Effective. Excavation is a proven technology, with little chance of failure.	Reduction through natural attenuation of radionuclides.	Low short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$2,086
216-S-22 Crib	Protective, because expect all contaminants would be excavated to meet RAOs.	Expected to comply.	Effective. Excavation is a proven technology, with little chance of failure.	Reduction through natural attenuation of radionuclides.	Low short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$1,812
216-S-23 Crib	Protective, because expect all contaminants would be excavated to meet RAOs.	Expected to comply.	Effective, because expect contaminants would be excavated to meet RAOs. Excavation is a proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Low short-term industrial and radiological risks to workers.	Implementability questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue. Also, at deep excavations, interference with surrounding structures/roads likely to become an issue.	$5,564

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (12 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Present-Worth Cost in Thousands**
216-T-20 Trench	Protective, because expect all contaminants would be excavated to meet RAOs.	Expected to comply.	Effective. Excavation is a proven technology, with little chance of failure.	Reduction through natural attenuation of radionuclides.	Low short-term industrial and radiological risks to workers.	Implementability may be questionable, because available capacity at the waste disposal facility and demands for backfill material from Pit 30 may be an issue.	$976

ARAR = applicable or relevant and appropriate requirement.
ERDF = Environmental Restoration Disposal Facility.
RAO = remedial action objective.

Table 6-3. Detailed Analysis Summary for Alternative 4 – Engineered Surface Barrier. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
Representative Site							
207-A South Retention Basin	Protective. Site is protected as-is.	Complies.	Effective, because is already protected.	N/A, because contamination already is acceptable.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,571
Waste Site Analogous to 207-A South Retention Basin							
200-W-22 Site Group	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$3,3783,494
Representative Site							
216-A-10 Crib	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,613
Waste Sites Analogous to 216-A-10 Crib							
216-A-5 Crib	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,314
216-A-45 Crib	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,830

Table 6-3. Detailed Analysis Summary for Alternative 4 – Engineered Surface Barrier. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Cost in Thousands**
216-C-1 Crib	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,301
200-E-58 Neutralization Tank	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,294
Representative Site							
216-A-19 Trench	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,302
Waste Sites Analogous to 216-A-19 Trench							
216-A-1 Crib	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,309
216-A-3 Crib	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,292
216-A-18 Trench	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,420

Table 6-3. Detailed Analysis Summary for Alternative 4 – Engineered Surface Barrier. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
216-A-20 Trench (includes overflow area)	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,758
216-A-22 Crib and UPR-200-E-17	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,265
216-A-28 Crib	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,270
216-A-34 Ditch	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$2,201
216-S-8 Trench	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,419
UPR-200-E-145	Protective. Placement of a barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,297

Table 6-3. Detailed Analysis Summary for Alternative 4 – Engineered Surface Barrier. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
Representative Site							
216-A-36B Crib	Protective for 1,000-year integrity period associated with Hanford Barriers. This alternative would break potential exposure pathways to receptors through placement of a barrier to limit infiltration and intrusion. Integrity of the Hanford Barrier cannot be ensured past 1,000 years.	Complies.	Effective for 1,000 years. Hanford-type barrier is protective to 1,000 years. Transuranic concentrations would remain for greater than this time period.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$5,232
Waste Sites Analogous to 216-A-36B Crib							
216-A-36A Crib	Protective for 1,000-years integrity period associated with Hanford Barriers. This alternative would break potential exposure pathways to receptors through placement of a barrier to limit infiltration and intrusion. Integrity of the Hanford Barrier cannot be ensured past 1,000 years.	Complies.	Effective for 1,000 years. Transuranic concentrations would remain for greater than this time period.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$4,222

Table 6-3. Detailed Analysis Summary for Alternative 4 – Engineered Surface Barrier. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
UPR-200-E-39	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue. May be covered by the proposed Plutonium-Uranium Extraction Plant CDI barrier.	$1,508
Representative Site							
216-A-37-1 Crib	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$2,193
Representative Site							
216-B-12 Crib	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,470
Waste Sites Analogous to 216-B-12 Crib							
216-B-60 Crib	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,297
216-C-3 Crib	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,315

Table 6-3. Detailed Analysis Summary for Alternative 4 – Engineered Surface Barrier. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
216-C-5 Crib	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,289
216-C-7 Crib	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,303
216-C-10 Crib	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,292
209-E-WS-3 Valve Pit and Hold-Up Tank	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	N/A	N/A
270-E-1 Neutralization Tank	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,305
UPR-200-E-64	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$2,590
Representative Site							
216-S-7 Crib	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$4,571

Table 6-3. Detailed Analysis Summary for Alternative 4 – Engineered Surface Barrier. (7 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost in Thousands
Waste Sites Analogous to 216-S-7 Crib							
216-S-1&2 Cribs and UPR-200-W-36	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$4,550
216-S-4 French Drain	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,274
216-S-22 Crib	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,338
216-S-23 Crib	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,552
216-T-20 Trench	Protective. Barrier would limit infiltration and intrusion.	Complies.	Barrier is effective for its design life of ~500 years.	Reduction through natural attenuation of radionuclides.	Low short-term risks to workers.	Implementable. Demands for barrier material from Pit 30 and Area C may be an issue.	$1,271

ARAR = applicable or relevant and appropriate requirement.
PRG = preliminary remediation goal.
RAO = remedial action objective.

Table 6-4. Detailed Analysis Summary for Alternative 5 – Partial Removal, Treatment, and Disposal with Engineered Surface Barrier. (10 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Present-Worth Cost in Thousands**
Representative Site							
207-A South Retention Basin	N/A. Site does not exceed RAO standards.	N/A	N/A	N/A	N/A	N/A	N/A
Waste Site Analogous to 207-A South Retention Basin							
200-W-22 Site Group	N/A, because no deep mobile contamination exists.	N/A	N/A	N/A	N/A	N/A	N/A
Representative Site							
216-A-10 Crib	Protective, because excavation would remove near-surface contamination and the barrier would limit infiltration and protect groundwater.	Expected to comply.	Effective. Barrier is effective for its design life of ~500 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementable.	$9,980
Waste Sites Analogous to 216-A-10 Crib							
216-A-5 Crib	Protective, because excavation would remove near-surface contamination and the barrier would limit infiltration and protect groundwater.	Expected to comply.	Effective. Barrier is effective for its design life of ~500 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementable.	$3,062

Table 6-4. Detailed Analysis Summary for Alternative 5 – Partial Removal, Treatment, and Disposal with Engineered Surface Barrier. (10 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Present-Worth Cost in Thousands**
216-A-45 Crib	Protective, because excavation would remove near-surface contamination and the barrier would limit infiltration and protect groundwater.	Expected to comply.	Effective. Barrier is effective for its design life of ~500 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementable.	$9,965
216-C-1 Crib	Protective, because excavation is expected to remove near-surface contaminants. Barriers will reduce infiltration and protect groundwater over the lifetime of the barrier.	Expected to comply.	Effective. Barrier is effective for its design life of ~500 years.	A portion of the contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementable.	$2,031
200-E-58 Neutralization Tank	N/A. Site contains a neutralization tank that has no documented history of leaks. Removal of near-surface contamination also would remove any potential groundwater threat.	N/A	N/A	N/A	N/A	N/A	N/A
Representative Site							
216-A-19 Trench	Protective. Excavation would remove near-surface contaminants. Barriers will reduce infiltration and protect groundwater over the lifetime of the barrier.	Complies.	Effective. Barrier is effective for its design life of ~500 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementable.	$2,398

