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CONTENTS

CONTENTS 1-III

1.0 INTRODUCTION 1-1
1.1 PURPOSE 1-2
1.2 SCOPE 1-3
1.3 U PLANT AREA APPROACH 1-3
1.4 CERCLA AND RCRA INTEGRATION 1-6
1.5 REPORT ORGANIZATION 1-6
1.6 REFERENCES 1-8

2.0 BACKGROUND INFORMATION 2-1
2.1 U PLANT AREA BACKGROUND AND HISTORY 2-1
2.1.1 Buildings and Ancillary Facilities 2-1
2.1.2 221-U Plant Canyon Building 2-2
2.1.3 Uranium Oxide Plant (224-U), Including Support Buildings 224-UA, 272-U, and 2715-UA 2-3
2.1.4 276-U Solvent Handling Building 2-4
2.1.5 222-U Laboratory 2-4
2.1.6 291-U-1 Stack, 291-U Filter Building, and 292-U Stack Monitoring Station 2-4
2.1.7 271-U Support Services Building 2-4
2.1.8 211-U and 211-UA Tank Farms 2-5
2.1.9 241-WR Vault 2-5
2.1.10 275-UR Chemical Storage Warehouse 2-5
2.1.11 2714-U UO_3 Storage Facility 2-6
2.1.12 Process Lines and Encasements 2-6
2.2 LIQUID WASTE DISPOSAL 2-6
2.3 PHYSICAL SETTING 2-7
2.3.1 Meteorology 2-8
2.3.2 Topography 2-8
2.3.3 Geology 2-9
2.3.4 Vadose Zone 2-10
2.3.5 Groundwater 2-11
2.4 NATURAL RESOURCES 2-12
2.4.1 Vegetation 2-12
2.4.2 Wildlife 2-13
2.4.3 Species of Concern 2-14
2.4.4 Cultural Resources 2-15
2.4.5 Aesthetics, Visual Resources, and Noise 2-16
2.4.6 Socioeconomics 2-16
2.5 REPRESENTATIVE SITES DESCRIPTIONS 2-17
2.5.1 Representative Sites Information 2-18
2.5.2 Summary of Data Collection Activities 2-23
2.5.3 Nature and Extent of Contamination 2-26
2.5.4 Summary of Groundwater Quality 2-33

2.6 EVALUATION OF THE ANALOGOUS WASTE SITES 2-34
2.6.1 Analogous Site Assignment to Representative Sites 2-36
2.6.2 Analogous Site Groupings 2-37
2.7 SUMMARY OF RISK ASSESSMENT 2-48
2.7.1 Human Health Risk Assessment 2-49
2.7.2 Ecological Risk Assessment 2-54
2.7.3 Evaluation of Ecological significance 2-55
2.8 SUMMARY OF GROUNDWATER PROTECTION FATE AND TRANSPORT MODELING 2-59
2.9 DATA INTEGRATION WITH HANFORD SITE COMPOSITE ANALYSIS EFFORT 2-60
2.10 REFERENCES 2-61

2.0 BACKGROUND FIGURES 2-69

2.0 BACKGROUND TABLES 2-83

CONTENTS 3-III

TABLES 3-III

3.0 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIATION GOALS 3-1
3.1 LAND USE 3-1
3.1.1 Current Land Use 3-1
3.1.2 Anticipated Future Land Use 3-2
3.1.3 Regional Land Use 3-5
3.1.4 Groundwater Use 3-5
3.2 CONTAMINANTS OF POTENTIAL CONCERN AND CONTAMINANTS OF CONCERN 3-6
3.3 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS 3-6
3.4 REMEDIAL ACTION OBJECTIVES 3-6
3.5 PRELIMINARY REMEDIATION GOALS 3-9
3.5.1 Direct Exposure Preliminary Remediation Goals for Nonradioactive Contaminants 3-10
3.5.2 Direct Exposure Remediation Goals for Radionuclides 3-11
3.5.3 Remediation Goals for the Protection of Groundwater 3-13
3.6 REFERENCES 3-15

CONTENTS 4-III

TABLES 4-III

4.0 REMEDIAL ACTION ALTERNATIVES 4-1
4.1 DEVELOPMENT OF ALTERNATIVES 4-1
4.1.1 Screening and Identification of Technologies 4-1

4.1.2 Summary of Remedial Technologies and Process Options Retained for 200-UW-1 Operable Unit Alternative Development 4-9
4.2 DESCRIPTION OF ALTERNATIVES 4-9
4.2.1 Alternative 1 – No Action 4-9
4.2.2 Alternative 2 – Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation 4-10
4.2.3 Alternative 3 – Removal, Treatment, and Disposal 4-11
4.2.4 Alternative 4 – Engineered Barrier 4-12
4.3 INDEPENDENT WORK ACTIVITIES 4-17
4.3.1 241-U-361 Settling Tank Sludge Removal 4-17
4.3.2 Monitoring 4-18
4.4 POSTREMEDIATION INTRUDER RISK EVALUATIONS 4-18
4.5 REFERENCES 4-19

5.0 DETAILED ANALYSIS OF ALTERNATIVES 5-1
5.1 DESCRIPTION OF EVALUATION CRITERIA 5-1
5.1.1 Overall Protection of Human Health and the Environment 5-2
5.1.2 Compliance with Applicable or Relevant and Appropriate Requirements 5-2
5.1.3 Long-Term Effectiveness and Permanence 5-3
5.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment 5-3
5.1.5 Short-Term Effectiveness 5-4
5.1.6 Implementability 5-4
5.1.7 Cost 5-5
5.1.8 State Acceptance 5-5
5.1.9 Community Acceptance 5-5
5.2 RCRA PERFORMANCE STANDARDS 5-6
5.2.1 Minimize Need for Further Maintenance 5-7
5.2.2 Protection of Human Health and the Environment 5-8
5.2.3 Site Reclamation 5-8
5.2.4 Landfill Requirements 5-8
5.2.5 Postclosure Requirements 5-9
5.3 DETAILED ANALYSIS OF ALTERNATIVES 5-9
5.3.1 Detailed Analysis of Alternative 1: No Action 5-10
5.3.2 Detailed Analysis of Alternative 2: Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation 5-12
5.3.3 Detailed Analysis of Alternative 3: Removal, Treatment, and Disposal 5-15
5.3.4 Detailed Analysis of Alternative 4: Engineered Barrier 5-24
5.4 NATIONAL ENVIRONMENTAL POLICY ACT OF 1969 VALUES EVALUATION 5-29
5.4.1 Description of National Environmental Policy Act of 1969 Values 5-30
5.4.2 Detailed Evaluation of the National Environmental Policy Act of 1969 5-31
5.5 REFERENCES 5-34

6.0 COMPARATIVE ANALYSIS OF ALTERNATIVES 6-1
6.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT 6-1
6.2 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS 6-2
6.3 LONG-TERM EFFECTIVENESS AND PERMANENCE 6-3
6.4 REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT 6-4
6.5 SHORT-TERM EFFECTIVENESS 6-4
6.6 IMPLEMENTABILITY 6-5
6.7 COST 6-5
6.8 REFERENCES 6-5

7.0 CONCLUSIONS AND PATH FORWARD 7-1
7.1 FEASIBILITY STUDY SUMMARY 7-1
7.1.1 Representative Sites 216-U-1/216-U-2 Cribs and Their Analogous Site 7-2
7.1.2 Representative Site 216-U-8 Crib and Its Analogous Site 7-2
7.1.3 Representative Site 216-U-12 Crib and Its Analogous Sites 7-3
7.1.4 Representative Sites 216-U-4 Reverse Well / 216-U-4A French Drain and Their Analogous Site 7-3
7.1.5 Representative Site UPR-200-W-19 and Its Analogous Sites 7-4
7.2 CLOSURE OF THE 216-U-12 CRIB TREATMENT, STORAGE, AND/OR DISPOSAL UNIT 7-5
7.3 PATH FORWARD 7-5
7.3.1 Proposed Plan, Record of Decision, Closure Plan, and Permit Modification 7-5
7.3.2 Sampling Before and After the Record of Decision 7-5
7.4 PLUG-IN OF U PLANT AREA SOIL WASTE SITES 7-6
7.4.1 Establishing the Site Conceptual Model and Associated Standard Remedies 7-7
7.4.2 Establishing the Need for Remedial Action 7-8
7.4.3 Public Involvement in the Plug-in Approach 7-8
7.5 REFERENCES 7-9

8.0 REFERENCES 1

APPENDICES

A 200-UW-1 OPERABLE UNIT WASTE SITE PHOTOGRAPHS ..... A-i

B POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS ..... B-i

C HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT ..... C-i

D 200-UW-1 OPERABLE UNIT WASTE SITES VADOSE ZONE CONTAMINANT FATE AND TRANSPORT MODELING ..... D-i

E RISK ASSESSMENT FOR AN INADVERTENT INTRUDER SCENARIO ..... E-i

F COST ESTIMATE BACKUP ..... F-i

G. EXCAVATION OF THE 216-U-1 / 216-U-2, 216-U-8, AND 216-U-12 CRIBS ..... G-i

H. HISTOGRAMS FOR THE 216-U-1 /216-U-2, 216-U-8, AND 216-U-12 CRIBS ..... H-i

FIGURES

Figure 1-1. Location of the U Plant Area in the 200 West Area, Hanford Site. 1-10

Figure 2-1. U Plant Area Geologic Cross Section Index. 2-71

Figure 2-2. U Plant Area Geologic Cross Section A-A' 2-72

Figure 2-3. U Plant Area Geologic Cross Section B-B'. 2-73

Figure 2-4. U Plant Area Geologic Cross Section C-C'. 2-74

Figure 2-5. 216-U-12 Crib Construction Diagram (DOE/RL-2000-60, Rev. 0). 2-75

Figure 2-6. 216-U-1 and 216-U-2 Cribs Conceptual Contaminant Distribution Model 2-76

Figure 2-7. 216-U-8 Crib Conceptual Contaminant Distribution Model (modified from DOE/RL-2000-60) 2-77

Figure 2-8. 216-U-12 Crib Conceptual Contaminant Distribution Model (modified from DOE/RL-2000-60) 2-78

Figure 2-9. 216-U-4 Reverse Well / 216-U-4A French Drain Conceptual Contaminant Distribution Model. 2-79

Figure 2-10. UPR-200-W-19 Unplanned Release Conceptual Contaminant Distribution Model 2-80

Figure 2-11. Application of Analogous Site Approach. 2-81

Figure 4-1. Generalized Removal, Treatment, and Disposal Alternative. 4-21

Figure 4-2. Illustration of Conceptual Monolithic and Capillary Barrier Designs. 4-22

Figure 4-3. Modified RCRA Subtitle C Barrier Design (modified from DOE/RL-93-33). 4-23

PLATE

Plate 1. U Plant Area.....(located in pocket at the end of this document)

TABLES

Table 1-1. 200-UW-1 Operable Unit Waste Sites. 1-11

Table 1-2. Crosswalk Between RCRA Treatment, Storage, and/or Disposal Closure Plan Requirements and Supporting Documentation..... 1-12

Table 2-1. Application of Analogous Site Approach to 200-UW-1 Operable Unit Representative Waste Sites. 2-85

Table 2-2. U Plant Area Groundwater Contaminant Trends (Modified from DOE/RL-2003-58)..... 2-86

Table 2-3. 216-U-1 and 216-U-2 Crib and Associated Analogous Waste Sites. (2 Pages)..... 2-87

Table 2-4. 216-U-8 Crib and Associated Analogous Waste Sites. (3 Pages)..... 2-89

Table 2-5. 216-U-12 Crib and Associated Analogous Waste Sites. (6 Pages)..... 2-92

Table 2-6. 216-U-4 Reverse Well/216-U-4A French Drain and Associated Analogous Waste Sites. (2 Pages) 2-98

Table 2-7. Unplanned Release UPR-200-W-19 and Associated Analogous Waste Sites. (11 Pages) 2-100

Table 2-8. Waste Site Risk Summary. (2 Pages)..... 2-111

Table 3-1. Summary of Nonradionuclide Soil Preliminary Remediation Goals for All Pathways. (4 Pages)..... 3-19

Table 3-2. Summary of Radionuclide Preliminary Remediation Goals for All Pathways. (2 Pages)..... 3-23

Table 4-1. Summary of Alternatives and Associated Components. 4-24

Table 4-2. Technology Types and Process Options for Soil and Sludge. (2 Pages)..... 4-25

Table 5-1. Crosswalk Between RCRA Treatment, Storage, and Disposal Postclosure Plan Requirements and Supporting Documentation. 5-37

Table 5-2. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation. (4 Pages) 5-38

Table 5-3. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (5 Pages) 5-42

Table 5-4. Detailed Analysis Summary for Alternative 4 – Engineered Barrier. (4 Pages) 5-47

Table 5-5. Net Present Worth Cost Estimates (in $1,000). (2 Pages) 5-51

Table 7-1. Preferred Alternative for Representative Sites 216-U-1/216-U-2 Cribs and Their Analogous Site. 7-10

Table 7-2. Preferred Alternative for the Representative Site 216-U-8 Crib and Its Analogous Site. 7-11

Table 7-3. Preferred Alternative for Representative Site 216-U-12 Crib and Its Analogous Sites. (2 Pages) 7-12

Table 7-4. Preferred Alternative for Representative Sites 216-U-4 Reverse Well / 216-U-4a French Drain and Its Analogous Site. (2 Pages) 7-14

Table 7-5. Preferred Alternative for Representative Site UPR-200-W-19 and Analogous Sites. 2 Pg 7-16

Table 7-6. Preferred Alternatives for Individual Waste Sites. 7-18

Table 7-7. Sampling Before and After the Record of Decision Sampling. 7-19

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TERMS

221-U Building	U Plant Canyon Building
221-U Facility	U Plant Canyon Building
224-U	Uranium Oxide Plant or UO_3 Plant
ALARA	as low as reasonably achievable
ALCD	Alternative Landfill Cover Demonstration
ALE	(Fitzner/Eberhardt) Arid Lands Ecology (Reserve)
amsl	above mean sea level
ARAR	applicable or relevant and appropriate requirement
AUF	area use factor
BCG	biota concentration guide
BDAC	Biota Dose Assessment Committee
bgs	below ground surface
BRMaP	Biological Resources Management Plan (DOE/RL-96-32)
CCU	Cold Creek unit
CDI	canyon disposition initiative
CERCLA	*Comprehensive Environmental Response, Compensation and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CLARC	cleanup levels and risk calculations, see Ecology 94-145
COC	contaminant of concern
COPC	contaminant of potential concern
CPP	CERCLA past-practice
CUL	cleanup level
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EE/CA	engineering evaluation/cost analysis
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
EPC	exposure-point concentration
ERA	ecological risk assessment
ERDF	Environmental Restoration Disposal Facility
ET	evapotranspiration
ETF	Effluent Treatment Facility
FFS	focused feasibility study
FS	feasibility study
GRA	general response action
HAB	Hanford Advisory Board
HEPA	high-efficiency particulate air (filter)
HHRA	human health risk assessment
HIC	high-integrity container
HNO_3	nitric acid
IAEA	International Atomic Energy Agency
IC	institutional controls
ICRP	International Commission on Radiological Protection

Implementation Plan	*200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*, DOE/RL-98-28
LFI	limited field investigation
MCL	maximum contaminant level
MESC	maintain existing soil cover
MNA	monitored natural attenuation
MSCM II	Mobile Surface Contamination Monitor
NA	not applicable
NBS	National Bureau of Standards
NCP	"National Oil and Hazardous Substances Pollution Contingency Plan" (40 CFR 300)
NEPA	*National Environmental Policy Act of 1969*
NPH	normal paraffin hydrocarbon
NPL	National Priorities List (40 CFR 300, Appendix B)
OU	operable unit
PP	proposed plan
PRG	preliminary remediation goal
PUREX	Plutonium-Uranium Extraction (Plant) or U Plant
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
RDL	required detection limit
REDOX	Reduction-Oxidation (Plant) or S Plant
RESRAD	RESidual RADioactivity (code)
RI Report	DOE/RL-2000-35
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RLS	Radionuclide Logging System
ROD	record of decision
RPP	RCRA past-practice
RTD	removal, treatment, and disposal
SAC	*System Assessment Capability* model and database (PNNL-14027)
SALDS	State-Approved Land Disposal Site
SAP	sampling and analysis plan
SCA	surface contamination area
SLERA	screening-level ecological risk assessment
STOMP	Subsurface Transport Over Multiple Phases (code)
TBP	tributyl phosphate
TEDF	Treated Effluent Disposal Facility
TMV	toxicity, mobility, or volume through treatment
Tri-Cities	Richland, Pasco, and Kennewick, Washington
Tri-Parties	Ecology, EPA, and DOE
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 disposal (unit)
UCL	upper confidence limit

UNH	uranyl nitrate hexahydrate
UO_3	uranium oxide or trioxide
UPR	unplanned release
USRADS	Ultrasonic Ranging and Data System
VCP	vitrified clay pipeline
WAC	*Washington Administrative Code*
WIDS	*Waste Information Data System* database

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CHAPTER 1.0

INTRODUCTION

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CONTENTS

1.0 INTRODUCTION 1-1
1.1 PURPOSE 1-2
1.2 SCOPE 1-3
1.3 U PLANT AREA APPROACH 1-3
1.4 CERCLA AND RCRA INTEGRATION 1-6
1.5 REPORT ORGANIZATION 1-6
1.6 REFERENCES 1-8

FIGURE

Figure 1-1. Location of the U Plant Area in the 200 West Area, Hanford Site. 1-10

PLATE

Plate 1. U Plant Area ..... (located in pocket at the end of this document)

TABLES

Table 1-1. 200-UW-1 Operable Unit Waste Sites. 1-11

Table 1-2. Crosswalk Between RCRA Treatment, Storage, and/or Disposal Closure Plan Requirements and Supporting Documentation 1-12

TERMS

221-U Building	U Plant Canyon Building
CDI	canyon disposition initiative
CERCLA	*Comprehensive Environmental Response, Compensation and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CPP	CERCLA past-practice
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EE/CA	engineering evaluation/cost analysis
EPA	U.S. Environmental Protection Agency
FFS	focused feasibility study
FS	feasibility study
Implementation Plan	*200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*, DOE/RL-98-28
NPL	National Priorities List (40 CFR 300, Appendix B)
OU	operable unit
PP	proposed plan
RCRA	*Resource Conservation and Recovery Act of 1976*
RI/FS	remedial investigation/feasibility study
ROD	record of decision
RPP	RCRA past-practice
Tri-Parties	Ecology, EPA, and DOE
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TSD	treatment, storage, and/or disposal (unit)

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 of the Hanford Site on the 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," Appendix B, "National Priorities List" (NPL) pursuant to the *Comprehensive Response, Compensation, and Liability Act of 1980* (CERCLA). The Central Plateau consists of the 200 West Area and 200 East Area (Figure 1-1), which contain waste management facilities and inactive irradiated fuel reprocessing facilities, and the 200 North Area, formerly used for interim storage and staging of irradiated fuel. Several waste sites in the 600 Area, located near these areas, also are included in the Central Plateau. The Central Plateau consists of approximately 700 waste sites organized into 24 waste site groups, called operable units (OU). This focused feasibility study (FFS) addresses the 200-UW-1 OU waste sites located in the U Plant Area, which is located near the center of the Hanford Site in the 200 West Area (Figure 1-1). The U Plant Area (Plate 1) has been divided into five distinct components. The following five components make up the U Plant Area:

- 221-U Facility[1] (to be addressed by the Canyon Disposition Initiative [CDI])
- Facilities that are ancillary or related to the 221-U Facility
- Underground pipelines
- Soil waste sites (such as the 200-UW-1 OU)
- Groundwater underlying the area.