Table 6-4. Detailed Analysis Summary for Alternative 5 – Partial Removal, Treatment, and Disposal with Engineered Surface Barrier. (10 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Present-Worth Cost in Thousands
Waste Sites Analogous to 216-A-19 Trench							
216-A-1 Crib	Protective, because excavation is expected to remove near-surface contamination. Barriers will reduce infiltration and protect groundwater over the lifetime of the barrier.	Complies.	Effective. Barrier is effective for its design life of ~500 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementable.	$2,194
216-A-3 Crib	Protective, because excavation is expected to remove near-surface contamination. Barriers will reduce infiltration and protect groundwater over the lifetime of the barrier.	Complies.	Effective. Barrier is effective for its design life of ~500 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementable.	$2,114
216-A-18 Trench	Protective, because excavation is expected to remove near-surface contamination. Barriers will reduce infiltration and protect groundwater over the lifetime of the barrier.	Complies.	Effective. Barrier is effective for its design life of ~500 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementable.	$3,964
216-A-20 Trench (includes overflow area)	Protective, because excavation is expected to remove near-surface contamination. Barriers will reduce infiltration and protect groundwater over the lifetime of the barrier.	Complies.	Effective. Barrier is effective for its design life of ~500 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementable.	$2,604

Table 6-4. Detailed Analysis Summary for Alternative 5 – Partial Removal, Treatment, and Disposal with Engineered Surface Barrier. (10 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Present-Worth Cost in Thousands**
216-A-22 French Drain and UPR-200-E-17	Protective, because excavation is expected to remove near-surface contamination. Barriers will reduce infiltration and protect groundwater over the lifetime of the barrier.	Complies.	Effective. Barrier is effective for its design life of ~500 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementable.	$1,862
216-A-28 Crib	Protective, because excavation is expected to remove near-surface contamination. Barriers will reduce infiltration and protect groundwater over the lifetime of the barrier.	Complies.	Effective; barrier designed for durability.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementable.	$1,778
216-A-34 Ditch	Protective, because excavation is expected to remove near-surface contamination. Barriers will reduce infiltration and protect groundwater over the lifetime of the barrier.	Complies.	Effective. Barrier is effective for its design life of ~500 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementable.	$6,059
216-S-8 Trench	Protective, because excavation is expected to remove near-surface contamination. Barriers will reduce infiltration and protect groundwater over the lifetime of the barrier.	Complies.	Effective. Barrier is effective for its design life of ~500 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementable.	$5,414

Table 6-4. Detailed Analysis Summary for Alternative 5 – Partial Removal, Treatment, and Disposal with Engineered Surface Barrier. (10 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Present-Worth Cost in Thousands
UPR-200-E-145	N/A, because no deep contaminants anticipated.	N/A	N/A	N/A	N/A	N/A	N/A
Representative Site							
216-A-36B Crib	Protective, because excavation is expected to remove contaminants to 9.1 m (30 ft). Barriers will reduce infiltration and protect groundwater over the lifetime of the barrier.	Complies.	Effective. Barrier is effective for its design life of ~1,000 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term industrial and radiological risks to workers.	Implementable.	$17,930
Waste Sites Analogous to 216-A-36B Crib							
216-A-36A Crib	Protective, because excavation is expected to remove contaminants to 9.1 m (30 ft). Barriers will reduce infiltration and protect groundwater over the lifetime of the barrier.	Expected to comply.	Effective. Barrier is effective for its design life of ~1,000 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	High short-term industrial and radiological risks to workers.	Implementable.	$6,285
UPR-200-E-39	N/A, because no deep contaminants anticipated.	N/A	N/A	N/A	N/A	N/A	N/A

Table 6-4. Detailed Analysis Summary for Alternative 5 – Partial Removal, Treatment, and Disposal with Engineered Surface Barrier. (10 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Present-Worth Cost in Thousands
Representative Site							
216-A-37-1 Crib	Protective, because excavation is expected to remove near-surface contaminants. Barriers will reduce infiltration and protect groundwater over the lifetime of the barrier	Complies.	Effective. Barrier is effective for its design life of ~500 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementable.	$4,654
Representative Site							
216-B-12 Crib	Protective, because excavation is expected to remove near-surface contamination. Barriers will reduce infiltration and protect groundwater over the lifetime of the barrier.	Complies.	Effective. Barrier is effective for its design life of ~500 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementable.	$16,821
Waste Sites Analogous to 216-B-12 Crib							
216-B-60 Crib	Protective, because excavation is expected to remove near-surface contamination. Barriers will reduce infiltration and protect groundwater over the lifetime of the barrier.	Complies.	Effective. Barrier is effective for its design life of ~500 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Not currently implementable, because this site is located beneath the 225-B Building (WESF), which is assumed to be removed within 20 years.	$5,389

Table 6-4. Detailed Analysis Summary for Alternative 5 – Partial Removal, Treatment, and Disposal with Engineered Surface Barrier. (10 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Present-Worth Cost in Thousands**
216-C-3 Crib	Protective, because excavation is expected to remove near-surface contamination. Barriers will reduce infiltration and protect groundwater over the lifetime of the barrier.	Complies.	Effective. Barrier is effective for its design life of ~500 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementable.	$2,043
216-C-5 Crib	Protective, because excavation is expected to remove near-surface contamination. Barriers will reduce infiltration and protect groundwater over the lifetime of the barrier.	Complies.	Effective. Barrier is effective for its design life of ~500 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementable.	$2,079
216-C-7 Crib	Protective, because excavation is expected to remove near-surface contamination. Barriers will reduce infiltration and protect groundwater over the lifetime of the barrier.	Complies.	Effective. Barrier is effective for its design life of ~500 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementable.	$2,048
216-C-10 Crib	Protective, because excavation is expected to remove near-surface contamination. Barriers will reduce infiltration and protect groundwater over the lifetime of the barrier.	Complies.	Effective. Barrier is effective for its design life of ~500 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementable.	$1,882

Table 6-4. Detailed Analysis Summary for Alternative 5 – Partial Removal, Treatment, and Disposal with Engineered Surface Barrier. (10 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Present-Worth Cost in Thousands**
209-E-WS-3 Valve Pit and Hold-Up Tank	N/A. Site contains a neutralization tank and valve pit that has no documented history of leaks.	N/A	N/A	N/A	N/A	N/A	N/A
270-E-1 Neutralization Tank	N/A. Site contains a neutralization tank that has no documented history of leaks.	N/A	N/A	N/A	N/A	N/A	N/A
UPR-200-E-64	N/A, because no deep contaminants anticipated.	N/A	N/A	N/A	N/A	N/A	N/A
Representative Site							
216-S-7 Crib	Protective, because excavation is expected to remove near-surface contamination. Barriers will reduce infiltration and protect groundwater over the lifetime of the barrier.	Complies.	Effective. Barrier is effective for its design life of ~500 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementable.	$3,272
Waste Sites Analogous to 216-S-7 Crib							
216-S-1&2 Cribs and UPR-200-W-36	Protective, because excavation is expected to remove near-surface contamination. Barriers will reduce infiltration and protect groundwater over the lifetime of the barrier.	Complies.	Effective. Barrier is effective for its design life of ~500 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementable.	$3,521