The 200-UW-1 OU waste sites consist of one CERCLA past-practice (CPP) site, 31 *Resource Conservation and Recovery Act of 1976* (RCRA) past-practice (RPP) sites, and one RCRA treatment, storage, and/or disposal (TSD) unit (Table 1-1). These waste sites predominantly consist of liquid waste disposal sites associated with 221-U Facility operations and a few solid waste sites such as debris piles and a burial trench. The liquid waste disposal sites include cribs, trenches, French drains, septic systems, unplanned release sites, one underground settling tank, and one underground pipeline with significant near-surface vadose zone contamination.

The process for characterization and remediation of waste sites at the Hanford Site is addressed in Ecology et al. 1989, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement). The Tri-Party Agreement establishes major milestones for completing the waste site investigation activity by December 31, 2008, and completing waste site remediation by September 30, 2024 (Milestones M-15-00C and M-16-00, respectively) for non-tank farm operable units in the Central Plateau. In 2002, the DOE Richland Operations Office, the EPA, and the Washington State Department of Ecology (Ecology) (the Tri-Parties) renegotiated the Central Plateau waste site cleanup milestones under the Tri-Party Agreement; the results of these negotiations are documented in Tri-Party Agreement change forms M-13-02-01, M-15-02-01, M-16-02-01, and M-20-02-01. As part of these negotiations, the Tri-Parties proposed a plan

[1] The 221-U Facility includes the 221-U Canyon Building, the 271-U Support Services Building, the 276-U Solvent Handling Facility, and other surrounding structures and waste sites within the footprint of the CDI Barrier.

(Interim Milestone M-015-47 due June 30, 2003) to conduct a remedial action(s) for source control at a high-risk waste site(s) in the Central Plateau, which would include an engineering evaluation of an engineered surface barrier. A high-risk waste site is a site that is a known source of groundwater contamination or that poses a significant risk of contaminating the groundwater.

A Tri-Party Agreement Change Form was initiated on March 16, 2004, to establish a new OU (i.e., 200-UW-1) for selected U Plant Area waste sites and to designate Ecology as the lead regulatory agency. Selected sites in the 200-IS-1, 200-LW-2, 200-PW-2, 200-PW-3, 200-PW-4, 200-ST-1, 200-SW-1, 200-SW-2, and 200-UR-1 OUs were moved into the newly established 200-UW-1 OU. This change was initiated from the need for a single record of decision (ROD) instead of multiple RODs. The change request also modified the Appendix B listing of TSD units to move the 216-U-12 Crib TSD from the 200-UP-2 OU to the 200-UW-1 OU (Ecology, EPA, and DOE, 2004, *Hanford Federal Facility Agreement and Consent Order Change Control Form*, Change Number C-03-01, March 16, 2004).

Submittal of this FFS and the associated proposed plan (PP) for the 200-UW-1 OU, including several high-risk waste sites, during June 2003 completed the requirements associated with Tri-Party Agreement Interim Milestone M-015-47. Discussions between the Tri-Parties resulted in an agreement (1) to include the additional sites and (2) that modification of the milestone was not needed to include the additional scope. The barrier evaluation component to the milestone is addressed through the development and evaluation of a remedial alternative that relies on surface barriers for containment. The scope of the 200-UW-1 OU FFS and PP is significantly greater than originally envisioned for Tri-Party Agreement Interim Milestone M-015-47. Instead of one or two high-priority waste sites, more than 30 waste sites and unplanned release sites are evaluated near the 221-U Facility. Addressing these waste sites under a single FFS is a key component of the U Plant Area initiative, which has been proposed to accelerate the remediation of the U Plant Area. The overall objective of the U Plant Area initiative is to accelerate all actions necessary to achieve cleanup, such that the area can move to a state of long-term stewardship. As discussed in Section 1.3, this initiative coordinates the disposition of excess facilities and the 221-U Facility with the remediation of surrounding waste sites.

1.1 PURPOSE

The purpose of this FFS is to develop and evaluate alternatives for remediation of the 33 waste sites in the 200-UW-1 OU and to function as a supporting document to the PP required for Tri-Party Agreement Interim Milestone M-015-47. This FFS will refine preliminary applicable or relevant and appropriate requirements, remedial action objectives, and general response actions initially identified in DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (Implementation Plan). The initial remedial alternative development provides the basis for developing a focused range of viable alternatives for the 200-UW-1 OU waste sites. The alternatives considered provide a range of response actions (e.g., no action; remove, treat, and dispose; containment) that are appropriate to address site-specific conditions. The alternatives will be evaluated and compared to the CERCLA criteria. The Tri-Parties will use this FFS as the basis for selecting a remedy to address potential risks to human health and the environment. A preferred remedial alternative(s)

will be presented to the public in a PP for review and comment. Ecology and the EPA then will prepare a CERCLA ROD that will identify which alternative(s) ultimately will be implemented by the Tri-Parties, based on the nine CERCLA criteria. This FFS also will support the closure of the 216-U-12 Crib, a TSD unit under RCRA. Information in this FFS and related documents will be used to prepare a draft permit modification, which also will be presented for public review and comment. Ecology then will modify WA7890008967, *Hanford Facility RCRA Permit*, to incorporate the 216-U-12 Crib. Additional discussion on RCRA and CERCLA integration is provided in Section 1.4.

1.2 SCOPE

Cleanup of the 200-UW-1 OU waste sites is a source control action that addresses contaminated soil and structures (e.g., tanks, pipes) associated with cribs, trenches, French drains, debris piles, septic systems, and unplanned release sites. The scope of this FFS does not include the remediation of groundwater beneath these waste sites. However, it is required for the action to be protective of groundwater in accordance with the remedial action objectives. Contaminated groundwater in the U Plant Area is being, and will continue to be, addressed under the 200-UP-1 Groundwater OU.

This FFS focuses on 33 waste sites, including high-risk waste sites associated with or located near the 221-U Facility. The U Plant Area lies within the exclusive-use boundary identified in DOE/EIS-0222-F, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*.

1.3 U PLANT AREA APPROACH

In 1999, the DOE developed the Central Plateau strategy, as described in the Implementation Plan (DOE/RL-98-28). This strategy established an approach for reaching remedial decisions for the non-tank-farm waste sites. Under this approach, the waste sites were grouped into process-based OUs to streamline characterization. Investigation work plans were prepared beginning in 1999 (e.g., DOE/RL-2000-60, *200-PW-2 Uranium-Rich Process Waste Group Operable Unit RI/FS Work Plan and Process Waste RCRA TSD Unit Sampling Plan*) and were followed by field sampling. As characterization proceeded, other streamlining initiatives, such as combining multiple OUs into a single investigation (e.g., 200-UW-1 OU) were implemented within the framework of DOE/RL-98-28. The strategy anticipated further revisions to the waste site groupings for evaluation and/or remediation. In particular, remediation might be accomplished most effectively by grouping sites geographically.

Consistent with the Central Plateau strategy and the ongoing effort to accelerate cleanup at the Hanford Site, the DOE partnered with Ecology and the EPA to identify new approaches for the Central Plateau cleanup process. One of these approaches is the geographic area closure concept (DOE/RL-2002-68, *Hanford's Groundwater Management Plan: Accelerated Cleanup and Protection*). The geographic-based cleanup goals are (1) to reduce environmental risks and protect underlying groundwater by addressing high-risk waste sites and (2) to accelerate remediation of the Hanford Site. In addition, economies of scale could be realized by performing remediation of waste sites within a given geographic area as an integrated activity.

Under this approach, the DOE would perform a comprehensive and coordinated cleanup of waste sites, facilities, and pipelines within a defined geographic area. The overall objective is to accelerate all actions necessary to achieve cleanup on an area basis and to place major portions of the Central Plateau into long-term stewardship. For several reasons, the area around the 221-U Facility has been identified as the first area to implement the geographic closure concept.

- The majority of the waste sites, facilities, and pipelines in the area are inactive.

- The waste sites in the area are sufficiently well characterized to apply the analogous site approach in making remedial decisions. Characterization of a significant number of high-risk waste sites in the 200-UW-1 OU, including the 216-U-12 Crib, was performed under a work plan implemented several years ago under the 200-UP-2 OU (DOE/RL-91-19, *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 200-UP-2 Operable Unit, Hanford Site, Richland, Washington*).

- A final feasibility study (FS) (DOE/RL-2001-11, Rev. 1, *Final Feasibility Study for the Canyon Disposition Initiative [221-U Facility]*) and PP (DOE/RL-2001-29, Rev. 0, *Proposed Plan for the Canyon Disposition Initiative [221-U Facility]*) were completed to address the 221-U Facility as part of the overall CDI. A ROD is expected on the CDI in the near future. Implementation of a remedial decision for the 221-U Facility will be contingent on the completion of remedial actions for adjacent or ancillary facilities, waste sites, and pipelines. Early decisions for all such sites are needed to coordinate with the CDI.

- The area includes several high-risk waste sites, some of which are known sources of a significant uranium and technetium groundwater plume beneath the U Plant Area. Final decision making for the 200-UP-1 Groundwater OU would be facilitated by accelerated remediation of the source sites.

The U Plant Area project consists of six coordinated activities with the following decision-making pathways:

- CDI: Preparation of an FS report and PP, followed by a ROD for the 221-U Facility under the CERCLA process. The initiative involves use of the 221-U Facility as a pilot to assess the feasibility of dispositioning the Hanford Site canyon facilities in place. At this time, the preferred alternative being considered for remediation of the 221-U Facility is to partially demolish the structure, fill void spaces with grout, and dispose in place the hazardous substances and the resulting demolition debris inside and adjacent to the remaining structure under an engineered barrier. Details on each of the alternatives for 221-U Facility remediation can be found in DOE/RL-2001-11, Rev. 1, which may be found in the Administrative Record

- Soil waste sites: Preparation of an FFS report and PP, followed by a ROD under CERCLA for the majority of the waste sites and unplanned release sites in the U Plant Area. The ROD is expected to include multiple remedies that are site dependent because of the varied nature and associated risks of the waste sites. The ROD also will include a clear process for allowing the selected remedy(ies) to be applied in the future to other U Plant Area waste sites (e.g., newly identified waste sites), eliminating the need for

additional waste site remedial investigation/feasibility study (RI/FS) activities in the U Plant Area

- Underground pipelines: Preparation of an engineering evaluation/cost analysis (EE/CA), or equivalent, that focuses on contaminated subsurface pipelines and associated structures, and unplanned releases in the U Plant Area, followed by an action memorandum under CERCLA

- Facilities that are ancillary to or related to the 221-U Facility: Preparation of EE/CAs for removal of excess ancillary facilities and equipment in the U Plant Area that contain hazardous substances, followed by an action memorandum under CERCLA

- Groundwater underlying the area: Monitoring and remediation of groundwater located under the U Plant Area, in accordance with the 200-UP-1 OU ROD (EPA/541/R-97/048, *Record of Decision for the 200-UP-1 Interim Remedial Measure*). Post-remediation groundwater monitoring plans would be developed in coordination with the remediation of the U Plant Area

- Additional actions are under way in support of U Plant Area cleanup. These include infrastructure modifications for eliminating artificial recharge conditions in the U Plant Area such as closeout of an active septic system, decommissioning noncompliant or unused wells, replacing or capping potentially leaking raw waterlines, and run-on/run-off control.

The first activities that will be completed under the U Plant Area geographic area closure include the remediation of waste sites; removal actions for associated pipelines; removal of excess ancillary facilities and equipment; and infrastructure modifications. These activities will occur in a coordinated manner and, for the locations immediately adjacent to the 221-U Facility, will need to be completed before final implementation of the selected remedial alternative for the 221-U Facility. Following removal of excess ancillary facilities and equipment, additional remediation might be required for remaining below-grade sources of contamination, such as residual soil contamination, subsurface structures, pipelines, tanks, drains, or unplanned release sites. Characterization, assessment of risk to human health and the environment, and evaluation of remedial/removal actions will have to be completed for sites in the immediate vicinity of the 221-U Facility before the selected 221-U Facility alternative is implemented.

Several of the 221-U Facility alternatives include the construction of a thick, protective, engineered surface barrier that would mitigate percolation of atmospheric water and would mitigate future biological intrusion. It is possible that the selected 221-U Facility alternative may be sufficient to address any remaining contamination in the immediate vicinity of the 221-U Facility. Should this be the case, no further remedial action other than the selected 221-U Facility alternative may be needed to address the remaining contamination at these adjacent waste sites.

Completion of the initial remedial and removal actions discussed above would prepare the area for final implementation of the selected 221-U Facility alternative. After all of the source terms have been remediated effectively, a final ROD for groundwater can be pursued, and associated cleanup actions can be performed.

Groundwater monitoring plans developed to monitor the effectiveness of remediation for the U Plant Area will be modified as the 221-U Facility ROD and subsequent CERCLA decision documents are issued, to create a comprehensive post-cleanup plan for the U Plant Area. Existing groundwater monitoring programs will be used to the extent practicable.

Following cleanup, the area would move to a condition of long-term care, postclosure care, or other condition suitable for long-term stewardship. Stewardship efforts typically consist of a 30-yr postclosure care period of monitoring, inspection, maintenance, and record keeping. Long-term care may be implemented after the postclosure period, as necessary, to ensure continuing protection of human health and the environment.

1.4 CERCLA AND RCRA INTEGRATION

The Tri-Party Agreement addresses the need for the cleanup programs to integrate the requirements of CERCLA and RCRA, to provide a standard approach to direct cleanup activities in a consistent manner, and to ensure that applicable regulatory requirements are met. Details of this integration are provided in Article IV and Sections 5.5 and 6.3 of the Tri-Party Agreement. Additionally, DOE/RL-98-28 provides a discussion on integration for the Central Plateau. Integration of CPP, RPP, and RCRA TSD sites in this FFS streamlines the evaluation of remedial alternatives and provides a consistent approach for reaching and implementing remedial decisions, while satisfying the requirements of the different regulations.

The 216-U-12 Crib, a TSD unit under RCRA, is incorporated into this FFS. The RCRA closure plan requirements for this TSD unit are identified in Table 1-2. The closure activities for the TSD unit are based on documentation found in this FFS, the PP, and the Administrative Record. Ecology is issuing a draft permit modification for incorporation of the 216-U-12 Crib into the *Hanford Facility RCRA Permit* (WA7890008967). The modification will identify all permit requirements for the TSD unit and is consistent with the associated CERCLA remedial action.

Information supporting the closure of the 216-U-12 Crib TSD unit is included in this FFS, the PP, or other Administrative Record documents. Table 1-2 provides a crosswalk between the information required in a RCRA closure plan and the location of the information in the applicable CERCLA document.

1.5 REPORT ORGANIZATION

The essential elements of the FFS process are presented in Chapters 1.0 through 8.0 and Appendices A though H and are summarized as follows.

- Chapter 1.0 presents the purpose, scope, and regulatory framework for the FFS, 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 site approach, and summarizes risk evaluations.

- Chapter 3.0 discusses land-use assumptions and develops the overall remedial action objectives and media-specific preliminary remediation goals for the waste sites.

- Chapter 4.0 identifies and screens technologies and develops remedial alternatives based on DOE/RL-98-28 and site-specific considerations, presents a description of each alternative, and defines the applicability of the alternative to the waste sites. This chapter also presents the results of the intruder risk evaluation.

- Chapter 5.0 presents a detailed analysis of each of the remedial alternatives against standard CERCLA criteria and *National Environmental Policy Act of 1969* values and includes the identification and evaluation of the performance standards for the TSD.

- Chapter 6.0 provides a comparative analysis of the alternatives, based on the same CERCLA criteria used in the detailed analyses.

- Chapter 7.0 summarizes the preferred alternative(s) for the waste sites and provides a description of the plug-in approach for future use and the path forward for the 200-UW-1 OU.

- Chapter 8.0 contains a compilation of all references for the main body of the report; each chapter and appendix contains its own reference section.