Table 6-4. Detailed Analysis Summary for Alternative 5 – Partial Removal, Treatment, and Disposal with Engineered Surface Barrier. (10 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Present-Worth Cost in Thousands
216-S-4 French Drain	Protective, because excavation is expected to remove near-surface contamination. Barriers will reduce infiltration and protect groundwater over the lifetime of the barrier.	Complies.	Effective. Barrier is effective for its design life of ~500 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementable.	$2,020
216-S-22-Crib	Protective, because excavation is expected to remove near-surface contamination. Barriers will reduce infiltration and protect groundwater over the lifetime of the barrier.	Complies.	Effective. Barrier is effective for its design life of ~500 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementable.	$1,964
216-S-23 Crib	Protective, because excavation is expected to remove near-surface contamination. Barriers will reduce infiltration and protect groundwater over the lifetime of the barrier.	Complies.	Effective. Barrier is effective for its design life of ~500 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementable.	$4,212

Table 6-4. Detailed Analysis Summary for Alternative 5 – Partial Removal, Treatment, and Disposal with Engineered Surface Barrier. (10 Pages)

Waste Site	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	**Compliance with ARARs**	**Long-Term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility, or Volume Through Treatment**	**Short-Term Effectiveness**	**Implementability**	**Present-Worth Cost in Thousands**
216-T-20 Trench	Protective, because excavation is expected to remove near-surface contamination. Barriers will reduce infiltration and protect groundwater over the lifetime of the barrier.	Complies.	Effective. Barrier is effective for its design life of ~500 years.	A portion of the contaminants is moved to a less mobile environment. Reduction through natural attenuation of radionuclides.	Moderate short-term industrial and radiological risks to workers.	Implementable.	$1,693

ARAR = applicable or relevant and appropriate requirement.
N/A = not applicable.
RAO = remedial action objective.
WESF = Waste Encapsulation and Storage Facility.

7.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

This chapter presents the comparative analysis of the five remedial alternatives for the 200-PW-2 and 200-PW-4 OU waste sites. Based on detailed analysis information (Chapter 6.0), this analysis compares alternatives to each other with regard to relative effectiveness in meeting CERCLA evaluation criteria. This comparison is based on the seven CERCLA evaluation criteria discussed in Chapter 6.0. The results of this analysis provide a basis for selecting a preferred remedial alternative(s) for each representative waste site and associated analogous waste sites. These remedial alternatives are as follows:

- Alternative 1 – No Action
- Alternative 2 – Maintain Existing Soil Cover, Institutional Controls (IC), and Monitored Natural Attenuation
- Alternative 3 – Removal, Treatment, and Disposal
- Alternative 4 – Engineered Surface Barrier
- Alternative 5 – Partial Removal, Treatment, and Disposal with Capping.

7.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Overall protection of human health and the environment evaluates each alternative for its ability to protect human health and the environment, in both the short-term and long-term. This criterion draws on the assessments of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

7.1.1 207-A South Retention Basin and Analogous Sites

Alternative 3, Removal, Treatment, and Disposal, would be most protective for the 207-A South Retention Basin, because, although characterization has shown no excessive contamination, all contamination potentially exceeding PRGs would be removed. In addition, the basin structure would be removed. Alternative 2 would be slightly less protective, because of potential residual contamination that would be expected to decay to acceptable levels within the IC period. Alternative 1 would be still less protective, because of the potential for residual contamination that was not revealed by limited sampling, to date, and the potential for access into that contamination if access were to be unrestricted. Finally, Alternative 4 would be less protective, because of potential environmental damage resulting from collection of soil to construct the cap. Alternative 5 is not applicable, because excavation of near-surface material would eliminate the need for a cap.

Analogous Site 200-W-22 Reduction-Oxidation (REDOX) Ancillary Facility and Structures (Underground)

Alternative 3, Removal, Treatment, and Disposal, is most protective for analogous site 200-W-22, because all contamination potentially exceeding PRGs would be removed. Alternative 2 is slightly less protective, because essentially no worker risk would be incurred while potential contamination decays further. Alternative 4 is ranked less protective, because of minor environmental damage resulting from collection of borrow site material for cap construction. Alternative 1 is not protective, because of expected unacceptable levels of near-surface contamination. Alternative 5 is not applicable, because near-surface excavation would eliminate the need for a cap.

7.1.2 216-A-19 Trench and Analogous Sites 216-A-1 Crib, 216-A-3 Crib, 216-A-18 Trench, 216-A-20 Trench, 216-A-22 French Drain (and Associated UPR-200-E-17 Spill), 216-A-28 Crib, 216-S-8 Trench, and 216-A-34 Ditch

Alternative 3 is most protective, because all contamination exceeding PRGs would be removed. Alternative 5 is slightly less protective, because near-surface contamination would be removed and a cap applied to protect groundwater. Alternative 4 is ranked slightly less protective, because the cap would protect groundwater and deter intrusion into residual near-surface contamination. Alternative 5 is not applicable, because near-surface excavation would eliminate the need for a cap.

Analogous Site UPR-200-E-145

Alternative 3 is most protective, because all contamination exceeding PRGs would be removed. Alternative 2 is slightly less protective, because essentially no worker risk would be incurred while potential contamination decays during the period of IC. Alternative 4 is less protective, because the cap would deter intrusion into residual near-surface contamination. Alternatives 1 and 2 are not protective.

7.1.3 216-B-12 Crib and Analogous Sites 216-B-60 Crib, 216-C-3 Crib, 216-C-5 Crib, 216-C-7 Crib, and 216-C-10 Crib

Alternative 3 is most protective, because all contamination exceeding PRGs would be removed. Alternative 5 is somewhat less protective, because near-surface contamination would be removed and a cap applied to protect groundwater. Alternative 4 is considered less protective, although the cap would deter intrusion into residual near-surface contamination while protecting groundwater. Alternatives 1 and 2 are not protective, except for the 216-B-60 Crib, which has minimal contaminant inventory.

Analogous Sites 216-E-WS-3 Valve Pit and Hold-Up Tank, 270-E-1 Tank, and UPR-200-E-64

Alternative 3 is most protective, because all contamination exceeding PRGs would be removed. Alternative 4 is considered less protective, although the cap would deter intrusion into residual near-surface contamination while protecting groundwater. Alternative 5 is not applicable, because the near-surface excavation would eliminate the need for capping. Alternatives 1 and 2 are not protective.

7.1.4 216-S-7 Crib and Analogous Sites 216-S-1&2 Cribs, 216-S-4 French Drain, 216-S-22 Crib, 216-T-20 Trench, 216-S-23 Crib, and UPR-200-W-36 Well

Alternative 3 is most protective, because all contamination exceeding PRGs would be removed. Alternative 5 is somewhat less protective, because near-surface contamination would be removed and a cap applied to protect groundwater. Alternative 4 is considered less protective, although the cap would deter intrusion into residual near-surface contamination while protecting groundwater. Alternatives 1 and 2 are not protective.