- Appendix A, "200-UW-1 Operable Unit Waste Site Photographs," includes current photographs of the waste sites.

- Appendix B, "Potential Applicable or Relevant and Appropriate Requirements," presents an analysis of regulatory requirements and available guidance with respect to the 200-UW-1 OU.

- Appendix C, "Human Health and Ecological Risk Assessment," presents the human health and ecological risk evaluations, including the methodology, results, and uncertainties.

- Appendix D, "200-UW-1 Operable Unit Waste Sites Vadose Zone Contaminant Fate and Transport Modeling," presents the methodology and results of the fate and transport modeling associated with select waste sites. The modeling is conducted based on baseline conditions as well as on simulating a future cap for a select number of waste sites.

- Appendix E, "Risk Assessment for an Inadvertent Intruder Scenario," presents the intruder risk evaluations, methodology, and results.

- Appendix F, "Cost Estimate Backup," presents the basis for the cost estimates.

- Appendix G, "Excavation of the 216-U-1 / 216-U-2, 216-U-8, and 216-U-12 Cribs," presents the worker dose evaluations, including methodology, assumptions, and results.
- Appendix H, "Histograms for the 216-U-1 / 216-U-2, 216-U-8, and 216-U-12 Cribs," presents contaminant profiles and discharge plots for the 216-U-1 / 216-U-2, 216-U-8, and 216-U-12 Cribs.

1.6 REFERENCES

40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," Appendix B, "National Priorities List," Title 40, *Code of Federal Regulations*, Part 300, as amended.

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DOE/RL-91-19, 1993, *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 200-UP-2 Operable Unit, Hanford Site, Richland, Washington*, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-98-28, 1999, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2000-60, 2001, *200-PW-2 Uranium Rich Process Waste Group Operable Unit RI/FS Work Plan and Process Waste RCRA TSD Unit Sampling Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

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Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington, as amended.

Ecology, EPA, and DOE, 2004, *Hanford Federal Facility Agreement and Consent Order Change Control Form*, Change Number C-03-01, dated March 16, 2004, "Modify Tri-Party Agreement Appendices B and C, Establish a New Operable Unit for Selected U Plant Area Waste Sites (200-UW-1) and Designate Ecology as the Lead Regulatory Agency," approved by Joel Hebdon, U.S. Department of Energy, Richland Operations Office, March 24, 2004; Nick Ceto, U.S. Environmental Protection Agency, April 27, 2004; and Michael A. Wilson, Washington State Department of Ecology, April 27, 2004.

EPA/541/R-97/048, 1997, *Record of Decision for the 200-UP-1 Interim Remedial Measure*, U.S. Environmental Protection Agency, Washington, D.C.

National Environmental Policy Act of 1969, 42 USC 4321, et seq.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.

WA7890008967, 1994, *Hanford Facility RCRA Permit*, Washington State Department of Ecology, Olympia, Washington.

Figure 1-1. Location of the U Plant Area in the 200 West Area, Hanford Site.

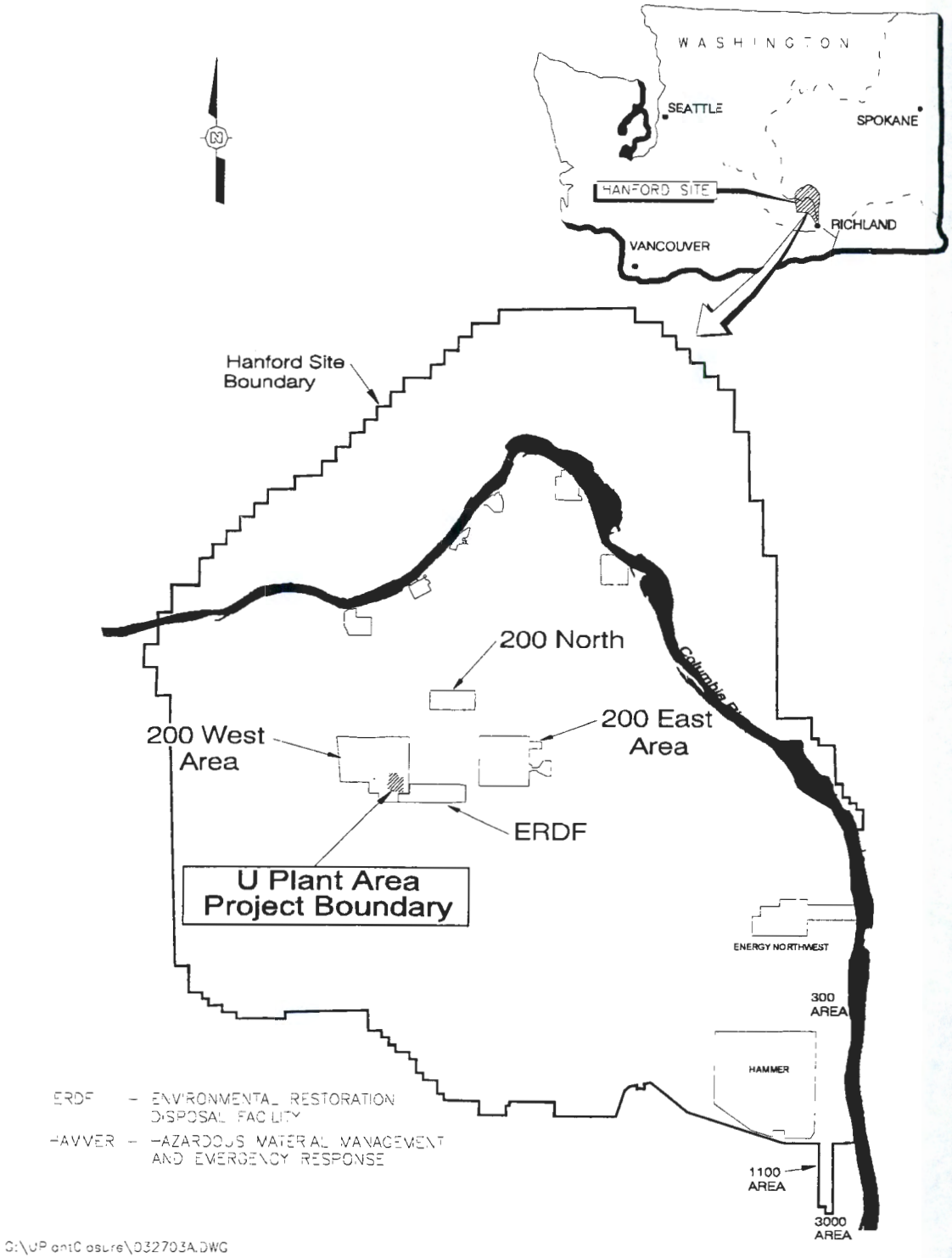

Table 1-1. 200-UW-1 Operable Unit Waste Sites.

Waste Site	Site Type	Waste Site Structure Type	Waste Site	Site Type	Waste Site Structure Type
200-W-42	RPP	pipeline	216-U-15	CPP	trench
200-W-56	RPP	dump	216-U-16	RPP	crib
200-W-57	RPP	dump	216-U-17	RPP	crib
200-W-71	RPP	trench	241-U-361	RPP	settling tank
200-W-77	RPP	unplanned release	2607-W5	RPP	septic tank and tile field
200-W-85	RPP	unplanned release	2607-W7	RPP	septic tank and tile field
200-W-87	RPP	unplanned release	UPR-200-W-8	RPP	burning ground
200-W-89	RPP	foundation	UPR-200-W-19	RPP	unplanned release
216-U-1 and 216-U-2	RPP	crib	UPR-200-W-33	RPP	unplanned release
216-U-4	RPP	reverse well	UPR-200-W-48	RPP	unplanned release
216-U-4A	RPP	French drain	UPR-200-W-55	RPP	unplanned release
216-U-4B	RPP	French drain	UPR-200-W-60	RPP	unplanned release
216-U-5	RPP	trench	UPR-200-W-78	RPP	unplanned release
216-U-6	RPP	trench	UPR-200-W-117	RPP	unplanned release
216-U-8	RPP	crib	UPR-200-W-118	RPP	unplanned release
216-U-12	TSD	crib	UPR-200-W-163	RPP	unplanned release

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq.
CPP = CERCLA past practice.
RCRA = *Resource Conservation and Recovery Act of 1976*, 42 USC 6901, et seq.
RPP = RCRA past practice.
TSD = treatment, storage, and/or disposal (unit).

Table 1-2. Crosswalk Between RCRA Treatment, Storage, and/or Disposal Closure Plan Requirements and Supporting Documentation.

RCRA Treatment, Storage, and Disposal Closure Plan Section	Information Contained	Location in Supporting Documents
1.0 Introduction	Permitting history.	FFS Chapter 2, Section 2.5.1.3.
	Closure strategy.	FFS Chapter 7, Section 7.2.
	Part A Permit Application.	DOE/RL-88-21, Section 4.2.3.8.
2.0 Facility Description and Location	Location maps and discussion.	DOE/RL-88-21, Section 4.2.3.8. FFS, Chapter 2, Section 2.5.1.3.
	Operational history.	DOE/RL-88-21, Section 4.2.3.8. FFS Chapter 2, Section 2.5.1.3.
3.0 Process Information	Process history for waste streams discharged to the TSD.	DOE/RL-88-21, Section 4.2.3.8. FFS Chapter 2, Section 2.5.1.3.
4.0 Waste Characteristics	Waste types and characteristics discharged to the TSD.	DOE/RL-88-21, Section 4.2.3.8. FFS Chapter 2, Section 2.5.1.3.
5.0 Groundwater Monitoring	Groundwater impacts and monitoring activities.	Groundwater monitoring requirements will be contained in the groundwater monitoring plan.
6.0 Closure Performance Standards	Closure strategy and performance standards.	FFS Chapter 5.0, Section 5.2, and Chapter 7.0, Section 7.2.
7.0 Closure Activities	Sampling and analysis; closure alternatives and closure requirements; includes schedule and certification of closure.	FFS, Chapter 2.0, Section 2.5.2.3. FFS, Appendix C, Tables C-3 and C-9. Closure actions and requirements described in FFS Chapters 5.0 through 7.0. Closure schedule included in the remedial design report/remedial action work plan and closure certification through the actual remediation and closeout verification process.
8.0 Postclosure Plan	Groundwater monitoring, cover design, surveillance and maintenance, inspection plan.	Will be incorporated through the U Plant Area Operations and Maintenance Plan, as necessary. Groundwater monitoring requirements will be contained in the groundwater monitoring plan.

DOE/RL-88-21, *Hanford Facility Dangerous Waste Part A Permit Application.*

FFS = focused feasibility study.
RCRA = *Resource Conservation and Recovery Act of 1976*, 42 USC 6901, et seq.
TSD = treatment, storage, and/or disposal (unit).

CHAPTER 2.0

BACKGROUND INFORMATION

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CONTENTS

2.0 BACKGROUND INFORMATION 2-1
2.1 U PLANT AREA BACKGROUND AND HISTORY 2-1
2.1.1 Buildings and Ancillary Facilities 2-1
2.1.2 221-U Plant Canyon Building 2-2
2.1.3 Uranium Oxide Plant (224-U), Including Support Buildings 224-UA, 272-U, and 2715-UA 2-3
2.1.4 276-U Solvent Handling Building 2-4
2.1.5 222-U Laboratory 2-4
2.1.6 291-U-1 Stack, 291-U Filter Building, and 292-U Stack Monitoring Station 2-4
2.1.7 271-U Support Services Building 2-4
2.1.8 211-U and 211-UA Tank Farms 2-5
2.1.9 241-WR Vault 2-5
2.1.10 275-UR Chemical Storage Warehouse 2-5
2.1.11 2714-U UO_3 Storage Facility 2-6
2.1.12 Process Lines and Encasements 2-6
2.2 LIQUID WASTE DISPOSAL 2-6
2.3 PHYSICAL SETTING 2-7
2.3.1 Meteorology 2-8
2.3.2 Topography 2-8
2.3.3 Geology 2-9
2.3.4 Vadose Zone 2-10
2.3.5 Groundwater 2-11
2.4 NATURAL RESOURCES 2-12
2.4.1 Vegetation 2-12
2.4.2 Wildlife 2-13
2.4.3 Species of Concern 2-14
2.4.4 Cultural Resources 2-15
2.4.5 Aesthetics, Visual Resources, and Noise 2-16
2.4.6 Socioeconomics 2-16
2.5 REPRESENTATIVE SITES DESCRIPTIONS 2-17
2.5.1 Representative Sites Information 2-18
2.5.2 Summary of Data Collection Activities 2-23
2.5.3 Nature and Extent of Contamination 2-26
2.5.4 Summary of Groundwater Quality 2-33
2.6 EVALUATION OF THE ANALOGOUS WASTE SITES 2-34
2.6.1 Analogous Site Assignment to Representative Sites 2-36
2.6.2 Analogous Site Groupings 2-37
2.7 SUMMARY OF RISK ASSESSMENT 2-48
2.7.1 Human Health Risk Assessment 2-49
2.7.2 Ecological Risk Assessment 2-54
2.7.3 Evaluation of Ecological significance 2-55

2.8 SUMMARY OF GROUNDWATER PROTECTION FATE AND TRANSPORT MODELING 2-59
2.9 DATA INTEGRATION WITH HANFORD SITE COMPOSITE ANALYSIS EFFORT 2-60
2.10 REFERENCES 2-61

FIGURES

Figure 2-1. U Plant Area Geologic Cross Section Index. 2-71

Figure 2-2. U Plant Area Geologic Cross Section A-A'. 2-72

Figure 2-3. U Plant Area Geologic Cross Section B-B'. 2-73

Figure 2-4. U Plant Area Geologic Cross Section C-C'. 2-74

Figure 2-5. 216-U-12 Crib Construction Diagram (DOE/RL-2000-60, Rev. 0). 2-75

Figure 2-6. 216-U-1 and 216-U-2 Cribs Conceptual Contaminant Distribution Model 2-76

Figure 2-7. 216-U-8 Crib Conceptual Contaminant Distribution Model (modified from DOE/RL-2000-60). 2-77

Figure 2-8. 216-U-12 Crib Conceptual Contaminant Distribution Model (modified from DOE/RL-2000-60). 2-78

Figure 2-9. 216-U-4 Reverse Well / 216-U-4A French Drain Conceptual Contaminant Distribution Model. 2-79

Figure 2-10. UPR-200-W-19 Unplanned Release Conceptual Contaminant Distribution Model. 2-80

Figure 2-11. Application of Analogous Site Approach. 2-81

TABLES

Table 2-1. Application of Analogous Site Approach to 200-UW-1 Operable Unit Representative Waste Sites. 2-85

Table 2-2. U Plant Area Groundwater Contaminant Trends (Modified from DOE/RL-2003-58). 2-86

Table 2-3. 216-U-1 and 216-U-2 Crib and Associated Analogous Waste Sites 2-87

Table 2-4. 216-U-8 Crib and Associated Analogous Waste Sites. 2-89

Table 2-5. 216-U-12 Crib and Associated Analogous Waste Sites. 2-92

Table 2-6. 216-U-4 Reverse Well/216-U-4A French Drain and Associated Analogous Waste Sites. 2-98

Table 2-7. Unplanned Release UPR-200-W-19 and Associated Analogous Waste Sites. 2-100

Table 2-8. Waste Site Risk Summary. 2-111

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TERMS

221-U Facility	U Plant Canyon Building
224-U	Uranium Oxide Plant or UO_3 Plant
ALE	(Fitzner/Eberhardt) Arid Lands Ecology (Reserve)
amsl	above mean sea level
AUF	area use factor
bgs	below ground surface
BCG	biota concentration guide
BDAC	Biota Dose Assessment Committee
BRMaP	Biological Resources Management Plan (DOE/RL-96-32)
CCU	Cold Creek unit
CERCLA	*Comprehensive Environmental Response, Compensation and Liability Act of 1980*
COPC	contaminant of potential concern
CUL	cleanup level
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
EPC	exposure-point concentration
ERA	ecological risk assessment
ETF	Effluent Treatment Facility
FFS	focused feasibility study
FS	feasibility study
HAB	Hanford Advisory Board
HHRA	human health risk assessment
HNO_3	nitric acid
LFI	limited field investigation
MCL	maximum contaminant level
MSCM II	Mobile Surface Contamination Monitor
NPH	normal paraffin hydrocarbon
OU	operable unit
PUREX	Plutonium-Uranium Extraction (Plant) or U Plant
RCRA	*Resource Conservation and Recovery Act of 1976*
REDOX	Reduction-Oxidation (Plant) or S Plant
RESRAD	RESidual RADioactivity (code)
RI	remedial investigation
RI Report	DOE/RL-2000-35
RLS	Radionuclide Logging System
SAC	*System Assessment Capability* model and database (PNNL-14027)
SALDS	State-Approved Land Disposal Site
SCA	surface contamination area
SLERA	screening-level ecological risk assessment
TBP	tributyl phosphate
TEDF	Treated Effluent Disposal Facility

Tri-Cities	Richland, Pasco, and Kennewick, Washington
Tri-Parties	Ecology, EPA, and DOE
TSD	treatment, storage, and/or disposal (unit)
UCL	upper confidence limit
UNH	uranyl nitrate hexahydrate
UO_3	uranium oxide or trioxide
USRADS	Ultrasonic Ranging and Data System
VCP	vitrified clay pipeline
WAC	*Washington Administrative Code*
WIDS	*Waste Information Data System* database

2.0 BACKGROUND INFORMATION

This chapter of the 200-UW-1 Operable Unit (OU) focused feasibility study (FFS) includes a brief background and history of the U Plant Area, including the liquid waste generating process, physical setting, natural resources, cultural resources, socioeconomics, representative site descriptions, evaluation of the analogous waste sites, and a summary of the risk assessment. This chapter also includes the available information on waste sites that were not characterized during the 200-UP-2 Groundwater OU limited field investigation (LFI), for the purpose of associating the analogous sites to the contaminant distribution models for the representative sites identified for each analogous group. This association between the representative sites and the analogous sites is needed to support the evaluation of remedial alternatives for the analogous sites, using the information from the representative sites, and is presented in Section 2.6 of this FFS.

Generally, the representative sites are similar to or bound the waste characteristics for the OU. The representative sites are investigated in the remedial investigation (RI), and then the data from these sites are used to make decisions for the OU as a whole. The representative sites are identified in Section 2.5 of this FFS (216-U-1 and 216-U-2 Cribs, 216-U-8 Crib, 216-U-12 Crib, 216-U-4 Reverse Well/216-U-4A French Drain, and unplanned release UPR-200-W-19). The 200-UW-1 OU waste sites are shown in Plate 1, located in the pocket at the end of this document.

2.1 U PLANT AREA BACKGROUND AND HISTORY

2.1.1 Buildings and Ancillary Facilities

The Hanford Site, established in 1943, was originally designed, built, 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 Areas and three chemical processing facilities (B, T, and U Plants) in the 200 Areas. Operations in the 200 East and 200 West Areas mainly were related to the separation of special nuclear materials from spent nuclear fuel (i.e., fuel that has been withdrawn from a nuclear reactor following irradiation). Operations in the 200 West Area consisted of four main processing areas:

- S Plant and T Plant, where initial processing to separate uranium and plutonium from irradiated fuel rods took place
- U Plant, where uranium recovery operations took place
- Z Plant, where plutonium separation and recovery operations took place.

The following sections describe the U Plant Canyon Building (221-U Facility) and associated ancillary buildings and facilities, including a summary of the history of operations, important

waste-generating processes, and liquid waste disposal practices. Although these buildings and ancillary facilities are not within the scope of this FFS, they represent the primary sources of waste disposed to the 200-UW-1 OU waste sites and are, therefore, of interest for this FFS.

2.1.2 221-U Plant Canyon Building

The 221-U Plant Canyon Building is one of three identical Hanford Site chemical separations plants constructed from 1944 through 1945 in support of World War II plutonium production. They were called canyon buildings because of their very large size and the canyon-like appearance of their interiors. The U Plant, like the B Plant and T Plant, was built to extract plutonium from fuel rods irradiated in the Hanford Site production reactors. Each separations plant was equipped to use a bismuth phosphate separation process. Because early operational experience indicated that the B Plant and T Plant were sufficient to meet production goals, the U Plant was held in reserve. The 221-U Plant was used to train B Plant and T Plant operators until 1952, when it was converted to the tributyl phosphate (TBP) process to recover uranium from bismuth phosphate process wastes. At that time, it became known as the Uranium Recovery Plant. A later operation conducted at the 221-U Facility was the scavenging or precipitation of long-lived fission products from process waste. The 221-U Facility was placed in standby in 1958 and subsequently was retired.

The 221-U Facility TBP process recovered residual uranium from B Plant and T Plant waste that had been stored in tank farms in the 200 East and 200 West Areas of the Hanford Site. The waste tanks were sluiced with their own supernatant liquid to produce slurries, which then were pumped to the 221-U Facility via underground stainless steel transfer lines. After the waste sludge was dissolved with nitric acid, uranium in the acidified feed was separated from the bulk of the fission products and small amounts of plutonium, using a solvent extraction process. The solvent extraction process used a light-phase solvent, TBP in a kerosene (paraffin hydrocarbon) diluent, to extract the uranium from the aqueous phase in countercurrent extraction columns. This process left the fission products, sulfate, nitrate, and phosphate ions in aqueous solution. The uranium was partitioned into the organic phase. Uranium was then stripped from the organic solvent with nitric acid. The organic solution was sent to the solvent recovery operation in the 296-U Solvent Recovery Building, while the uranium-rich aqueous solution (uranyl nitrate hexahydrate [UNH]) was sent to the uranium trioxide process in the UO_3 Plant (HW-19140, *Uranium Recovery Technical Manual*). The UNH then was converted to uranium oxide (UO_3) by calcination at high temperatures in the UO_3 Plant (SD-DD-FL-001, *Rockwell Retired Contaminated Facility Listing and Description*; RHO-HS-ST-10, *Historical Timelines of Hanford Operations*; PNL-6964, *A History of Major Hanford Operations Involving Radioactive Materials*; and the *Waste Information Data System* [WIDS] database).

Within the extraction process, a condensate stream containing radioactive and chemical contaminants was generated in evaporators that concentrated process solutions. An offgas stream containing radioactive and chemical contaminants also was generated in the evaporation process and the vessel vent system. An additional source of liquid waste was spillage of process liquids in the building. Sumps collected spilled liquids and other cell drainage and discharged the materials to the cribs. A steam condensate stream was produced from heating the process equipment and tanks. The steam condensate stream generally was uncontaminated. Cooling

water from evaporator condensers and process equipment were additional sources of generally uncontaminated wastewater. Process condensate, process waste, cell drainage, and spent solvent were disposed to the 216-U-1 Crib, 216-U-2 Crib, 216-U-5 Trench, 216-U-6 Trench, and 216-U-8 Crib. Steam condensate, chemical sewer waste, and cooling water were disposed to the 216-U-14 Ditch.

The same underground lines used to pump bismuth phosphate process wastes from the tank farms to the 221-U Facility were used to pump TBP process waste approximately 4.8 km (3 mi) from the 221-U Facility to disposal facilities (ultimately cribs and trenches) near the B Plant in the 200 East Area. The 221-U Facility non-TBP waste was disposed of in nearby waste sites in the U Plant Area and to the east in the 216-U-14 Ditch and the 216-U-10 Pond (DOE/RL-91-52, *U Plant Source Aggregate Area Management Study Report*).

2.1.3 Uranium Oxide Plant (224-U), Including Support Buildings 224-UA, 272-U, and 2715-UA

Located immediately south of the 221-U Facility, the Uranium Oxide or UO_3 Plant is a complex of several buildings, aboveground tanks, storage areas, and loading/unloading facilities. The three-story 224-U Building is the primary building in the complex. 224-UA, 272-U, and 2715-UA are support buildings. The UO_3 Plant was constructed as part of the original 221-U Facility complex in 1944 to be a production facility for fuel processing, but it never was used for this original purpose. It was operated as a training facility from 1944 to 1950 and then was converted in 1952 to a uranium reduction facility. It was converted again in 1955 to its current UO_3 configuration in support of the plutonium-uranium extraction (PUREX) UO_3 mission. The UO_3 Plant operated until 1972 when the PUREX Plant was put in stand-down. During that time, the UO_3 Plant converted UNH received from the PUREX Plant and the Reduction Oxidation (REDOX) S Plant into UO_3 powder. The UO_3 powder was packaged and interim stored at the UO_3 Plant before being sent to the Oak Ridge National Laboratory in Tennessee and later to Fernald, Ohio, where it was converted to uranium metal and then returned to the Hanford Site 300 Area for fuel extrusion rework. The UO_3 Plant resumed operations in 1984 to process UNH from the PUREX Plant. Because the feed lines from the REDOX Plant and the 221-U Facility were no longer in use, they were disconnected and capped in the UO_3 Plant. Operations of the UO_3 Plant ceased in 1988 (DOE/RL-2000-60, *200-PW-2 Uranium-Rich Process Waste Group Operable Unit RI/FS Work Plan and Process Waste RCRA TSD Unit Sampling Plan*).

The 224-U Building produced process condensate waste from the concentration and calcination of UNH. The process condensate consisted mainly of condensed water; it included rain water collected in the radiation zone sumps and nitric acid vapor, both of which were neutralized before being discharged to cribs. Noncorrosive steam condensate from the building heating systems, process equipment cooling water from the condensers, and rain water from the nonradiation areas were discharged to the 207-U Retention Basin and the 216-U-14 Ditch to the west. Other condensate and cooling water from the facility went to the 241-U-361 Settling Tank. Liquid waste from the 224-U Building contributed to the waste inventories in the 216-U-1, -2, -8, -12, -16, and -17 Cribs.

2.1.4 276-U Solvent Handling Building

The 276-U Solvent Handling Building is attached to the south end of the 221-U Facility. Organic solvents used in the uranium extraction processes at the 221-U Facility were sent to the 276-U Solvent Handling Building for treatment and makeup. There the solvents (particularly TBP) were cleaned by a carbonate scrub process and returned to the 221-U Facility. A carbonate scrub solution waste was generated that contained sludge materials (soils and materials picked up during processing) cleaned from the solvents and discharged to cribs. Spent solvents also were a part of this waste stream.

2.1.5 222-U Laboratory

The U Complex Laboratory (222-U Laboratory) located directly southeast of the 221-U Facility operated from about 1947 to 1970 and provided analytical services in support of the 221-U and 224-U Building operations. Later, it was used for laboratory space and offices in support of soil analysis for radioactive waste disposal. A liquid waste stream was generated from the laboratory facility that included sample disposal waste and hood and hot-cell cleanup waste. This waste was disposed to the 216-U-4 Reverse Well, the 216-U-4A French Drain, and the 216-U-4B French Drain.

2.1.6 291-U-1 Stack, 291-U Filter Building, and 292-U Stack Monitoring Station

The 291-U-1 Stack, which provides stack ventilation, is a 61-m (200-ft)-high concrete stack, located south of the 221-U Facility. Air from the 221-U Facility is filtered through sand filters located in the 291-U Filter Building before being exhausted up the 291-U-1 Stack. Exhausted air enters the filter building through its floor and is directed upward through sand beds held in wooden trays. Exhaust fans move the air through the filters and up the stack. The 292-U Stack Monitoring Station provided support for monitoring the air discharge. The sand filter is designated as the 200-W-44 Waste Site, which will be demolished as part of the ancillary structure work scope. Drainage from the 291-U Stack was discharged to cribs. The area around these facilities has been posted as a contamination area.

2.1.7 271-U Support Services Building

The 271-U Support Services Building is adjacent to the 221-U Facility and shares its northern wall. The three-story, reinforced-concrete and pumice block structure is 48.8 m (160 ft) long, 15 m (48 ft) wide, and 20 m (65 ft) high. An exhaust stack, the 296-U-10 Stack, sits atop the building and is considered a part of this facility. The building has been used for office space, craft shops, storage, and training facilities in support of the 221-U Facility. Some minimal contamination exists in various parts of the building.

2.1.8 211-U and 211-UA Tank Farms

Both tank farms are located on the west side of the 221-U Facility. The 211-U Tank Farm was a bulk liquid storage area, consisting of nine aboveground tanks. Of six horizontal tanks, three were used for storage of sodium hydroxide, one was used for storage of demineralized water, and two were spare tanks. The remaining three tanks were vertical and were used for storage of demineralized water or as chemical makeup tanks.

The 211-UA Tank Farm consisted of 16 aboveground tanks. Thirteen tanks have a capacity of 380,000 L (100,000 gal) each. Nine of these tanks were used for nitric acid storage, while the remaining four tanks stored sodium hydroxide. Three smaller tanks also were used for storing nitric acid. Bulk liquid was transported to the tanks in the tank farms in railcars or trucks. The area around these tank farms is posted as a contamination area.

2.1.9 241-WR Vault

Constructed in 1952 as part of 221-U uranium recovery program modification, the 241-WR Vault is an underground concrete structure northwest of the 221-U Facility and contains nine 190,000 L (50,000-gal) storage tanks and associated pumps, valves, and agitators. These were used during 221-U Facility operation (from 1952 through 1958) to store UNH for feed to the 221-U Facility, for temporary storage of recovered nitric acid (HNO_3), and to hold TBP waste[1] before routing it to B Plant cribs and trenches. The UNH, HNO_3, and TBP wastes were transferred to the vault through underground transfer lines. Following termination of 221-U Facility operations in 1958, the 241-WR Vault was used to store HNO_3 and thorium from the REDOX and PUREX Plants. The HNO_3 was transferred by railroad tank car, and the thorium was transferred by truck (Knight, 1990, *Interview Conducted by D. H. Deford on October 4*; SD-DD-FL-001).

The facility is now completely sealed. The aboveground structures, entry port, and vents have been dismantled, and the facility has been sealed with a plasticized foam. All tanks and related equipment remain in place in the facility (WIDS; Knight 1990).

2.1.10 275-UR Chemical Storage Warehouse

The 275-UR Chemical Storage Warehouse, located on the north side of the 221-U Facility, is a one-story, steel-frame prefabricated building on a concrete foundation with a service ramp. The building is used as a warehouse.

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[1] TBP waste is typically defined as the organic solution of tributyl phosphate diluted with kerosene containing organic degradation products from the process and contaminated with nitrates, uranium (possibly plutonium), Tc-99, and some fission products (Cs-137 and Sr-90).

2.1.11 2714-U UO_3 Storage Facility

The 2714-U OU_3 Storage Facility, located on the north side of the 221-U Facility adjacent to the 275-UR Chemical Storage Warehouse, stores a small amount of miscellaneous equipment.

2.1.12 Process Lines and Encasements

Process lines, sometimes referred to as transfer lines or process sewer lines, connect the major process facilities with each other and with their waste-handling facilities or waste sites. Most high-level waste transfer lines are 7.6 cm (3-in.)-diameter stainless steel pipes with welded joints. These lines generally are enclosed in steel reinforced-concrete encasements and are set below grade. A few lines that pass between adjacent facilities are elevated aboveground on wooden poles. Transfer lines to liquid effluent disposal facilities (e.g., cribs) were constructed of a variety of materials including vitreous clay and galvanized metal. Some of the underground process lines and encasements have been given waste site designations such as 200-W-42 Vitrified Clay Pipeline (VCP), 200-W-84 Pipeline, 200-W-100 Pipeline, and UPR-600-20 Pipeline in the WIDS. The 241-UX-154 Diversion Box at the 221-U Facility permits routing of process fluids to various lines including transfer lines to tank farms.

2.2 LIQUID WASTE DISPOSAL

The primary liquid-waste generating processes in the U Plant Area and the associated building locations in the U Plant Area include the following:

- Uranium Recovery Process — 221-U Facility
- UO_3 Conversion Process — 224-U Building
- Solvent Treatment — 276-U Solvent Handling Building
- Analytical Laboratory Programs — 222-U Laboratory.

Liquid wastes often were discharged to the soil column via several types of structures in the U Plant Area including cribs, French drains, a reverse well, trenches, and septic systems. The following provides a general description of the function of these types of liquid waste disposal structures. Waste-site-specific descriptions are provided in Section 2.6. Additional discussion on types of waste disposal structures and associated categories of waste received is provided in the WIDS; DOE/RL-91-52; and DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan — Environmental Restoration Program.*

Cribs, French drains, and reverse well drains were designed to inject or percolate wastewater into the ground without exposing it to the open air. Water flowed directly into the backfilled material or covered open space and percolated into the vadose zone soils. The 200-UW-1 OU waste sites consist of eight cribs, two French drains, and one reverse well. Most cribs, drains, and trenches were designed to receive liquid until either the unit's specific retention or radionuclide capacity was met. The term "specific retention" is defined as that volume of waste liquid that may be disposed to the soil and held against the force of gravity by the molecular attraction between sand grains and the surface tension of the water, when expressed as a percent of the packed soil volume (HW-61644, *Techniques for Estimating the Specific Retention Properties of Hanford*

Soils). Radionuclide capacity refers to a specific number of curies of radioactivity that the waste management units were allowed to receive until they were shut down (ARH-ST-156, *Evaluation of Scintillation Probe Profiles from 200 Area Crib Monitoring Wells*).

Cribs were shallow excavations that either are backfilled with permeable material (gravel) or were held open by wooded structures and covered with an impermeable layer. They were designed to receive low- to moderate-volume low-level liquid waste streams, which included the general waste category of process condensate wastes. These wastes generally had higher levels of radionuclides, resulting from direct contact with process chemistry (e.g., acid or solvent recovery processes). Process condensates, as the name implies, were derived from process streams (often uranium-rich in the case of U Plant sites) that had been heated to boiling or near-boiling conditions or that were evolving a vapor, gas, or fume phase. The acid recovery process produced and discharged condensates with generally low pH, although neutralization of acidic wastes often occurred. Neutralization of crib wastes was performed on line at underground limestone-charged flowthrough tanks (270-W Neutralization Tank). One concern associated with this practice was that calcium liberated from the limestone out-competed cesium for exchange sites in the soil column and may have mobilized cesium.

French drains generally were constructed of vertical steel or concrete pipe placed into the ground and may have been either open or filled with gravel. French drains commonly were used for very low-volume streams. Reverse wells, also known as injection wells or dry wells, were drilled, cased boreholes with perforations (holes were drilled or punched in the casing) near the bottom of the wells. This method of waste disposal introduced contaminants deeper into the vadose zone.

Trenches were excavated to dispose of one-time discharges of low-level "uncribbable" process wastes into the ground. Waste disposed to trenches usually was limited in volume, compared to waste disposed to cribs, and was delivered by temporary overground hose or pipelines. During the 1950s, process wastes from the U Plant were discharged to two trenches. Tank cleanout sludge was discharged to a third trench. Process wastes were nonirradiated wastes resulting from the cold start-up testing of a process, a step that typically included decladding and dissolving fuel rods. Process wastes differed from process condensates in that the latter had no or negligible quantities of fission products or plutonium.

Septic systems used for sewage, kitchen waste, and janitorial waste disposal were very similar in design to gravel cribs. These facilities consisted of a large holding tank for solids and a gravel tile field for liquid overflow percolation. Piping in the tile fields normally was configured in a herringbone arrangement and was made of concrete, vitrified clay, or plastic pipe. Typically, each septic system was sized for the human occupancy in the facilities served, and dimensions of holding tanks and tile fields vary accordingly. The U Plant Area contains two septic systems.