7.1.5 216-A-10 Crib and Analogous Sites 216-C-1 Crib, 216-A-5 Crib, 216-A-45 Crib, and 200-E-58 Tank

Alternative 3 is most protective, because all contamination exceeding PRGs would be removed. Alternative 5 is somewhat less protective, because near-surface contamination would be removed and a cap applied to protect groundwater. Alternative 4 is considered less protective, although the cap would deter intrusion into residual near-surface contamination while protecting groundwater. Alternatives 1 and 2 are not protective.

7.1.6 216-A-36B Crib and Analogous Site 216-A-36A

Alternative 4 is most protective, although the cap would deter intrusion into residual near-surface contamination while protecting groundwater. Alternative 5 is less protective, although near-surface contamination would be removed and a cap applied to protect groundwater, worker risk during excavation is considered high. Alternative 3 is less protective, although all contamination exceeding PRGs would be removed, because worker risk during excavation is considered high. Alternatives 1 and 2 are not protective.

Analogous Site UPR-200-E-39

Alternative 3 is most protective, because all contamination exceeding PRGs would be removed. Alternative 4 is only slightly less protective, because it would place the contamination beneath a thicker protective soil cover until it decays to acceptable levels. Alternative 2 is slightly less protective, because essentially no worker risk would be incurred while potential contamination decays further. Alternative 1 is not protective. Alternative 5 is not applicable, because excavation of near-surface material would eliminate the need for a cap.

7.1.7 216-A-37-1 Crib

Alternative 3 is most protective, because all contamination exceeding PRGs would be removed. Alternative 5 is slightly less protective, because near-surface contamination would be removed and a cap applied to protect groundwater. Alternative 4 is considered less protective, although the cap would deter intrusion into residual near-surface contamination while protecting groundwater. Alternative 2 is still less protective, because of the long half-life associated with the uranium inventory. Alternative 1 is not protective.

7.2 ARAR COMPLIANCE

ARAR compliance considers whether each alternative would comply with ARAR state and federal laws.

7.2.1 207-A South Retention Basin

All alternatives would comply with all potential ARARs, because no contamination exceeding risk-based criteria were found during characterization of this waste site.

Analogous Site 200-W-22 REDOX Ancillary Facility and Structures (Underground)

Because of the potential for residual near-surface contamination to exist at this waste site, Alternative 1 would not comply. All other alternatives would be expected to comply, because potential exposure pathways would be broken.

7.2.2 216-A-19 Trench and Analogous Sites 216-A-1 Crib, 216-A-3 Crib, 216-A-18 Trench, 216-A-20 Trench, 216-A-22 French Drain (and Associated UPR-200-E-17 Spill), 216-A-28 Crib, 216-S-8 Trench, and 216-A-34 Ditch

Alternative 3 complies most fully with the ARARS by removing all contamination and transferring it to an engineered waste disposal facility. Human health and groundwater protection requirements would be satisfied, although mobile long-lived contaminants would eventually reach groundwater, albeit at reduced concentrations in the distant future. Alternatives 4 and 5 would comply equally with groundwater protection requirements. Alternatives 1 and 2 would not comply, because contamination levels exceed risk-based criteria.

Analogous Site UPR-200-E-145

Alternative 3 complies most fully with the ARARS by removing all contamination and transferring it to an engineered waste disposal facility. Alternatives 4 and 5 would comply equally with groundwater protection requirements. Alternatives 1 and 2 would not comply, because long-lived contamination levels exceed risk-based criteria.

7.2.3 216-B-12 Crib and Analogous Sites 216-B-60 Crib, 216-C-3 Crib, 216-C-5 Crib, 216-C-7 Crib, and 216-C-10 Crib

Alternative 3 complies most fully with the ARARS by removing all contamination and transferring it to an engineered waste disposal facility. Human health and groundwater protection requirements would be satisfied, although mobile long-lived contaminants would eventually reach groundwater, albeit at reduced concentrations in the distant future. Alternatives 4 and 5 would comply equally with groundwater protection requirements. Alternatives 1 and 2 would not comply, because contamination levels exceed risk-based criteria.

Analogous Sites 270-E-1 Tank and 216-E-WS-3 Valve Pit/Tank

Alternative 3 complies most fully with the ARARS by removing all contamination and transferring it to an engineered waste disposal facility. Human health and groundwater protection requirements would be satisfied, although mobile long-lived contaminants would eventually reach groundwater, albeit at reduced concentrations in the distant future. Alternatives 4 and 5 would comply equally with groundwater protection requirements. Alternatives 1 and 2 would not comply, because contamination levels exceed risk-based criteria.

Analogous Site UPR-200-E-64

Alternative 3 complies most fully with the ARARS by removing all contamination and transferring it to an engineered waste disposal facility. Alternatives 4 and 5 would comply equally with groundwater protection requirements. Alternative 2 would comply, by preventing contact with contamination until radioactive decay reduces the concentration to less than risk-based criteria. Alternative 1 would not comply, because long-lived contamination levels exceed risk-based criteria.

7.2.4 216-S-7 Crib and Analogous Sites 216-S-1&2 Cribs, 216-S-4 Crib, 216-S-22 Crib, 216-T-20 Trench, 216-S-23 Crib, and UPR-200-W-36 Well

Alternative 3 complies most fully with the ARARS by removing all contamination and transferring it to an engineered waste disposal facility. Human health and groundwater protection requirements would be satisfied, although mobile long-lived contaminants would eventually reach groundwater, albeit at reduced concentrations in the distant future. Alternatives 4 and 5 would comply equally with groundwater protection requirements. Alternatives 1 and 2 would not comply, because contamination levels exceed risk-based criteria.

7.2.5 216-A-10 Crib and Analogous Sites 216-C-1 Crib, 216-A-5 Crib, 216-A-45 Crib, and 200-E-58 Tank

Alternative 3 complies most fully with the ARARS by removing all contamination and transferring it to an engineered waste disposal facility. Human health and groundwater protection requirements would be satisfied, although mobile long-lived contaminants would eventually reach groundwater, albeit at reduced concentrations in the distant future.

Alternatives 4 and 5 would comply equally with groundwater protection requirements. Alternatives 1 and 2 would not comply, because contamination levels exceed risk-based criteria.

Analogous Site 200-E-58 Tank

Alternative 3 complies most fully with the ARARS by removing all contamination and transferring it to an engineered waste disposal facility. Human health and groundwater protection requirements would be satisfied, although mobile long-lived contaminants would eventually reach groundwater, albeit at reduced concentrations in the distant future. Alternatives 4 and 5 would comply equally with groundwater protection requirements. Alternative 2 would comply, depending on confirmation that residual contamination in the tank is at acceptable levels. Alternative 1 would not comply, because contamination levels exceed risk-based criteria.

7.2.6 216-A-36B Crib and Analogous Site 216-A-36A

Alternative 3 complies most fully with the ARARS by removing all contamination and transferring it to an engineered waste disposal facility. Human health and groundwater protection requirements would be satisfied, although mobile long-lived contaminants would eventually reach groundwater, albeit at reduced concentrations in the distant future. Alternatives 4 and 5 would comply equally with groundwater protection requirements. Alternatives 1 and 2 would not comply, because contamination levels exceed risk-based criteria.

Analogous Site UPR-200-E-39

Alternative 3 complies most fully with the ARARS by removing all contamination and transferring it to an engineered waste disposal facility. Alternatives 4 and 5 would comply equally with groundwater protection requirements. Alternative 2 would comply, by preventing contact with contamination until radioactive decay reduces the concentration to less than risk-based criteria. Alternative 1 would not comply, because long-lived contamination levels exceed risk-based criteria.

7.2.7 216-A-37-1 Crib

Alternative 3 complies most fully with the ARARS by removing all contamination and transferring it to an engineered waste disposal facility. Human health and groundwater protection requirements would be satisfied, although mobile long-lived contaminants would eventually reach groundwater, albeit at reduced concentrations in the distant future. Alternatives 4 and 5 would comply equally with groundwater protection requirements. Alternatives 1 and 2 would not comply, because contamination levels exceed risk-based criteria.

7.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

Long-term effectiveness and permanence evaluates residual risk, adequacy of IC, and time to restore sustainable environmental conditions. In general, Alternative 3 best satisfies this criterion, because it permanently removes all contaminant from the waste site, thereby eliminating the need for future ICs. Restoration of the site following excavation would provide sustainable environmental controls. Alternatives 4 and 5 would be less effective, because of reliance on ICs to maintain the cap. Alternatives 1 and 2 generally are least effective, because little is done to remove future risk.

7.3.1 207-A South Retention Basin

Alternative 3 is most effective and permanent, although no contamination exceeding PRGs has been observed through initial characterization, because all potential residual risk would be removed, the excavation filled, and natural vegetation restored. Alternative 2 is slightly less effective and permanent, because of reliance on IC to provide protection from potential residual contamination. Alternative 4 is less effective and permanent, because of reliance on IC following capping, which would include restoration of natural vegetation. Alternative 1 is still less effective and permanent, because of the potential for undetected residual contamination.

Analogous Site 200-W-22 REDOX Ancillary Facility and Structures (Underground)

Alternative 3 is most effective and permanent, because all potential residual risk would be removed, there would be no reliance on IC, and restoration time would be short. Alternative 4 is less effective and permanent, because of reliance on IC following capping, which would include restoration of natural vegetation. Alternative 2 is less effective and permanent, because expected minor residual contamination probably would decay to acceptable levels within the IC period. Alternative 1 is not expected to be effective and permanent, because of residual contamination associated with the underground structures. Alternative 5 is not applicable, because removal of near-surface contamination would eliminate the need for a cap.

7.3.2 216-A-19 Trench and Analogous Sites 216-A-1 Crib, 216-A-3 Crib, 216-A-18 Trench, 216-A-20 Trench, 216-A-22 French Drain (and Associated UPR-200-E-17 Spill), 216-A-28 Crib, 216-S-8 Trench, and 216-A-34 Ditch

Alternative 3 is most effective and permanent, because all potential residual risk would be removed, there would be no reliance on IC, and restoration time would be short. Alternative 5 is effective and permanent, because near-surface contamination would be removed, thereby lessening IC requirements and a cap with natural vegetation would protect groundwater. Alternative 4 is still less effective and permanent, because of the greater quantity of residual contamination, at least equal reliance on IC as Alternative 5, but less time to achieve remediation, because no excavation is involved. Alternative 2 is still less effective and permanent, because of the impossibility of providing sufficiently long IC. Alternative 1 is not effective and permanent, because of accessible contamination.

Analogous Site UPR-200-E-145

Alternative 3 is most effective and permanent, because all potential residual risk would be removed, there would be no reliance on IC, and restoration time would be short. Alternative 4 is less effective and permanent, because residual contamination would be left beneath a cap that would rely on IC to prevent intrusion. The vegetated cap would provide prompt restoration of natural habitat. Alternative 2 is less effective and permanent, because existing contamination would remain, but with IC to prevent intrusion. Alternative 1 is least effective and permanent, because existing contamination would remain with no controls to provide protection. Alternative 5 is not applicable, because once the near-surface contamination is removed, there would be no need for a cap.

7.3.3 216-B-12 Crib and Analogous Sites 216-B-60 Crib, 216-C-3 Crib, 216-C-5 Crib, 216-C-7 Crib, and 216-C-10 Crib

Alternative 3 is most effective and permanent, because all potential residual risk would be removed, there would be no reliance on IC, and restoration time would be short. Alternative 5 is effective and permanent, because near-surface contamination would be removed, thereby lessening IC requirements and a cap with natural vegetation would protect groundwater. Alternative 4 is still less effective and permanent, because of the greater quantity of residual contamination, at least equal reliance on IC as Alternative 5, but less time to achieve remediation, because no excavation is involved.

Alternatives 1 and 2 do not provide any meaningful degree of long-term effectiveness and permanence.

Analogous Sites 270-E-1 Tank and 216-E-WS-3 Valve Pit/Tank

Alternative 3 is most effective and permanent, because all potential residual risk associated with residual liquid and sludge within the tanks would be removed, there would be no reliance on IC, and restoration time would be short. Alternative 4 is less effective and permanent, because residual contamination would be left beneath a cap that would rely on IC to prevent intrusion. The vegetated cap would provide prompt restoration of natural habitat. Alternative 2 is still less effective and permanent, because residual contamination would be left intact with intrusion controlled by IC. Alternative 1 would not provide any meaningful degree of long-term effectiveness and permanence. Alternative 5 is not applicable, because removal of near-surface contamination would eliminate the need for a cap.

Analogous Site UPR-200-E-64

Alternative 3 is most effective and permanent, because all potential residual risk would be removed, there would be no reliance on IC, and restoration time would be short. Alternative 4 is less effective and permanent, because residual contamination would be left beneath a cap that would rely on IC to prevent intrusion. The vegetated cap would provide prompt restoration of natural habitat. Alternative 2 is still less effective and permanent, because residual contamination would be left intact with intrusion controlled by IC. Alternative 1 would not provide any meaningful degree of long-term effectiveness and permanence. Alternative 5 is not applicable, because removal of near-surface contamination would eliminate the need for a cap.

7.3.4 216-S-7 Crib and Analogous Sites 216-S-1&2 Cribs, 216-S-4 Crib, 216-S-22 Crib, 216-T-20 Trench, 216-S-23 Crib, and UPR-200-W-36 Well

Alternative 3 is most effective and permanent, because all potential residual risk would be removed, there would be no reliance on IC, and restoration time would be short. Alternative 5 is effective and permanent, because near-surface contamination would be removed, thereby lessening IC requirements and providing a cap with natural vegetation, which would protect groundwater. Alternative 4 is still less effective and permanent, because of the greater quantity of residual contamination, at least equal reliance on IC as Alternative 5, but less time to achieve remediation, because no excavation is involved. Alternative 2 is still less effective and permanent, because residual contamination would be left intact with intrusion controlled by IC. Alternative 1 would not provide any meaningful degree of long-term effectiveness and permanence.

7.3.5 216-A-10 Crib and Analogous Sites 216-C-1 Crib, 216-A-5 Crib, 216-A-45 Crib, and 200-E-58 Tank

Alternative 3 is most effective and permanent, because all potential residual risk would be removed, there would be no reliance on IC, and restoration time would be short. Alternative 5 is effective and permanent, because near-surface contamination would be removed, thereby lessening IC requirements and a cap with natural vegetation would protect groundwater. Alternative 4 is still less effective and permanent, because of the greater quantity of residual contamination, at least equal reliance on IC as Alternative 5, but less time to achieve remediation, because no excavation is involved. Alternative 2 is still less effective and permanent, because residual contamination would be left intact with intrusion controlled by IC. Alternative 1 would not provide any meaningful degree of long-term effectiveness and permanence.