2.3 PHYSICAL SETTING

The meteorology, topography, and hydrogeologic frameworks for the 200-UW-1 OU waste sites are briefly described in the following sections. Additional discussions are provided in DOE/RL-92-19, *200 East Groundwater Aggregate Area Management Study Report*; DOE/RL-2000-35, *200-CW-1 Operable Unit Remedial Investigation Report* (RI Report);

PNNL-13788, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*; PNNL-13910, *Hanford Site Environmental Report for Calendar Year 2001*; and PNNL-6415, *Hanford Site National Environmental Policy Act (NEPA) Characterization.*

2.3.1 Meteorology

The Hanford Site lies east of the Cascade Mountains and has a semiarid climate caused by the rainshadow 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). 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 it 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 Meteorological 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.

2.3.2 Topography

The Hanford Site is located in the Pasco Basin on the Columbia Plateau. The 200 West Area is located on the Central Plateau near the center of the Hanford Site. The 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 (amsl). The Cold Creek Bar formed during the cataclysmic flooding events of the Missoula floods, which ended approximately 13,000 years ago. The floodwaters deposited a thick sand and gravel bar that constitutes the higher southern portion of the Central Plateau. In the waning stages of the ice age, these floodwaters also eroded a channel north of the Central Plateau in the area currently occupied by Gable Mountain Pond. The northern half of the 200 East Area lies within this ancient flood channel. The southern half of the 200 East Area and most of the 200 West Area are situated on the flood bar. A secondary flood channel running southerly from the main channel bisects the 200 West Area. The surface in the 200 West Area slopes gently to the west. In general, natural slopes within the U Plant Area range from 0.5 to 5 percent.

2.3.3 Geology

The following discussion of geology uses terminology from DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for Post-Ringold Formation Sediments Within the Central Pasco Basin*. Basalt of the Columbia River Basalt Group and a sequence of suprabasalt sediments underlie the 200 West Area. From oldest to youngest, major geologic units of interest are the Elephant Mountain Basalt Member, the Ringold Formation, the Cold Creek unit (CCU), the Hanford formation, and the Holocene deposits. Cross Sections A-A', B-B', and C-C' were generated from boreholes in the U Plant Area and present the spatial relationships of these units across that area. Figure 2-1 provides a cross section index map to the three cross sections provided in Figures 2-2 through 2-4. Included on these figures are the referenced wells and key structures(e.g., waste sites, facilities). Note that the structures are not to scale.

The uppermost unit of the Columbia River Basalt Group beneath the U Plant Area is the Elephant Mountain Basalt Member, a medium- to fine-grained tholeiitic basalt with abundant microphenocrysts of plagioclase (DOE/RW-0164, *Consultation Draft, Site Characterization Plan, Reference Repository Location, Hanford Site, Washington*). The basalt is overlain by the Ringold Formation in the 200 West Area.

The fluvial-lacustrine Ringold Formation is informally divided into several units. This formation consists of an interstratified sequence of unconsolidated clay, silt, sand, and granule-to-cobble gravel deposited by the ancestral Columbia River. These alluvial sediments consist of four major units (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 unit. The Ringold Formation is overlain by the Plio-Pleistocene and CCU-aged units in the 200 West Area.

The CCU includes the sedimentary sequence that disconformably overlies the Ringold Formation and underlies cataclysmic flood deposits of the Hanford formation in the 200 West Area. The CCU includes those deposits formerly referred to as the "Plio-Pleistocene unit" and "pre-Missoula Gravels," as well as the "early Palouse soil" and "caliche layer" in the 200 West Area. The CCU consists of poorly sorted, interbedded, reworked loess, silt, sand, and basaltic gravel (WHC-SD-EN-T1-290, *Geologic Setting of the Low-Level Burial Grounds*). The subunit is interpreted to be a weathering surface developed on the top of the Ringold Formation (WHC-SD-EN-T1-290; PNL-7336, *Geohydrology of the 218-W-5 Burial Ground, 200 West Area, Hanford Site*) and consists of a lower carbonate-rich paleosol (caliche of the carbonate unit) and an upper eolian facies. The carbonate-rich section consists of interbedded carbonate-poor and carbonate-rich strata. The upper silty eolian facies previously was interpreted to be early Pleistocene loess and was referred to as the early Palouse soil (PNL-7336). Generally, it is well-sorted quartz-rich/basalt-poor silty sand to sandy silt (BHI-00270, *Preoperational Baseline and Site Characterization Report for the Environmental Restoration Disposal Facility*).

Glaciofluvial cataclysmic flood deposits of the Hanford formation are present throughout the 200 Areas. The Hanford formation consists of unconsolidated gravel, sand, and silts deposited by cataclysmic floodwaters. These deposits consist of gravel-dominated and sand-dominated facies. The gravel-dominated facies are cross-stratified coarse-grained sands and

granule-to-boulder gravel. The gravel is uncemented and matrix-poor. The sand facies are well-stratified fine- to coarse-grained sand and granule gravel. Silt in these facies is variable and may be interbedded with the sand. Where the silt content is low, an open-framework texture is common.

Holocene-aged deposits overlie the Hanford formation and are dominated by eolian sheets of sand that form a thin veneer across the site, except in localized areas where the deposits 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 has settled out through standing water over many years.

2.3.4 Vadose Zone

In the 200 West Area, the vadose zone thickness ranges from 79 m (261 ft) in the southeast corner to 102 m (337 ft) in the northwest corner. Sediments in the vadose zone are the Ringold Formation (the uppermost Ringold unit E and the Upper Ringold), the CCU, and the Hanford formation. Erosion during cataclysmic flooding removed some of the Ringold Formation and CCU. Perched water historically has been documented above the CCU at locations in the 200 West Area. Because most discharge to the surface was ceased in the late 1980s, perched water is infrequently encountered in the vadose zone.

Recharge to the unconfined aquifer in the 200 West Area is from artificial and possibly natural sources. Any natural recharge originates from precipitation. Estimates of recharge from precipitation at 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 (PNL-10285, *Estimated Recharge Rates at the Hanford Site*). For the disturbed areas above the waste sites (i.e. stabilization cover), a recharge rate of 1.44 cm/yr has been assumed. Artificial recharge occurred when effluents such as cooling water and process waste water were disposed to the ground. PNL-5506, *Hanford Site Water Table Changes 1950 Through 1980 – Data Observations and Evaluation*, reports that between 1943 and 1980, 6.33×10^{11} L (1.67×10^{11} gal) of liquid wastes were discharged to the soil column.

The 2607-W5 and 2607-W7 Septic Systems located in the U Plant Area continued to discharge after 1980. The 2607-W7 Septic System was removed from service in 1999, and the 2607-W5 Septic System is expected to be removed from service in the next several years as the U Plant closure progresses. The total effluent volume discharged through these systems is unknown; however, during their operation, the discharge rates were estimated at 12,100 L/day for the 2607-W5 Septic System and 1,000 L/day for the 2607-W7 Septic System.

According to HNF-EP-0527-12, *Environmental Releases for Calendar Year 2002*, by August 1997, all Central Plateau significant liquid-effluent discharges to the ground were either discontinued or rerouted to the 200 Areas Treated Effluent Disposal Facility (TEDF). Significant wastewater streams from the Plutonium Finishing Plant, T Plant, PUREX Plant, B Plant, 242-A-81 Water Service Building, and 283-E and 283-W Water Treatment Plants were rerouted to the Central Plateau TEDF. Other rerouted streams consist of steam condensate and

cooling water from the 242-A Evaporator, A Tank Farm, 244-AR Vault, and B Plant. Reporting on individual contributory liquid effluent streams no longer is required. Data are reported on the collective effluent discharged to the two Central Plateau TEDF disposal basins. Beginning in November 1995, the Effluent Treatment Facility (ETF) began treating 242-A Evaporator process condensate, which previously had been discharged directly to the ground. The ETF also treats other radioactive liquids generated at the Hanford Site, such as groundwater from the 200-UP-1 Groundwater OU and wastewater from the 222-S Laboratory retention basins when the effluent will not meet Central Plateau TEDF acceptance criteria. The ETF treats liquid waste by filtration, ultraviolet oxidation, pH adjustment, and reverse osmosis before it is sampled, analyzed, and approved for discharge to the State-Approved Land Disposal Site (SALDS). Data are reported on the collective effluent discharged from the ETF in HNF-EP-0527-12 on a yearly basis.

According to PNNL-14301, *Monitoring Plan for RCRA Groundwater Assessment at the 216-U-12 Crib*, although process information suggests that several mobile constituents may have been released to the crib, groundwater monitoring indicates that nitrate and Tc-99 (not *Resource Conservation and Recovery Act of 1976* [RCRA] dangerous waste constituents) are the only significant contaminants of concern that have been detected. Nitrate and Tc-99 are mobile in the groundwater. The vadose zone is a continuing source of these constituents to the groundwater. Both nitrate and Tc-99 concentrations are declining as residual drainage from the vadose zone beneath the crib decreases.

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. However, residual moisture in the vadose zone may 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.

A SALDS is located 1,200 ft north of the 200 West Area exclusion fence and receives liquid waste that has been treated at the Central Plateau ETF in the 200 East Area (*Waste Information Data System, 600-211 General Summary Report* database), but has no impact on the vadose zone in the U Plant Area.

2.3.5 Groundwater

The unconfined aquifer in the Central Plateau occurs in the Hanford formation, the CCU, 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 it is lower (the Columbia River) (PNNL-13788). In general, groundwater flow through the 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 Pond (U Pond) in the 200 West Area and 216-B-3 (B Pond) in the 200 East Area. 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 to the south of the 216-B-3 Pond. As the hydraulic effects of these two discharge 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*).

Groundwater in the 200 West Area occurs primarily in the Ringold Formation. The depth to the water table varies from about 50 m (164 ft) in the southwest corner near the 216-U-10 Pond to greater than 100 m (328 ft) in the north. Beneath the 216-U-8 and 216-U-12 Cribs, depth to water measures approximately 78 m (255 ft), and groundwater flow is to the southeast. The water table beneath the 200 West Area is declining at a rate of 0.36 m/yr (1.2 ft/yr). A pump-and-treat system associated with Tc-99 and uranium contamination from the 216-U-1 and 216-U-2 Cribs has operated since 1994 as part of remediation activities at the 200-UP-1 Groundwater OU and has treated more than 6.09×10^6 L of groundwater (DOE/RL-2002-67, *Fiscal Year 2002 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations*).

2.4 NATURAL RESOURCES

Natural resources encompass many resources; included among these are soil, air, water, vegetation, wildlife and soil biota, transportation, socioeconomics, noise, land usage, aesthetics, and cultural resources. This section considers all of the above natural resources as associated with the 200 West Area and the U Plant. Recognizing that biological and ecological information assists in evaluating contaminant impacts and the potential effects of implementing remedial action(s) to the environment, information compiled in DOE/RL-2001-54, *Central Plateau Ecological Evaluation*, Draft B, has been included in the following sections. This information includes plant community descriptions, identification of plant and wildlife species, and avian census data. Additional information pertaining to designated levels of habitat, including rare plant populations, identified under DOE/RL-96-32, *Hanford Site Biological Resources Management Plan* (BRMaP), also is provided.

The data and descriptive information used in the following subsections were collected before the range fire that occurred from June 27 to July 1, 2000, burning 163,884 acres on the central part of the Hanford Site and the Fitzner/Eberhardt Arid Lands Ecology (ALE) Reserve. However, the fire did not impact any of the waste sites being considered in this FFS. Further detailed information regarding the ecological setting is provided in Appendix C.

2.4.1 Vegetation

As documented in the BRMaP (DOE/RL-96-32), much of the land associated with the U Plant facilities and waste sites has been disturbed by construction, operation, and waste management practices.

Most areas related to the U Plant Area are nonvegetated to sparsely vegetated with invasive grasses and forbs. Some native vegetation is present in less-disturbed areas within the 200 West Area. Available habitat in the areas immediately adjacent to the U Plant study area is

characterized as gray rubber rabbitbrush/cheatgrass (*Chrysothamnus nauseosus/Bromus tectorum*) (DOE/RL-96-32). Many of the waste disposal and storage sites in the Central Plateau have been 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).

Distant to the U Plant Area, in the lesser-disturbed tracts of native shrub-steppe within the nonindustrialized Central Plateau, 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*) (DOE/RL-96-32). Other shrubs typically present include rabbitbrush (*Chrysothamnus spp.*), spiny hopsage (*Grayia spinosa*), and antelope bitterbrush (*Purshia tridentata*). Other native bunchgrasses that also are present in shrub-steppe communities of the Central Plateau 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.*). These species may be encountered incidentally in mosaic patches throughout the 200 West Area. Dwarf evening primrose is a rare plant that has been identified on the Central Plateau, but it has not been encountered in the U Plant study area.

2.4.2 Wildlife

This section characterizes wildlife species that are present within the Central Plateau and that have been previously identified in the 200 West Area. Wildlife species specific to the U Plant Area will be identified in site-specific ecological resource reviews.

The largest mammal frequenting the Central Plateau is the mule deer (*Odocoileus hemionus*). While mule deer are much more common along the Columbia River, the few that forage throughout the Central Plateau 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 ALE, and a few animals occasionally have been observed south of the 200 Areas.

Other mammals common to the Central Plateau 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 Central Plateau 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 searches for food, 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 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 vicinity of the U Plant Area include the starling (*Sturnus vulgaris*), horned lark (*Eremophila alpestris*), western 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 Central Plateau in abandoned badger or coyote holes or in open-ended stormwater pipes along roadsides in more industrialized areas. The 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 vegetated with cheatgrass.

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

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

2.4.3 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 have been 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).

No plants, invertebrates, amphibians, reptiles, or mammals are on the Federal or State of Washington threatened and endangered species lists. Several threatened, endangered, and candidate species are found in and near the 200 Areas, such as 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 may occur in the study area include dwarf evening primrose and Piper's daisy (*Erigeron piperianus*) (WNHP 1998, *Washington Rare Plant Species by County*).

Both plant and animal species of concern, their designations, and the places of their occurrence can change over time. At this time, none are suspected of having the potential to affect the characterization or remediation of the U Plant Area waste site significantly, but incorporating the needs of these species into project planning will help to 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 has been designated as Level 3 habitat in the BRMaP (DOE/RL-96-32), which requires mitigation of any

disturbance (for example through avoidance and minimization) and possibly rectification and compensation. More detailed direction on protecting Level 3 habitats and species of concern is provided in the BRMaP guidance. 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.

2.4.4 Cultural Resources

A comprehensive archaeological survey of the Central Plateau found artifacts in conjunction with areas of high topographic relief or nearby 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 that crosses northeast to southwest in the northwest corner of the 200 West Area. The report concluded that additional cultural resource reviews are required only for proposed projects within 100 m of this road. None of the waste sites associated with the U Plant Area closure are within 100 m of this road (PNL-7264).

PNL-7264 addressed only undisturbed portions of the Central Plateau 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, have been 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 these requirements and to determine the eligibility of historic properties for the "National Register of Historic Places" (36 CFR 60). The treatment plan evaluated and classified waste sites and structures on the Hanford Site, including those in the 200 Areas, and proposed recommendations for mitigation. Treatment options for mitigation were determined using 36 CFR 60, Section 60.4, "National Register of Historic Places," "Criteria for Evaluation." None of the 200-UW-1 OU waste sites were recommended for individual documentation as contributing properties. Sites beginning with "216" (e.g., 216-U-5 Trench, 216-U-8 Crib) were identified as noncontributing exempt properties (DOE/RL-97-56). Some sites not addressed in DOE/RL-97-56, such as unplanned releases and septic tanks, that were not considered to be significant enough to be evaluated will be evaluated under site-specific preremediation cultural resource reviews.

No cultural resources have been directly associated with 200-UW-1 OU waste sites (PNL-7264, DOE/RL-97-56, PNNL-6415). However, site-specific cultural resource reviews will be required for each waste site before remediation or other ground-disturbing activities are begun. In addition to the site-specific review, a cursory field review of plant and animal life may be conducted in concert with this effort.

2.4.5 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) amsl, forms the southwestern boundary of the Hanford Site, and Gable Mountain and Gable Butte are the next highest landforms on the Hanford Site itself. The view toward Rattlesnake Mountain is visually 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 Site and forming the eastern boundary, generally is considered scenic.

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

2.4.6 Socioeconomics

The Hanford Site plays a dominant role in the socioeconomics of the Tri-Cities (the cities of Richland, Pasco, and Kennewick) and other parts of Benton and Franklin Counties. Major changes in Hanford Site activity and employment likely would affect these areas.

In 2001, the average number of jobs in the Tri-Cities was 89,100 (PNNL-6415, Rev. 14). Of these, the U.S. Department of Energy (DOE) and its prime contractors employed an average of 10,700 people, making the Hanford Site the largest single source of employment in the area. The total wage payroll for the Hanford Site accounted for nearly 21 percent of the total wage income in the area. In addition to the direct employment and payrolls, Hanford Site activities also support a large number of jobs in the local economy through their procurement of equipment, supplies, and business services. Direct procurements and subcontracts represented about 12 percent of the total sales in the Tri-Cities economy during fiscal year 1999. Overall, about 28,250 Tri-Cities jobs, or 32 percent of the nonfarm jobs in the economy, are supported directly or indirectly by the Hanford Site payroll, procurements, and contracts (PNNL-6415, Rev. 14).

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

- Energy Northwest
- The agricultural community (including the ConAgra food processing plant)
- Tyson Fresh Meats Plant
- AREVAFramatome ANP
- Boise Paper Solutions
- Burlington Northern Railroad.