Analogous Site 200-E-58 Tank

Alternative 3 is most effective and permanent, because all potential residual risk would be removed by removing the tank and its contents, there would be no reliance on IC, and restoration time would be short. Alternative 4 is less effective and permanent, because residual contamination would be left beneath a cap that would rely on IC to prevent intrusion. The vegetated cap would provide prompt restoration of natural habitat. Alternative 2 is still less effective and permanent, because residual contamination would be left intact with intrusion controlled by IC. Alternative 1 would not provide any meaningful degree of long-term effectiveness and permanence. Alternative 5 is not applicable, because removal of near-surface contamination would eliminate the need for a cap.

7.3.6 216-A-36B Crib and Analogous Site 216-A-36A

Alternative 3 is most effective and permanent, because all potential residual risk would be removed, there would be no reliance on IC, and restoration time would be short. Alternative 5 is effective and permanent, because near-surface contamination would be removed, thereby lessening IC requirements and a cap with natural vegetation would protect groundwater. Alternative 4 is still less effective and permanent, because of the greater quantity of residual contamination, at least equal reliance on IC as Alternative 5, but less time to achieve remediation, because no excavation is involved. Alternatives 1 and 2 would not provide any meaningful degree of long-term effectiveness and permanence.

Analogous Site UPR-200-E-39

Alternative 3 is most effective and permanent, because all potential residual risk would be removed by removing the tank and its contents, there would be no reliance on IC, and restoration time would be short. Alternative 4 is less effective and permanent, because residual contamination would be left beneath a cap that would rely on IC to prevent intrusion. The vegetated cap would provide prompt restoration of natural habitat. Alternative 2 is still less effective and permanent, because residual contamination would be left intact with intrusion controlled by IC. Alternative 1 would not provide any meaningful degree of long-term effectiveness and permanence. Alternative 5 is not applicable, because removal of near-surface contamination would eliminate the need for a cap.

7.3.7 216-A-37-1 Crib

Alternative 3 is most effective and permanent, because all potential residual risk would be removed, there would be no reliance on IC, and restoration time would be short. Alternative 5 is effective and permanent, because near-surface contamination would be removed, thereby lessening IC requirements and a cap with natural vegetation would protect groundwater. Alternative 4 is still less effective and permanent, because of the greater quantity of residual contamination, at least equal reliance on IC as Alternative 5, but less time to achieve remediation, because no excavation is involved. Alternative 2 is still less effective and permanent, because residual contamination would be left intact with intrusion controlled by IC. Alternative 1 would not provide any meaningful degree of long-term effectiveness and permanence.

7.4 REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

This criterion evaluates the extent to which alternatives employ treatment to reduce the toxicity, mobility, or volume of contaminants. Factors considered are the extent that the alternative destroys or treats the contamination to reduce its mobility, and the extent to which the treatment is irreversible.

7.4.1 All Representative and Analogous Sites

All alternatives are equally poor in this regard, because none of the alternatives involves treatment.

7.5 SHORT-TERM EFFECTIVENESS

Short-term effectiveness consists of worker safety, biological/cultural impacts, and time to achieve RAOs. In general, Alternative 1 best satisfies these criteria, because no worker safety issues exist and biological/cultural impacts are minimal, but the time to achieve RAOs is dependent on radioactive decay. Alternative 2 is slightly less effective because of worker involvement to effect the ICs. Alternative 4 also is slightly less effective, because the greater industrial hazard to workers is balanced by the more rapid achievement of RAOs by emplacing a cap. Alternatives 3 and 5 are least effective, because of the industrial and radiological hazards associated with excavation.

7.5.1 207-A South Retention Basin

Alternative 1 is best for short-term effectiveness, because there would be no remediation worker risk, no apparent contamination exists that could impact biota, and essentially no time is required to achieve RAOs. Alternative 2 is slightly less effective, because some worker involvement in effecting ICs would occur. The time period would depend on when sufficient data would be obtained to proclaim the site acceptable. Alternative 4 is less effective, because minor remediation worker risk would be involved to construct a cap. Alternative 3 is still less effective, because of the higher risk associated with removal of the essentially clean concrete basin. Alternative 5 is not applicable, because once the near-surface structure is removed, there would be no need for a cap.

Analogous Site 200-W-22 REDOX Ancillary Facility and Structures (Underground)

Alternative 2 is most effective, because only minor remediation worker involvement in effecting ICs would occur. Existing biological habitat would be maintained. The time period would depend on when sufficient data could be obtained to proclaim the site acceptable. Alternative 4 is less effective, because minor remediation worker risk would be involved to construct a cap that would include revegetation. Alternative 3 is still effective, because of the higher risk associated with removal of the underground structures. Alternative 1 is least effective, because of potential adverse biological impact resulting from abandoning the site.

7.5.2 216-A-19 Trench and Analogous Sites 216-A-1 Crib, 216-A-3 Crib, 216-A-18 Trench, 216-A-20 Trench, 216-A-22 French Drain (and Associated UPR-200-E-17 Spill), 216-A-28 Crib, 216-S-8 Trench, and 216-A-34 Ditch

Alternative 2 is most effective, because minor remediation worker involvement in effecting ICs would occur. Existing biological habitat would be maintained. Time to achieve RAOs would be lengthy, though. Alternative 1 is less effective, because of potential adverse biological impact resulting from abandoning the site. There would be no remediation worker risk and the time to achieve RAOs would be essentially the same as for Alternative 2. Alternative 4 is less effective, because only minor remediation worker risk would be involved to construct a cap that would achieve RAOs with insignificant biological impact. For this alternative, RAOs would be achieved upon completion of cap construction. Alternative 5 is less effective, because slightly increased remediation worker risk would result from excavation of near-surface contamination. Time to achieve RAOs would be only slightly longer than the time required for Alternative 4 and biological impacts would be similar. Alternative 3 is least effective, because of greater remediation worker risk.

Analogous Site UPR-200-E-145

Alternative 2 is most effective, because only minor remediation worker involvement in effecting ICs would occur. Existing biological habitat would be maintained. Time to achieve RAOs would be lengthy, though. Alternative 1 is slightly less effective, because of potential adverse biological impact resulting from abandoning the site. There would be no remediation worker risk and the time to achieve RAOs would be essentially the same as for Alternative 2. Alternative 4 is less effective, because only minor remediation worker risk would be involved to construct a cap that would achieve RAOs with insignificant biological impact. For this alternative, RAOs would be achieved upon completion of cap construction. Alternative 5 is less effective, because slightly increased remediation worker risk would result from excavation of near-surface contamination. Time to achieve RAOs would be only slightly longer than the time required for Alternative 4 and biological impacts would be similar. Alternative 3 is least effective, because of greater remediation worker risk.

7.5.3 216-B-12 Crib and Analogous Sites 216-B-60 Crib, 216-C-3 Crib, 216-C-5 Crib, 216-C-7 Crib, and 216-C-10 Crib

Alternative 2 is most effective, because only minor remediation worker involvement in effecting ICs would occur. Existing biological habitat would be maintained. Time to achieve RAOs would be lengthy, though. Alternative 1 is slightly less effective, because of potential adverse biological impact resulting from abandoning the site. There would be no remediation worker risk and the time to achieve RAOs would be essentially the same as for Alternative 2. Alternative 4 is less effective, because only minor remediation worker risk would be involved to construct a cap that would achieve RAOs with insignificant biological impact. For this alternative, RAOs would be achieved upon completion of cap construction. Alternative 5 is less effective, because slightly increased remediation worker risk would result from excavation of near-surface contamination. Time to achieve RAOs would be only slightly longer than the time required for Alternative 4 and biological impacts would be similar. Alternative 3 is least effective, because of greater remediation worker risk.

Analogous Sites 270-E-1 Tank and 216-E-WS-3 Valve Pit/Tank

Alternative 2 is most effective, because only minor remediation worker involvement in effecting ICs would occur. Existing biological habitat would be maintained. Time to achieve RAOs would be lengthy, though. Alternative 1 is slightly less effective, because of potential adverse biological impact resulting from abandoning the site. There would be no remediation worker risk and the time to achieve RAOs would be essentially the same as for Alternative 2. Alternative 4 is less effective, because only minor remediation worker risk would be involved to construct a cap that would achieve RAOs with insignificant biological impact. For this alternative, RAOs would be achieved upon completion of cap construction. Alternative 3 is least effective, because of greater remediation worker risk. Alternative 5 is not applicable, because once the near-surface contamination is removed, there would be no need for a cap.

Analogous Site UPR-200-E-64

Alternative 2 is most effective, because only minor remediation worker involvement in effecting ICs would occur. Existing biological habitat would be maintained. Time to achieve RAOs would be lengthy, though. Alternative 1 is slightly less effective, because of potential adverse biological impact resulting from abandoning the site. There would be no remediation worker risk and the time to achieve RAOs would be essentially the same as for Alternative 2. Alternative 4 is less effective, because only minor remediation worker risk would be involved to construct a cap that would achieve RAOs with insignificant biological impact. For this alternative, RAOs would be achieved upon completion of cap construction. Alternative 5 is less effective, because slightly increased remediation worker risk would result from excavation of near-surface contamination. Time to achieve RAOs would be only slightly longer than the time required for Alternative 4 and biological impacts would be similar. Alternative 3 is least effective, because of greater remediation worker risk.

7.5.4 216-S-7 Crib and Analogous Sites 216-S-1&2 Cribs, 216-S-4 Crib, 216-S-22 Crib, 216-T-20 Trench, 216-S-23 Crib, and UPR-200-W-36 Well

Alternative 2 is most effective, because only minor remediation worker involvement in effecting ICs would occur. Existing biological habitat would be maintained. Time to achieve RAOs would be lengthy, though. Alternative 1 is slightly less effective, because of potential adverse biological impact resulting from abandoning the site. There would be no remediation worker risk and the time to achieve RAOs would be essentially the same as for Alternative 2. Alternative 4 is less effective, because only minor remediation worker risk would be involved to construct a cap that would achieve RAOs with insignificant biological impact. For this alternative, RAOs would be achieved upon completion of cap construction. Alternative 5 is less effective, because increased remediation worker risk would result from excavation of near-surface contamination. Time to achieve RAOs would be only slightly longer than the time required for Alternative 4 and biological impacts would be similar. Alternative 3 is least effective, because of greater remediation worker risk.

7.5.5 216-A-10 Crib and Analogous Sites 216-C-1 Crib, 216-A-5 Crib, 216-A-45 Crib, and 200-E-58 Tank

Alternative 2 is most effective, because only minor remediation worker involvement in effecting ICs would occur. Existing biological habitat would be maintained. Time to achieve RAOs would be lengthy, though. Alternative 1 is slightly less effective, because of potential adverse biological impact resulting from abandoning the site. There would be no remediation worker risk and the time to achieve RAOs would be essentially the same as for Alternative 2. Alternative 4 is less effective, because only minor remediation worker risk would be involved to construct a cap that would achieve RAOs with insignificant biological impact. For this alternative, RAOs would be achieved upon completion of cap construction. Alternative 5 is less effective, because increased remediation worker risk would result from excavation of near-surface contamination. Time to achieve RAOs would be only slightly longer than the time required for Alternative 4 and biological impacts would be similar. Alternative 3 is least effective, because of greater remediation worker risk.

7.5.6 216-A-36B Crib and Analogous Site 216-A-36A

Alternative 2 is most effective, because only minor remediation worker involvement in effecting ICs would occur. Existing biological habitat would be maintained. Time to achieve RAOs would be lengthy, though. Alternative 1 is slightly less effective, because of potential adverse biological impact resulting from abandoning the site. There would be no remediation worker risk and the time to achieve RAOs would be essentially the same as for Alternative 2. Alternative 4 is less effective, because only minor remediation worker risk would be involved to construct a cap that would achieve RAOs with insignificant biological impact. For this alternative, RAOs would be achieved upon completion of cap construction. Alternative 5 is less effective, because increased remediation worker risk would result from excavation of near-surface contamination. Time to achieve RAOs would be only slightly longer than the time required for Alternative 4 and biological impacts would be similar. Alternative 3 is least effective, because of greater remediation worker risk.

Analogous Site UPR-200-E-39

Alternative 2 is most effective, because only minor remediation worker involvement in effecting ICs would occur. Existing biological habitat would be maintained. Time to achieve RAOs would be lengthy, though. Alternative 1 is slightly less effective, because of potential adverse biological impact resulting from abandoning the site. There would be no remediation worker risk and the time to achieve RAOs would be essentially the same as for Alternative 2. Alternative 4 is less effective, because only minor remediation worker risk would be involved to construct a cap that would achieve RAOs with insignificant biological impact. For this alternative, RAOs would be achieved upon completion of cap construction. Alternative 3 is least effective, because of greater remediation worker risk. Alternative 5 is not applicable, because once the near-surface contamination is removed, there would be no need for a cap.

7.5.7 216-A-37-1 Crib

Alternative 2 is most effective, because only minor remediation worker involvement in effecting ICs would occur. Existing biological habitat would be maintained. Time to achieve RAOs would be lengthy, though. Alternative 1 is slightly less effective, because of potential adverse biological impact resulting from abandoning the site. There would be no remediation worker risk and the time to achieve RAOs would be essentially the same as for Alternative 2. Alternative 4 is less effective, because only minor remediation worker risk would be involved to construct a cap that would achieve RAOs with insignificant biological impact. For this alternative, RAOs would be achieved upon completion of cap construction. Alternative 5 is less effective, because increased remediation worker risk would result from excavation of near-surface contamination. Time to achieve RAOs would be only slightly longer than the time required for Alternative 4 and biological impacts would be similar. Alternative 3 is least effective, because of greater remediation worker risk.

7.6 IMPLEMENTABILITY

Implementability evaluates each alternative for its technical feasibility, administrative feasibility, and availability of services and materials.

In general, Alternatives 1 and 2 are most implementable, because of the minimal activity required to effect them. All of the other alternatives are considered readily implementable, because excavation and capping technologies have been demonstrated, no administrative roadblocks exist (unless disposition of TRU waste presents special problems), and all necessary materials and services are available.