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

Data from the 2000 Census indicated population totals for Benton and Franklin Counties at 142,500 and 49,300, respectively (U.S. Census Bureau, Washington QuickFacts at http://quickfacts.census.gov/qfd/states/53/53005.html for Benton County and http://quickfacts.census.gov/qfd/states/53/53021.html for Franklin County). When compared to the 1990 census data, the current population totals reflect the continued growth occurring in these two counties. Increased growth is expected in the future.

The 2000 Census data for ethnic categories indicate that, in Benton and Franklin Counties, Asians represent a lower proportion, and individuals of Hispanic origin represent a higher proportion of the ethnic distribution than elsewhere in Washington State.

2.5 REPRESENTATIVE SITES DESCRIPTIONS

Facilities can have multiple waste sites that are geologically similar and that have similar process and waste disposal histories. In these situations, the analogous site concept can be used to reduce the amount of site characterization and evaluation required to support remedial action decision making. For the analogous site approach, waste sites are combined into groups of sites with similar location, geology, waste site history, contaminants, etc. Within each group, one or more representative sites are then selected for comprehensive field investigations, including sampling. Findings from site investigations at representative sites then are applied to other waste sites in the waste group that were not characterized. Sites for which field data have not been collected are assumed to have similar or "analogous" chemical characteristics to the site(s) that were characterized. Confirmatory investigations of limited scope, rather than full characterization efforts, will be performed at the sites not selected as representative sites.

The evaluation of remedial alternatives focuses on the representative sites but is acknowledged to extend to other sites in the group. A remedy is selected for all of the sites in the group, based on the investigation of the representative sites. Confirmation sampling of the analogous sites may be required after remedy selection and is built into the remedial design planning to demonstrate that analogous conditions exist.

This section describes the waste sites that were selected as representative sites for the 200-UW-1 OU. The following representative sites were identified in the 200-UW-1 OU:

- 216-U-1 and 216-U-2 Cribs
- 216-U-8 Crib
- 216-U-12 Crib
- 216-U-4 Reverse Well/216-U-4A French Drain
- Unplanned release UPR-200-W-19.

Each of these representative sites was characterized during the 200-UP-2 Groundwater OU LFI (DOE/RL-95-13, *Limited Field Investigation for the 200-UP-2 Operable Unit*). The findings from site investigations at representative sites, the contaminant distribution model, and the risk assessments are extended to apply to other sites in the waste group (analogous sites) that were not characterized. Analogous sites for which field data have not been collected are assumed to have contaminant distribution and risk characteristics similar to those of the representative sites, based on process knowledge and site conditions. Although a degree of uncertainty exists in

employing the analogous site concept, substantial benefit is realized in the early selection of a remedy that allows early cleanup action to be performed. The representative sites are discussed in this section, and the analogous site groupings are discussed in the following section. Table 2-1 provides a listing of the representative waste sites and the analogous sites assigned to each representative site. The criteria and rationale for selecting representative sites and assigning analogous site groupings are discussed further in Section 2.6 of this FFS.

2.5.1 Representative Sites Information

Descriptions and historical use of the representative sites are briefly described below. Representative site information has been compiled from the WIDS, supplemented by the following reference documents:

- DOE/RL-2000-60
- DOE/RL-95-106, *Focused Feasibility Study for the 200-UP-2 Operable Unit*
- DOE/RL-91-52
- BHI-00174, *U Plant Aggregate Area Management Study Technical Baseline Report*
- PNNL-14301.

2.5.1.1 216-U-1 and 216-U-2 Cribs

The 216-U-1 and 216-U-2 Cribs have been selected as a representative site for the 200-UW-1 OU. Table 2-3 provides the rationale for selection of this site as a representative site, along with the background and a description of the analogous waste sites included in this group. This section provides a brief description of the 216-U-1 and 216-U-2 representative site and its background.

Although the 216-U-1 and 216-U-2 Cribs have individual site designations, they are connected in cascade by a stainless steel pipe. Each crib consists of a subsurface box-shaped wooden structure constructed at the bottom of an open excavation that was backfilled. The wood structure itself was not backfilled with gravel, and therefore remains as void space. Vent pipes were installed within the cribs and extended above the ground surface.

The waste discharged to the 216-U-1 and 216-U-2 Cribs passed through the 241-U-361 Settling Tank to remove suspended solids. From 1951 to 1957, the 216-U-1 and 216-U-2 Cribs received cell drainage from the 5-6 tank in the 221-U Canyon Building, waste from the conversion of uranyl nitrate to UO_3 in the 224-U Building, 276-U Building solvent scrubbing waste, and waste from the 224-U Building UO_3 equipment decontamination liquids. The uranium recovery process operations in the 221-U Canyon Building were shut down from 1957 until May 1967, after which these cribs received waste from the 224-U Facility UO_3 equipment decontamination waste and reclamation waste from the 221-U Canyon Building (WHC-SD-EN-ES-040, *Engineering Study of 50 Miscellaneous Inactive Underground Radioactive Waste Tanks Located at the Hanford Site, Washington*).

In the spring of 1953, organic wastes and cell drainage from the TBP process in the 221-U Facility and waste from the 224-U Building (UO_3) overflowed to the ground. Contamination covered an area of approximately 4.6 m^2 (50 ft^2). The area where the release occurred is

currently marked as an Underground Radioactive Material Area, which contains the 216-U-1 Crib, 216-U-2 Crib, and the 241-U-361 Settling Tank. A portion of the 2607-W5 Septic Tank and Tile Field also is included in the Underground Radioactive Material Area. This area was designated as UPR-200-W-19; see Section 2.5.1.5 for further discussion.

In early 1985, liquid discharges to the 216-U-16 Crib were sufficient to pool above a caliche layer (about 165 ft below the surface), move laterally northward below the 216-U-1 and 216-U-2 Cribs, and transport uranium from those cribs through holes in the caliche layer to groundwater. The resulting uranium and Tc-99 groundwater plume continues to be addressed today by the 200-UP-1 Groundwater OU pump-and-treat system.

Characterization data from three borings installed in the 1994 200-UP-2 Groundwater OU LFI are available in DOE/RL-95-106.

2.5.1.2 216-U-8 Crib

The 216-U-8 Crib has been selected as a representative site for the 200-UW-1 OU. Table 2-4 provides the rationale for selection of this site as a representative site, along with the background and a description of the analogous waste sites included in this group. This section provides a brief description of the 216-U-8 Crib representative site and its background. The 216-U-8 Crib is located approximately 137 m (450 ft) west of Beloit Avenue and 229 m (750 ft) south of 16th Street. The crib received acidic process condensate from the 221-U and 224-U Buildings, along with drainage from the 291-U-1 Stack via an underground 15 cm (6–in.) VCP. The site is marked and posted with Underground Radioactive Material Area signs.

The site consists of three wood timber cribs in series at the bottom of a backfilled trench oriented north-south. The bottom of the excavation measures 48 by 15 m (160 by 50 ft). Each timber crib measures 4.9 by 4.9 by 3.0 m deep (16 by 16 by 10 ft). The cribs were filled with crushed stone to the tops of the timber structures. The site contains roughly 2,070 m^3 (73,000 ft^3) of gravel fill within the three timber crib structures.

The 216-U-8 Crib was in operation from June 1952 to March 1960, when it was deactivated by blanking the pipeline approximately 18 m (60 ft) north of the unit when ground settling occurred around the crib vent risers. The effluent was rerouted to the 216-U-12 Crib. The sink holes were backfilled around the vent risers.

In 1994, the area over the crib and a portion of the VCP were stabilized. About 8 to 10 cm (3 to 4 in.) of soil were removed from the area above the VCP (200-W-42 VCP/UPR-200-W-163) and consolidated over the top of the 216-U-8 Crib. The area over the crib and consolidated soils was covered with about 0.5 to 0.6 m (1.5 to 2 ft) of soil (BHI-00268, *216-U-8 and UN-216-W-33 Interim Stabilization Final Report).*

2.5.1.3 216-U-12 Crib

The 216-U-12 Crib has been selected as a representative site for the 200-UW-1 OU. Table 2-5 provides the rationale for selection of this site as a representative site, along with the background and a description of the analogous waste sites included in this group. This section provides a brief description of the 216-U-12 Crib representative site and its background.

The 216-U-12 Crib is located in the 200 West Area about 650 m (2,130 ft) south of the 221-U Facility 140 m (460 ft) north of Beloit Avenue and is south of the 216-U-8 Crib. The 216-U-12 Crib was built in 1960 to replace the 216-U-8 Crib when it showed signs of cave-in. The 216-U-12 Crib was operational until 1988, when the pipeline was cut and capped. The 216-U-12 Crib was replaced by the 216-U-17 Crib. In 1992, the site surface was radiologically surveyed and downposted from a Surface Contamination Area to an Underground Radioactive Material Area. (See Plate 1, located in a pocket at the end of this FFS).

The 216-U-12 Crib, a percolation unit, was used to dispose of UO_3 (uranium-oxide) process condensate. The unit was designed to receive mixed waste (corrosive, D002) from the 221-U Facility, via a 15 cm (6-in.) VCP, for approximately 5 minutes every hour, at the rate of 378 L/min (100 gal/min), and to dispose of the process condensate by percolation into the soil column (DOE/RL-95-13). These process condensate discharges were considered only a dangerous waste because of corrosivity caused by the 221-U Facility operations.

From April 1960 to May 1967, the site received 291-U-1 Stack drainage; 241-WR Vault waste; and 224-U Building process condensate via the C-5 Tank in the 224-U Building. Contaminated water that included 3.14 kg (6.9 lb) of thorium from the 241-WR Vault was discharged to the crib in October 1965. From May 1967 to September 1972, the site received the above wastes (excluding the 241-WR Vault waste) and occasional waste via the C-7 Tank in the 224-U Building. From September 1972 to November 1981, the site was taken out of service. From November 1981 to January 1987, the site received corrosive process condensate (corrosive: [D002] typical pH range is 0.5-1.5) from the 224-U Building. In 1987, the process condensate was administratively controlled, to prevent corrosive dangerous waste discharge to the 216-U-12 Crib, by neutralizing the condensate before it was discharged. The pH during operations ranged from 0.5 to 1.5. During periodic shutdown of the plant, the pH ranged from 2.0 to 4.0. The unit continued to receive process condensate until 1988, when the crib pipeline was cut and permanently capped.

The crib (Figure 2-5) is approximately 4.6 m (15 ft) deep and contains no structure (other than backfill, vent risers, and VCP). The bottom of the crib measures 30 m (100 ft) long and 3 m (10 ft) wide. The crib was constructed with approximately 2:1 (horizontal:vertical) earth sideslopes. The surface dimensions of the crib excavation are 46 m (150 ft) long by 18 m (60 ft) wide according to Hanford Site Drawing H-2-31322, *Crib Details of No. 216-U-12 Disposal of UO_3 Plant Condensate*. The bottom 2.1 m (7 ft) of the crib were backfilled with graduated layers of sand and gravel that are covered with a polyethylene barrier. The crib is backfilled with soil to the ground surface. A perforated 30 cm (12-in.) VCP runs horizontally the length of the unit below grade. A 4 m (13-ft) long, 30 cm (12-in.) diameter VCP serves as a vent riser at the south end, extending from 3 m (10 ft) beneath the surface to 0.9 m (3 ft) above grade. Based on

hearsay, it is assumed that the risers were set within the gravel beds and served to vent the void space. Air was displaced by the liquid influent.

A 15-cm (6-in.) VCP waste line conveyed waste to the crib from the location where the 216-U-8 Crib feed line was blanked off and diverted to the 216-U-12 Crib. Two 5.2 m (17-ft) long VCP liquid-level monitoring wells extend 0.9 m (3 ft) above the surface. According to Hanford Site Drawing H-2-31322, the diameters of these wells are 20 cm (8 in.) and 46 cm (18 in.), respectively. Each well was installed on a precast concrete block extending 0.3 m (1 ft) below the bottom of crib backfill. No stabilization soil cover has been placed over the site.

The 216-U-12 Crib is the only RCRA treatment, storage, and/or disposal (TSD) unit in the 200-UW-1 OU. The original RCRA Part A permit application (Part A), Form 3 (Rev. 0), was submitted to the Washington State Department of Ecology (Ecology) in 1987 (DOE/RL-2000-60, Appendix A).

2.5.1.4 216-U-4 Reverse Well/216-U-4A French Drain

The 216-U-4 Reverse Well and 216-U-4A French Drain have been selected as a representative site for the 200-UW-1 OU. Table 2-6 provides the rationale for selection of this site as a representative site, along with the background and a description of the analogous waste sites included in this group. This section provides a brief description of the 216-U-4 Reverse Well and 216-U-4A French Drain representative site and its background. These sites are discussed as a single representative waste site because of their proximity to one another and because they received the same waste stream.

The 216-U-4 Reverse Well is located 5.2 m west and 0.6 m north of the 222-U Laboratory. The well is located inside the fence of the UO_3 exclusion area. As defined in the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989), a reverse well is a "...liquid waste disposal structure consisting of a well (sometimes drilled into the water table) into which waste solutions were pumped."

This site consists of a deactivated reverse well and a (replacement) French drain. The well site received acidic decontamination waste containing fission products from the 222-U Laboratory hood sinks. The well site is marked with a small cement cover and a bronze marker. It is posted as an Underground Radioactive Material Area. The well site began to receive waste in March 1947 and was retired when the unit was plugged in July 1955. The well site was deactivated by installing an overflow line to the new 216-U-4A French Drain.

The well consists of a 7.6-cm (3–in.)-diameter pipe installed 23 m (75 ft) into the ground with the bottom 8 m (25 ft) of pipe perforated. The end of the pipe was nearly closed by flattening. An overflow pipe connects the 216-U-4 Reverse Well with the 216-U-4A French Drain. No stabilization cover exists over the 216-U-4 Reverse Well.

The 216-U-4A French Drain is located at the southwest corner of the 222-U Laboratory. The 216-U-4A French Drain is located 0.3 m southeast of the 216-U-4 Reverse Well (BHI-00034, *Borehole Summary Report for the 200-UP-2 Operable Unit, 200 West Area*). This site is posted as an Underground Radioactive Material Area. The top of the drain is painted yellow and has a removable lid. The site operated from July 1955 to July 1970. From July 1955 to January 1965,

the site received acidic decontamination waste containing fission products from hood sinks in the 222-U Laboratory. Waste flowed to the 216-U-4A French Drain via the overflow line from the 216-U-4 Reverse Well. From January 1965 to July 1970, the site received Pacific Northwest Laboratory operations decontamination waste from a hood sink in the 222-U Laboratory. The site has been inactive since Pacific Northwest Laboratory operations in the 222-U Laboratory were shut down.

The site consists of a 1.3-m (51-in.)-diameter concrete pipe placed vertically in the ground. The pipe extends downward a minimum of 1.2 m (4 ft) and its top is 1.5 m (5 ft) below grade. The pipe is not gravel filled and is covered by a 12.7-cm (5-in.)-thick wooden lid. The drain rests on undisturbed soil. A 7.6-cm (3-in.)-stainless steel pipe runs from the 216-U-4 Reverse Well to the 216-U-4A French Drain a few centimeters below its lid.

2.5.1.5 Unplanned Release UPR-200-W-19

Unplanned release UPR-200-W-19 has been selected as a representative site for the 200-UW-1 OU. Table 2-7 provides the rationale for selection of this site as a representative site, along with the background and a description of the analogous waste sites included in this group. This section provides a brief description of the UPR-200-W-19 representative site and its background.

The UPR-200-W-19 site is located north of 16th Street, near the 241-U-361 Settling Tank and the 216-U-1 and 216-U-2 Cribs. In the spring of 1953, organic wastes and cell drainage from the TBP process in the 221-U Facility and waste from the 224-U Building (UO_3) overflowed to the ground by way of the 241-U-361 Settling Tank and the 216-U-1 and 216-U-2 Crib vents. Contamination readings of 11.5 rad/h at a distance of 7.6 cm (3 in.) were reported over an area of approximately 4.6 m^2 (50 ft^2). The area where the release occurred is marked as an Underground Radioactive Material Area, which contains the 216-U-1 Crib, 216-U-2 Crib, and the 241-U-361 Settling Tank. A portion of the 2607-W5 Septic Tank and Tile Field also is included in the Underground Radioactive Material Area.

As noted in Section 2.5.1.1, the unplanned release was the result of an overflow in the spring of 1953. Later that year, decontamination was attempted and the area was backfilled, delineated by a wooden fence, and posted with Radiation Zone signs. In 1992, contaminated soil in the vicinity of the 216-U-1 and 216-U-2 Cribs was scraped and consolidated near the 241-U-361 Settling Tank. Stabilization actions conducted at the site in 1991 included removing approximately 15 to 30 cm (6 to 12 in.) of soil from the areas associated with UPR-200-W-19, the 216-U-1 and 216-U-2 Cribs, and the 2607-W5 Septic Tank and Tile Field and consolidating it southeast of the 241-U-361 Settling Tank (WHC-SD-DD-TI-063, *216-U-1 and 216-U-2 Cribs Interim Stabilization Final Report*). Stabilization cover 46 to 61 cm (18 to 24 in.) thick was placed over the areas that were not removed from radiological posting. The surface surrounding the 241-U-361 Settling Tank was surface stabilized with 10 cm (4 in.) of shotcrete (WHC-SD-DD-TI-063). In 1994, contamination specks were found on the surface again, presumably caused by insect intrusion. Approximately 63 m^2 (700 ft^2) of contamination was covered with clean dirt to restore the area to an Underground Radioactive Material Area. The area was downposted from a Surface Contamination Area to an Underground Radioactive Material Area.

2.5.2 Summary of Data Collection Activities

The 200-UP-2 Groundwater OU LFI, conducted in 1994, included surface and subsurface sampling activities at several 200-UW-1 OU waste sites. These sites include the four representative waste sites listed in Section 2.5.1 as well as the 200-W-42 VCP/UPR-200-W-163 site.

Along with the collection of surface and subsurface samples, radionuclide logging using the Radionuclide Logging System (RLS) was performed at several boreholes at selected sites. Contaminants detected with the RLS generally correlate well with data from sediment samples analyzed in the laboratory. Discrepancies in results between the RLS and laboratory analysis are likely the result of differences in the methods. Results from the RLS are biased, because inputs to the detector are averaged values 0.6 m (2 ft) above and below the tool. This represents an interval generally larger than the sediment sample interval.

The following sections provide a brief summary of field activities conducted under the LFI.

2.5.2.1 216-U-1 and 216-U-2 Cribs

This section is a summary of information provided in the LFI (DOE/RL-95-13). Three boreholes were drilled near the 216-U-1 and 216-U-2 Cribs system, to focus on the effects of a lateral migration of effluent from the 216-U-16 Crib along an impermeable caliche layer, northward to beneath the 216-U-1 and 216-U-2 Cribs (RHO-RE-SA-116P, *Characterization and Anion Exchange Removal of Uranium from Hanford Groundwater*; DOE/RL-91-52). The discharge of large volumes of cooling water to the crib in 1984-1985 resulted in the mobilization of contaminants from the vadose zone beneath the 216-U-1 and 216-U-2 Cribs to groundwater. All boreholes were drilled into or through the caliche layer.

Also of interest were the effects of the active use of the 2607-W5 Septic Tank and Tile Field, which lies roughly 15 m (50 ft) northeast of the 216-U-1 and 216-U-2 Cribs. This system received roughly 12,000 L/day (3,200 gal/day) of sanitary waste and sewage discharge. DOE/RL-95-13 speculates that water discharged to drain fields is a potential reason for continued uranium contamination of groundwater.

As part of the LFI, the integrity of the 216-U-1 and 216-U-2 Cribs effluent pipeline was evaluated in 1994. The pipeline is a 7.6-cm (3-in.) stainless steel line that transferred liquid waste from the 221-U Facility and its support facilities to the 216-U-1 and 216-U-2 Cribs system. The results of this survey are discussed in Section 2.5.3.5.

2.5.2.2 216-U-8 Crib

This section is a summary of the data collection activities at the 216-U-8 Crib during the LFI (DOE/RL-95-13). At the time of LFI activities, a surface contamination area (SCA) surrounded the 216-U-8 Crib and extended north to 16th Avenue along the route of the 200-W-42 VCP/UPR-200-W-163 site. The 216-U-12 Crib was designated as an Underground Radioactive Material Area. The area surveyed consisted of the SCA associated with the

216-U-8 Crib. Roughly 20,000 m^2 of the area was surveyed with the Ultrasonic Ranging and Data System (USRADS).[2] The area with the highest activity level was directly over and along the 200-W-42 VCP/UPR-200-W-163 site, with additional elevated readings found scattered throughout the remainder of the survey area. These findings fit with the conceptual model of this area.

As part of the LFI, an in-line camera survey of the VCP was conducted. The intention of this survey was to document the condition of the pipe material and the joints along the pipeline. This was also done to help evaluate any correlation that might exist between surface contamination and the condition of the pipeline. The pipeline was entered from two excavations, to view as much of the line as possible and to view both of the sections that lead to the 216-U-8 Crib and the 216-U-12 Crib.

As a result of the surface radiation survey and the camera survey of this system, 4 surface soil samples and 4 vegetation samples were collected to characterize the SCA, and a total of 17 soil samples (including surface and subsurface) and 4 vegetation samples were collected to characterize the VCP soils.

The maximum concentrations for all analytes generally can be found in the soils closest to the 200-W-42 VCP/UPR-200-W-163 site except for Sr-90, which is found at its maximum concentration in vegetation samples. Lateral spreading of contaminants also was investigated at one location. This location showed minimal lateral movement of contaminants. A graphical presentation of surface and subsurface analytical data and a detailed discussion of sample site selection and sample collection are contained in BHI-00033, *Surface and Near Surface Field Investigation Data Summary Report for the 200-UP-2 Operable Unit.*

During the LFI, contamination beneath the 216-U-8 Crib was assessed by collecting soil samples from borehole 299-W19-94. Boreholes in the vicinity of the crib were logged with the RLS. Borehole 299-W19-94 was drilled halfway between two of three equally spaced underground timber structures on the northern half of the waste site. Soil samples were collected and analyzed for volatile organic compounds; semivolatile organic compounds; inorganics; cyanide; fluoride; chloride; nitrate; nitrite; sulfate; gross alpha and gross beta; total uranium; radioisotopes including Cs-137, Co-60, and Sr-90; dry density; moisture content; specific gravity; calcium carbonate; and porosity. Borehole 299-W19-94, as well as others in the vicinity of the crib, was logged with the RLS to determine the presence of manmade and naturally occurring gamma-emitting radionuclides. Three of the boreholes (299-W19-70, 299-W19-71, and 299-W19-2) are existing wells and are part of the crib-monitoring system. The maximum depth of the investigation was 61 m (199 ft). RLS logs are available for boreholes 299-W19-70,

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[2] USRADS is a trademark of CHEMRAD Tennessee Corporation, Oak Ridge Tennessee. The USRADS radiation detection equipment consisted of a sodium iodide detector reporting gamma in counts per minute and a micro Roentgen meter reporting dose rate information in micro Roentgens per hour. The gamma detector was suspended 6 in. from the soil surface, with the dose rate meter positioned 3 ft high attached to a backpack worn by a technician. The instruments were connected to a CHEMRAD Tennessee Corporation Series 2000 USRADS to record the detector readings (BHI-00033).

299-W19-71, and 299-W19-2. Four radionuclides (Cs-137, Eu-154, U-235, and U-238) were detected with the RLS in boreholes drilled through the 216-U-8 Crib system.

2.5.2.3 216-U-12 Crib

This section is a summary of the data collection activities conducted as part of the LFI (DOE/RL-95-13). The site was characterized in 1995 as part of the 200-UP-2 Groundwater OU characterization activities. This included installation of a borehole adjacent to the crib, collection of soil and vegetation samples, and an in-line camera survey of a potion of the pipeline that led to the waste site.

Borehole 299-W22-78 was drilled (and abandoned) adjacent to the 216-U-12 Crib as part of the LFI. Three manmade radionuclides (Cs-137, U-235, and U-238) were identified at the 216-U-12 Crib with the RLS. Contaminants were detected in existing crib-monitoring borehole 299-W22-75, which was drilled through the crib, and 299-W22-78, which was drilled adjacent to the crib.

2.5.2.4 216-U-4 Reverse Well/216-U-4A French Drain

This section is a summary of the data collection activities near the 216-U-4 Reverse Well/ 216-U-4A French Drain that were conducted as part of the LFI (DOE/RL-95-13). Soil samples were collected from characterization borehole 299-W19-98, which was drilled between the 216-U-4 Reverse Well and the 216-U-4A French Drain.

No radiological postings were associated with this system at the beginning of LFI activities. The surface area of the system is relatively small, roughly 3 by 3 m (10 by 10 ft). The area is void of vegetation and consists of compacted earth and gravel.

Because of space limitations, the site was excavated by hand to locate the two waste facilities and any utilities in the area. During this hand excavation, the site was hand surveyed for radiological concerns. The first field indication of contamination was found at a depth of 1.4 m (4.5 ft), which is approximately 0.15 m (0.5 ft) above the top of the French drain. For the entire survey area, elevated readings of up to 100 d/min alpha and 15,000 d/min beta were recorded. As a result of this excavation work, an SCA was established around the two waste sites. After LFI activities ceased, the area was returned to its original condition and released from the SCA posting, because the clean backfill was replaced over the site. The area is posted as an Underground Radioactive Material area, because contamination remains beneath the surface. Because the radiological survey was performed after drilling had begun for the vadose zone borehole, no surface soils were collected from this system.

2.5.2.5 Unplanned Release UPR-200-W-19

Unplanned release UPR-200-W-19 overlies the 216-U-1 and 216-U-2 Cribs, 241-U-361 Settling Tank, 2607-W5 Septic Tank/Diversion Boxes, and portions of the abandoned and active 2607-W5 Tile Field. This section is a summary of the data collection activities near UPR-200-W-19 that were conducted as part of the LFI (DOE/RL-95-13).

At the time of the LFI activities, an SCA surrounded the cribs, and an Underground Radioactive Material Area was posted around the 241-U-361 Settling Tank. The 2607-W5 Septic Tank and Tile Field are located in a depression roughly 15 m (50 ft) northeast of the 216-U-1 and 216-U-2 Cribs. This unit had no radiological posting at the time of the initial survey. The survey area is almost entirely void of vegetation because of management practices used to control plant growth.

This area was surveyed entirely with the USRADS because of a potential collapse condition at the 216-U-1 and 216-U-2 Cribs and a potential for damage to the 2607-W5 Tile Field, prohibiting the use of heavy equipment (i.e., Mobile Surface Contamination Monitor [MSCM II]. Because of borehole drilling activities at the 216-U-1 and 216-U-2 Cribs, a portion of the crib surface had been stabilized with gravel and could not be surveyed. Roughly 25,000 m^2 of surface area associated with the 216-U-1 and 216-U-2 Cribs system was surveyed. Of the area surveyed, the highest concentrations of data points above established background were in the northwest and northeast corners of the survey area. Other areas of high concentration were identified along the eastern border of the 2607-W5 Tile Field, in the accessible area of the 216-U-1 and 216-U-2 Cribs, and in the vicinity of the 241-U-361 Settling Tank.

As a result of the surface radiation survey of the 216-U-1 and 216-U-2 Cribs system, five soil samples were collected from this unit (not counting quality control samples). No vegetation samples were collected, because the site is mostly void of vegetation. Surface soil samples were collected from the areas with the highest readings recorded during the surface radiological surveys. These areas were located east of the 2607-W5 Septic Tank and Tile Field (BHI-00033).

2.5.2.6 200-W-42 Vitrified Clay Pipe/Unplanned Release UPR-200-W-163

In addition to the representative sites selected for the 200-UW-1 OU, one additional site, the 200-W-42 VCP/Unplanned Release UPR-200-W-163 site, was identified as having sufficient data to perform risk assessment. A discussion of this site has been included here in support of the risk assessment summarized in Section 2.7 of this FFS.

As part of the LFI at the 216-U-8 Crib, an integrity investigation was conducted on the pipeline that discharged to the 200-W-42 VCP/UPR-200-W-163 site south of 16th Street. The objective of the investigation was to determine the potential of the schedule 40 stainless steel and VCP portions of the pipeline to leak and cause soil contamination. Sections of pipeline were surveyed with an in-line video camera, and 23 surface and near-surface soil samples were collected to depths of 2 to 4 m (7 to 12 ft). These depths represent the approximate location of the pipeline in the subsurface.

2.5.3 Nature and Extent of Contamination

This section provides a discussion of the nature and extend of sites within the U Plant area where sampling and RLS data have been conducted. Contaminant concentrations discussed in this section represent values at the time of sample collection and/or RLS logging. Radioactive decay that has occurred since the time of sampling has not been considered for the purpose of this discussion (see Appendix C, Section C3.2.1). Data used for the human health and ecological risk

assessment (Appendix C) and vadose zone contaminant fate and transport modeling (Appendix D) did consider the effects of radioactive decay.

2.5.3.1 216-U-1 and 216-U-2 Cribs

This section provides a summary of the nature and extent of contamination associated with the 216-U-1 and 216-U-2 Cribs from the LFI (DOE/RL-95-13). Figure 2-6 provides a conceptual contaminant distribution model for this site.

Subsurface soil samples from borehole 299-W19-96, drilled at the northern edge of the 216-U-1 and 216-U-2 Cribs subsurface timber structure, showed two areas high in contamination. The first area is located below the crib bottom, generally 6 to 12 m (20 to 40 ft) below ground surface (bgs) where the highest concentrations of constituents are located. The maximum concentrations of Am-241 (33 pCi/g), Co-60 (10.6 pCi/g), Cs-137 (1.8 E+06 pCi/g), Sr-90 (2.4 E+06 pCi/g), U-233/234 (1,400 pCi/g), and U-238 (10,800 pCi/g) occur either at the bottom of the crib (6.25 m [20.5 ft] bgs) or at the bottom of this first contamination zone (12.3 m [40.5 ft] bgs). The next area high in contamination is the top of the caliche layer (at roughly 52 m [170 ft] of depth), where uranium isotopes were seen to increase in concentration when compared to the vadose zone above this layer. The U-233/234 concentration at the caliche layer was 32 pCi/g, the U-235 concentration was 2.2 pCi/g, and the U-238 concentration was 32 pCi/g. Between the zone directly beneath the crib and the top of the caliche layer, constituents are present, but at levels generally at or near background (DOE/RL-92-24, *Hanford Site Soil Background: Part 1, Soil Background for Nonradioactive Analytes*).

Boreholes 299-W19-95 and 299-W19-97 were drilled to investigate lateral migration of any contaminants along the caliche layer, found at roughly 52 m (170 ft) of depth. Borehole 299-W19-95 was drilled 40 m (130 ft) southeast of the 216-U-1 Crib, and borehole 299-W19-97 was drilled 25 m (82 ft) northeast of the 216-U-1 Crib. Sediment samples from these boreholes show maximum concentrations for uranium isotopes (U-238 at 2.2 pCi/g and U-233/234 at 2.4 pCi/g) in these boreholes at the caliche layer. These concentrations are near background levels for these isotopes.

The RLS data show six manmade radionuclides (Cs-137, Co-60, Eu-152, Eu-154, U-235, and U-238) identified in borehole 299-W19-96, which was drilled through the crib unit as part of the LFI. The two boreholes drilled adjacent to the 216-U-1 and 216-U-16 Cribs (299-W19-95 and 299-W19-97) to evaluate lateral migration in the vadose zone revealed detectable amounts of only Cs-137; this contaminant was found in the top 2.3 m (7.5 ft) of the vadose zone with a maximum concentration of 20 pCi/g. The logging results for the three boreholes investigated, and data from sediment samples analyzed in the laboratory from the same zone, are included in DOE/RL-95-13 for comparison of results.

The evaluation of lateral spreading of contaminants in the vadose zone, along the caliche layer, is a key part of understanding the nature and extent of contamination within the vadose zone. The 216-U-16 Crib operated from 1984 through 1987, and it is believed that by 1985 the volume of discharge formed a perched groundwater zone at the caliche layer, which moved laterally and mobilized uranium beneath the 216-U-1 and 216-U-2 Cribs into groundwater (WHC-EP-0133, *U1/U2 Uranium Plume Characterization, Remedial Action Review and Recommendation for*

Future Action). It is hypothesized that the uranium reached groundwater by way of an improperly sealed well. Water discharged from the 2607-W5 Tile Field also may have contributed to contaminant migration from the 216-U-1 and 216-U-2 Cribs to groundwater (DOE/RL-95-13). A contaminant profile and discharge plot for the cribs are shown in Appendix H.

Soil sediment data and RLS data from boreholes 299-W19-95 and 299-W19-97 showed little to no lateral spread of contamination at the caliche layer. Sediment and RLS data do point to constituents remaining in the soil column directly beneath the 216-U-1 and 216-U-2 Cribs. These concentrations decreased as the investigation moved away from the crib, yet contamination is present at reduced levels (generally near background) throughout the expanse of the borehole. As the investigation approached the caliche layer, located at roughly 52 m (170 ft) bgs, an increase in uranium isotopes beneath the crib was seen both in sediment and in RLS data.

As part of the LFI, the integrity of the effluent pipeline feeding the 216-U-1 and 216-U-2 Cribs was evaluated. The pipeline is a 7.6-cm (3-in) stainless steel line that transferred liquid waste from the U Plant and its support facilities to the 216-U-1/2 Cribs system. An in-line camera survey was performed to visually examine 120 to 150 m (400 to 500 ft) of the pipeline's interior. When the pipeline was cut to gain access for the camera survey, wipe samples of the pipeline interior showed up to 30,000 c/min. There was no surface radiological survey dedicated to examining surface radiological conditions for this pipeline. However, a portion of the surface over the stainless steel pipeline was included in the surface survey of the 216-U-1 and 216-U-2 Crib area. The area above the stainless steel pipeline did not show elevated readings above the readings shown in adjacent areas surveyed, and therefore no evidence of releases from the stainless steel pipeline are apparent at the ground surface. Visual field inspections were consistent with the survey results. The camera survey performed on the stainless steel pipeline showed the following.

- No loss of integrity was found in the line.
- The exterior of the pipe as well as the surrounding soil showed no radiological activity.
- Minor amounts of liquid remained at low spots along the line.
- The final 6 to 9 m (20 to 30 ft) before entering the 241-U-361 Settling Tank was totally filled with liquid.
- Some areas of the system contained a slag/crusty material.
- Two tie-ins from other pipelines were verified with the camera survey (one from the 276-U Solvent Handling Building and the other from the U Plant).

2.5.3.2 216-U-8 Crib

The current understanding of the nature and extent of contamination at the 216-U-8 Crib is summarized from DOE/RL-95-13, BHI-00034, and DOE/RL-95-106. Figure 2-7 provides a conceptual contaminant distribution model for this site.