7.6.1 207-A South Retention Basin

Alternative 2 is most implementable, because it is currently being performed at this site. Alternative 1 is readily implementable, but less so than Alternative 2, because it would require additional sampling and administrative concurrence to confirm this action. Alternative 3 is readily implementable, because the shallow excavation could be easily performed. Alternative 4 also is readily implementable, despite this action being not normally considered for near-surface contamination, because cap materials are available and capping has been successfully demonstrated. Alternative 5 is not applicable, because once the near-surface contamination is removed, there would be no need for a cap.

Analogous Site 200-W-22 REDOX Ancillary Facility and Structures (Underground)

Alternative 2 is most implementable, because it is currently being performed at this site. Alternative 3 is readily implementable, because the shallow excavation could be easily performed. Alternative 4 also is readily implementable, despite this action being not normally considered for near-surface contamination, because cap materials are available and capping has been successfully demonstrated. Alternative 1 is not implementable, because of the expected residual contamination. Alternative 5 is not applicable, because once the near-surface contamination is removed, there would be no need for a cap.

7.6.2 216-A-19 Trench and Analogous Sites 216-A-1 Crib, 216-A-3 Crib, 216-A-18 Trench, 216-A-20 Trench, 216-A-22 French Drain (and Associated UPR-200-E-17 Spill), 216-A-28 Crib, 216-S-8 Trench, and 216-A-34 Ditch

Alternative 2 is most implementable, because it is currently being performed at this site. Alternative 1 is less implementable, because no technical or administrative challenges would exist. Alternative 4 is readily implementable, because cap materials are available and capping has been successfully demonstrated. Alternative 5 also is readily implementable, because excavation and capping activities have been successfully demonstrated. Alternative 3 is readily implementable, because excavation technologies have been demonstrated.

Analogous Site UPR-200-E-145

Alternative 2 is most implementable, because it is currently being performed at this site. Alternative 1 is readily implementable, but less so than Alternative 2, because it would require additional sampling and administrative concurrence to confirm this action. Alternative 3 is readily implementable, because the shallow excavation could be easily performed. Alternative 4 also is readily implementable, despite this action being not normally considered for near-surface contamination, because cap materials are available and capping has been successfully demonstrated. Alternative 5 is not applicable, because once the near-surface contamination is removed, there would be no need for a cap.

7.6.3 216-B-12 Crib and Analogous Sites 216-B-60 Crib, 216-C-3 Crib, 216-C-5 Crib, 216-C-7 Crib, and 216-C-10 Crib

Alternative 2 is most implementable, because it is currently being performed at this site. Alternative 1 is less implementable, because no technical or administrative challenges would exist. Alternative 4 is readily implementable, because cap materials are available and capping has been successfully demonstrated. Alternative 5 also is readily implementable, because excavation and capping activities have been successfully demonstrated. Alternative 3 is readily implementable, because excavation technologies have been demonstrated.

Analogous Sites 270-E-1 Tank and 216-E-WS-3 Valve Pit/Tank

Alternative 2 is most implementable, because it is currently being performed at this site. Alternative 1 is less implementable, because no technical or administrative challenges would exist. Alternative 4 is readily implementable, because cap materials are available and capping has been successfully demonstrated. Alternative 3 is readily implementable, because excavation technologies have been demonstrated. Alternative 5 is not applicable, because once the near-surface contamination is removed, there would be no need for a cap.

Analogous Site UPR-200-E-64

Alternative 2 is most implementable, because it is currently being performed at this site. Alternative 1 is less implementable, because no technical or administrative challenges would exist. Alternative 3 is readily implementable, because the shallow excavation could be easily performed. Alternative 4 also is readily implementable, despite this action being not normally considered for near-surface contamination, because cap materials are available and capping has been successfully demonstrated. Alternative 5 is not applicable, because once the near-surface contamination is removed, there would be no need for a cap.

7.6.4 216-S-7 Crib and Analogous Sites 216-S-1&2 Cribs, 216-S-4 Crib, 216-S-22 Crib, 216-T-20 Trench, 216-S-23 Crib, and UPR-200-W-36 Well

Alternative 2 is most implementable, because it is currently being performed at this site. Alternative 1 is less implementable, because no technical or administrative challenges would exist. Alternative 4 is readily implementable, because cap materials are available and capping has been successfully demonstrated. Alternative 5 also is readily implementable, because excavation and capping activities have been successfully demonstrated. Alternative 3 is readily implementable, because excavation technologies have been demonstrated.

7.6.5 216-A-10 Crib and Analogous Sites 216-C-1 Crib, 216-A-5 Crib, 216-A-45 Crib, and 200-E-58 Tank

Alternative 2 is most implementable, because it is currently being performed at this site. Alternative 1 is less implementable, because no technical or administrative challenges would exist. Alternative 4 is readily implementable, because cap materials are available and capping has been successfully demonstrated. Alternative 5 also is readily implementable, because excavation and capping activities have been successfully demonstrated. Alternative 3 is readily implementable, because excavation technologies have been demonstrated.

7.6.6 216-A-36B Crib and Analogous Site 216-A-36A

Alternative 2 is most implementable, because it is currently being performed at this site. Alternative 1 is less implementable, because no technical or administrative challenges would exist. Alternative 4 is readily implementable, because cap materials are available and capping has been successfully demonstrated. Alternative 5 also is readily implementable, because excavation and capping activities have been successfully demonstrated. Alternative 3 is readily implementable, because excavation technologies have been demonstrated.

Analogous Site UPR-200-E-39

Alternative 2 is most implementable, because it is currently being performed at this site. Alternative 1 is less implementable, because no technical or administrative challenges would exist. Alternative 3 is readily implementable, because the shallow excavation could be easily performed. Alternative 4 also is readily implementable, despite this action being not normally considered for near-surface contamination, because cap materials are available and capping has been successfully demonstrated. Alternative 5 is not applicable, because once the near-surface contamination is removed, there would be no need for a cap.

7.6.7 216-A-37-1 Crib

Alternative 2 is most implementable, because it is currently being performed at this site. Alternative 1 is less implementable, because no technical or administrative challenges would exist. Alternative 4 is readily implementable, because cap materials are available and capping has been successfully demonstrated. Alternative 5 also is readily implementable, because excavation and capping activities have been successfully demonstrated. Alternative 3 is readily implementable, because excavation technologies have been demonstrated.

7.7 COST

The cost to implement the alternatives is presented in Chapter 6.0, Chapter 8.0, and Appendix F. The following comparisons are generic in nature only to compare the relative costs of the alternatives. If specific cost comparisons are required, consult Chapter 6.0, Chapter 8.0, or Appendix F.

Alternative 1 has no cost associated with it. Alternative 2 generally has low cost, because it is minimally invasive and does not include labor-intensive activities, but it does include costs for extended ICs. Alternative 3 generally is the most costly in terms of capital cost because of the depth of excavation and high contamination levels that will require specialized excavation and waste-handling processes. This alternative does not have costs associated with extended monitoring and ICs, however. Alternative 4 generally is less expensive than Alternatives 3 and 5, provided the ICs cost for Alternative 4 does not exceed the Alternative 3 excavation cost.