Various contaminants of potential concern (primarily Cs-137, Sr-90, and uranium isotopes) were detected throughout the vadose zone beneath the 216-U-8 Crib; the more mobile contaminants were detected to the maximum depth of the investigation. Boreholes 299-W19-3, 299-W19-70, 299-W19-71, and 299-W19-94 are associated with the 216-U-8 Crib. Borehole 299-W19-94 is one of the primary site-specific data sources for the 216-U-8 Crib. The total depth of borehole 299-W19-94 is 61 m (199 ft). The highest levels of contamination, with the exception of Sr-90, which was present throughout the soil column, were detected at the bottom of the crib at a depth of approximately 9 m (31 ft). Elevated levels of contamination (Cs-137, U-233/234, U-235, and U-238) extend to a depth of approximately 13 m (42 ft) and generally decrease with depth to the bottom of the borehole. For example, Cs-137 activities ranged from 91,190 to 1,700 pCi/g between the crib-soil interface (at 8 m [32 ft]) and 13 m (42 ft). From this point to approximately 30 m (100 ft), Cs-137 activities ranged between 3.4 and 56 pCi/g. Cesium-137 was not detected below 30 m (100 ft). The distribution of contaminants with large contaminant distribution coefficients such as plutonium and americium were similar to the distribution of Cs-137. However, the vertical extent of contamination was less than 15 m (50 ft), and concentrations were typically less than 1 pCi/g. The RLS data from other boreholes (299-W19-70 and 299-W19-71) correlate well with soil data collected from borehole 299-W19-94. The log data indicate that the highest contaminant concentrations were associated with the bottom of the crib at about 9 m (30 ft) bgs. Concentrations decreased with depth to the bottom of each borehole at about 25 m (80 ft) bgs. Less than 10 pCi/g of Cs-137 were detected above the bottom of the crib. A detailed discussion of the distribution of contamination based on RLS data is presented in BHI-00034.

The distribution of uranium isotopes in the subsurface beneath the crib indicates that the mobility of these isotopes varies within the vadose zone. The highest concentrations of uranium were detected at the bottom of the crib and at approximately 57 m (188 ft) bgs, associated with a caliche layer within the Cold Creek unit. Near the base of the crib, U-238 concentrations ranged between 29 and 94 pCi/g. Beneath this zone of higher contamination and to a depth of approximately 50 m (165 ft), U-238 concentrations ranged between 4.3 and 19 pCi/g. The maximum concentration of U-238 (150 pCi/g) was detected at the caliche layer at 57 m (188 ft) bgs. At the maximum extent (61 m [199 ft]) of the investigation, the U-238 concentration was less than 1 pCi/g. Uranium-233/234 and U-235 were distributed similarly to U-238. However, contaminant concentrations were not as high. Near the bottom of the crib, concentrations ranged between 1.1 to 28 pCi/g. Beneath this upper zone of contamination to a depth of approximately 50 m (165 ft), concentrations ranged between the detection limit and 20 pCi/g. Similar to U-238, elevated levels of U-233/234 and U-235 were detected associated with the caliche layer. Concentrations of these isotopes at the caliche layer were 140 and 6.7 pCi/g. At the maximum extent of the investigation, concentrations were less than 1 pCi/g. These data indicate that the wetting front and mobile contaminants have migrated deep within the vadose zone, and uranium mobility varies greatly.

Strontium-90, a moderately mobile contaminant, was present throughout the soil column beneath the 216-U-8 Crib. Concentrations ranged between 36 to 130 pCi/g from the bottom of the crib to about 27 m (90 ft). Below 27 m (90 ft) bgs, concentrations generally increased with depth to 50 m (165 ft) and ranged between 370 and 520 pCi/g. A maximum concentration of 520 pCi/g was detected at 35 m (115 ft) and 50 m (165 ft) bgs in the sand-dominated sequence of the Hanford formation. Concentrations decreased to 270 pCi/g at a depth of 60 m (197 ft) bgs. The

sample at 60 m (197 ft) bgs was collected at the bottom of the caliche layer. Borehole 299-W-19-94 did not continue to groundwater, which in 1994 was approximately at 75 m (245 ft) bgs

Groundwater data from well 299-W19-2 on the east side of the crib shows Sr-90 concentrations in groundwater. The maximum concentration in groundwater at this well was approximately 170 pCi/L in 1962 (DOE/RL-98-48, *Groundwater/Vadose Zone Integration Project Science and Technology Summary Description*, Vol III, Rev. 1). The well recently was decommissioned because of dropping water level. The strontium was made more mobile by the acidic waste stream and the addition of calcium ions (the 271-U Neutralization Tank was in use for part of the 216-U-8 Crib operation) which competed with the soil sites where strontium would have been captured .

In addition to the contaminants of potential concern described above, arsenic, chromium, Am-241, Eu-154, Np-237, Pu-238, Pu-239/240, Ra-226, Ra-228, and Th-234 were detected during the LFI. The distribution and presence of these contaminants of potential concern in the soil column are slightly above background, single detects, and sporadic detection. A summary of all contaminants detected during the LFI is presented in BHI-00034. A contaminant profile and discharge plot for the 216-U-8 Crib is shown in Appendix H.

The effluent volume discharged at this site is greater than the soil pore volume, as indicated in Table 2-4. These data indicate an impact to groundwater at this site. Impacts to groundwater near the 216-U-8 Crib and major plumes in the vicinity of the 200 West Area are discussed further in Section 2.5.4.

2.5.3.3 216-U-12 Crib

This section is a summary of the nature and extent of contamination associated with the 216-U-12 Crib from DOE/RL-2000-60. Figure 2-8 provides a conceptual contaminant distribution model for this site. The nature and extent of contamination at the 216-U-12 Crib was evaluated using the RLS and soil data. The RLS data from borehole 299-W22-75 provide the only data available to evaluate contamination directly through the 216-U-12 Crib. Data were obtained from this borehole over a log interval of 57 m (175 ft) in 1991. The RLS and analytical chemistry data from borehole 299-W22-78 provide information to assess contamination immediately adjacent to the crib. Data were collected from this borehole to a depth of 71 m (233 ft) in 1994 to support the 200-UP-2 Groundwater OU LFI (DOE/RL-95-13). Although soil chemistry data are not available to evaluate contamination directly beneath the 216-U-12 Crib, DOE/RL-95-13 and DOE/RL-95-106 suggest that the site is similar to the 216-U-8 Crib. These sites are located relatively close together and received the same type of waste, although the 216-U-12 Crib waste stream was more dilute.

Three manmade radionuclides (Cs-137, U-235, and U-238) were identified beneath the 216-U-12 Crib with the RLS. Cesium-137 was detected to a maximum depth of 8 m (59 ft). Concentrations greater than 5,000 pCi/g were detected at 6 to 8 m (20 to 25 ft) bgs. The maximum activity was estimated at 16,100 pCi/g at 7 m (23 ft) bgs. Cesium-137 detected with the RLS adjacent to the crib in borehole 299-W22-78 was less than 1 pCi/g at less than 0.3 m (1 ft) bgs. Cesium-137 was not detected in soil samples collected in the adjacent borehole. Cesium-137 concentrations generally decreased with depth at the crib and were not detected at

depths greater than 8 m (59 ft) bgs. Uranium-235 was detected within a 2-m (7-ft) zone beneath the crib at a depth between 22 and 24 m (73 and 80 ft) with the RLS. The maximum activity of U-235 in this zone is approximately 20 pCi/g and corresponds to maximum U-238 concentrations detected with the RLS. The maximum concentration (500 pCi/g) of U-238 was detected 23 m (77 ft) bgs and indicates that higher concentrations were detected with depth. Uranium-238 initially was detected at a depth of 5 m (17 ft) (approximate depth of inlet pipe) to a maximum depth of 24 m (80 ft). Its distribution above the hot spot is sporadic. Uranium was detected in soil samples throughout the vadose zone adjacent to the crib to a depth of 70 m (230 ft). Activities typically were less than 1 pCi/g, except as noted.

Uranium isotopes were detected 4 to 7 m (13 to 23 ft) bgs, adjacent to the 216-U-12 Crib, in borehole 299-W22-78. A maximum of 66 pCi/g was detected with the RLS at the bottom of the crib 6 m (19 ft) bgs. Isotopic uranium detected in soil chemistry samples adjacent to the crib was less than 1.1 pCi/g. Soil sampling efforts from borehole 299-W22-78 near the 216-U-12 Crib indicate that the constituents were not detected above background levels (DOE/RL-95-13). Higher levels of contaminants likely were not detected because the soil samples were collected outside of the crib. These data suggest that the lateral spread of contaminants at the crib may be limited to the immediate area of the crib. A contaminant profile and discharge plot for the 216-U-12 Crib is shown in Appendix H.

The effluent volume discharged at this site is greater than the soil pore volume, as indicated in Table 2-5. These data indicate that there has been impact to groundwater at this site. The status of groundwater contamination in the vicinity of the 216-U-12 Crib is described in PNNL-14187, *Hanford Site Groundwater Monitoring for Fiscal Year 2002*, and indicates that the site in the past was one of several contributing sources.

PNNL-14187 indicates that the 216-U-12 Crib is the source of elevated nitrate and Tc-99 that have been detected in downgradient wells. The regional nitrate and Tc-99 plumes are a co-mingled series of smaller plumes with sources from several cribs (216-U-1, 216-U-2, 216-U-8, and 216-U-12) in the U Plant area. Iodine-129 and tritium were detected repeatedly in several monitoring wells downgradient from the 216-U-12 Crib, but the sources appear to be the REDOX Plant effluent disposal cribs that are upgradient of the 216-U-12 Crib.

2.5.3.4 216-U-4 Reverse Well/216-U-4A French Drain

This section provides a summary of the nature and extent of contamination associated with the 216-U-4 Reverse Well and 216-U-4A French Drain from the LFI (DOE/RL-95-13). During the LFI, the 216-U-4 Reverse Well and 216-U-4A French Drain system was characterized with a vadose zone borehole, 299-W19-98. Borehole 299-W19-98 was drilled to a depth of 61 m (195 ft). Figure 2-9 provides a conceptual contaminant distribution model for this site. Subsurface soil samples from the LFI showed two distinct areas of contamination. The first is associated with the 216-U-4A French Drain and extends to a depth of 5 m (16 ft). In this zone, Am-241 (200 pCi/g) and Cs-137 (420 pCi/g) are at their maximum concentrations. Between 5 and 11 m (16 and 37 ft) of depth, activity levels are near or below background. At the 11 m (37 ft) depth, activity levels once again increase, extending to a depth of roughly 30 m (100 ft), with maximum concentrations located at or near the top of the 216-U-4 Reverse Well screening interval (roughly 20 m [60 ft] bgs). Within this zone the maximum concentrations of Am-241

(190 pCi/g), Cs-137 (1,980 pCi/g), Eu-152 (0.6 pCi/g), Np-237 (0.85 pCi/g), U-234 (5.8 pCi/g), and U-238 (7.8 pCi/g) are seen. RLS data show similar contaminant distribution and concentrations to the subsurface soil sampling data. A maximum Cs-137 concentration of 1,460 pCi/g was detected with RLS at 19 m (62 ft).

Very little activity above background levels is seen from 30 m (100 ft) to the top of the caliche layer located at roughly 53 m (175 ft) of depth. At the caliche layer, Am-241 (0.8 pCi/g), Eu-152 (0.2 pCi/g), U-234 (1.8 pCi/g), U-235 (0.08 pCi/g), and U-238 (1.6 pCi/g) once again are found above background levels.

2.5.3.5 Unplanned Release UPR-200-W-19

This section provides a summary of the nature and extent of contamination associated with the UPR-200-W-19 site, based on surface soil observations from the LFI (DOE/RL-95-13). Figure 2-10 provides a conceptual contaminant distribution model for this site. Unplanned release UPR-200-W-19 occurred when the 241-U-361 Settling Tank and 216-U-1 and 216-U-2 Cribs overflowed to the ground surface.

The shallow subsurface soil samples collected from soil borings 299-W19-96 and 299-W19-97 show a maximum concentration of Cs-137 and Sr-90 of 259 pCi/g and 42 pCi/g, respectively. These soil samples were collected at depths above the discharge depth of the 216-U-1 and 216-U-2 Cribs. Surface soil samples in the vicinity of the unplanned release have shown maximum levels of Cs-137 and Sr-90 of 53 pCi/g and 8.4 pCi/g, respectively.

Shallow subsurface soil samples from soil borings 299-W19-96 and 299-W19-97 and surface soil samples in the vicinity of the unplanned release show uranium concentrations at or slightly above background levels. Although higher levels of uranium contamination were found deeper in the vadose zone beneath the 216-U-1 and 216-U-2 Cribs, the concentration of uranium associated with unplanned release UPR-200-W-19 are believed to be low, because the amount of uranium present in the waste stream was significantly lower than the amount of Cs-137 and Sr-90. Because the levels of Cs-137 and Sr-90 contamination near the surface of the 216-U-1 and 216-U-2 Cribs are significantly lower than deeper in the vadose zone, the levels of uranium contamination near the surface are expected to be low. This is consistent with a one-time release to the surface from the crib vent risers.

Surface soil investigations point to movement of contamination from the surface of the 216-U-1 and 216-U-2 Cribs and 241-U-361 Settling Tank to the surrounding area. This surface contamination is found to the east of the 216-U-1 and 216-U-2 Cribs and 241-U-361 Settling Tank and north to the 2607-W5 Septic Tank and Tile Field. It also is suspected that some of the surface contamination in this area may have resulted from upward migration of deeper contaminants from the 216-U-1 and 216-U-2 Cribs and the 241-U-361 Settling Tank through root hydraulic uplift from vegetation. The area around the 216-U-1 and 216-U-2 Cribs and the 241-U-361 Settling Tank currently are chemically controlled to prevent growth of vegetation, so this migration pathway likely has been reduced.

2.5.3.6 200-W-42 Vitrified Clay Pipe/Unplanned Release UPR-200-W-163

This section provides a summary of the nature and extent of contamination, based on the activities performed during the LFI. The results are described in detail in BHI-00033, DOE/RL-95-13, and DOE/RL-95-106.

The pipeline integrity investigation yielded a number of observations. In the vitrified clay section of the pipeline, many of the joints were dislodged; the degree of dislodgment varied from very minor to very serious, and silty sandy material was observed. The stainless steel section of the pipe was in excellent condition and the joints were sound. However, silty material also was observed in the pipe. Surface soil samples collected during the pipeline investigation typically showed background levels of activity for analyzed constituents. The highest levels of contamination were detected in the subsurface near the VCP. However, many constituents were distributed throughout the 4 m (12-ft) depth of the investigation. The data also suggested that minor lateral spreading (no more than 1 to 2 m [3 to 5 ft]) was apparent. The maximum concentrations of Am-241, Cs-137, Pu-239/240, and Sr-90 detected during the pipeline investigation were 426 pCi/g, 49,100 pCi/g, 70.6 pCi/g, and 180 pCi/g, respectively. The highest strontium activity was detected in a vegetation sample at a concentration of 1,380 pCi/g. Maximum concentrations of U-233/234 and U-238 were 38 pCi/g and 43 pCi/g, respectively. Soil sampling results for constituents are presented graphically in BHI-00033. No vadose zone sampling was conducted at a depth greater than 4 m (12 ft).

2.5.4 Summary of Groundwater Quality

This section provides a brief summary of groundwater quality within the U Plant Area. Plate 1 (located in a pocket at the end of this document), provides the well locations for the U Plant Area and Table 2-2 provides the area groundwater contaminant trends. PNNL-14187 reports that the groundwater contaminant plume underlying the U Plant disposal facilities includes I-129, nitrate, trichloroethene, Tc-99, and uranium. These constituents originated from the U Plant disposal facilities and extend beyond the 200 West Area fence line to the east. Carbon tetrachloride contamination also is present in groundwater beneath the U Plant, but its sources include disposal facilities in the 200-ZP-1 Groundwater OU. The groundwater flow in the vicinity of the U Plant Area is primarily in an easterly direction, only changing 5 to 10 degrees over the past decade as reported by PNNL-13788. The flow rates have held fairly constant as well and range from 0.02 to 0.08 m/day. However, the water table continues to decline at a rate of approximately 0.36 m/year. Additional information is contained in DOE/RL-92-76, *Remedial Investigation/Feasibility Study Work Plan for the 200-UP-1 Groundwater Operable Unit*; EPA/541/R-97/048, 1997, *Record of Decision for the 200-UP-1 Interim Remedial Measure*; and the annual *Hanford Site Groundwater Monitoring* reports produced by the Pacific Northwest National Laboratory (see the most recent annual report [2004] at http://groundwater.pnl.gov/pubs.asp).

2.5.4.1 Summary of Groundwater in the Vicinity of the 216-U-1 and 216-U-2 Cribs

The 216-U-1 and 216-U-2 Cribs are the major sources of the plume beneath the U Plant Area. Waste from these cribs is believed to have been remobilized by disposal of waste to the

216-U-16 Crib (WHC-EP-0133). Additional discussion of the trends of constituents associated with the plume beneath the 200-UW-1 OU are provided in Section 2.5.4.4.

2.5.4.2 Summary of Groundwater in the Vicinity of the 216-U-8 Crib

The status of groundwater contamination in the vicinity of the 216-U-8 Crib is described in PNNL-13116, *Hanford Site Groundwater Monitoring for Fiscal Year 1999*, which indicates that this site was one of several sources contributing to the impact. The report indicates that nitrate, carbon tetrachloride, I-129, tritium, and uranium exceed groundwater protection standards/guidelines in the vicinity of the crib. Uranium is a major groundwater contaminant at the 216-U-8 Crib and was monitored in groundwater at borehole 299-W19-2. No groundwater data are available to evaluate impact on the aquifer at the crib during the periods of effluent discharge (1952 to 1960), according to DOE/RL-2000-60. Monitoring at the crib began in 1974, was stopped in the spring of 1990, was resumed again in the summer of 1994, and finally was discontinued in 1995 because well 299-W19-2 did not produce enough water for sampling because of the decline in the elevation of the water table across the 200 West Area. The well was decommissioned in March 1998. Trend analysis indicates that uranium has been detected in the aquifer since monitoring began. Between 1974 and 1984, uranium concentrations were decreasing over time and ranged between 1 and 71 µg/L.

After 1986, uranium concentrations increased sharply to approximately 150 µg/L, exceeding the maximum contaminant level (MCL) of 30 µg/L. A general decrease in the level of contamination was observed after 1989; however, sampling was halted. Samples collected in 1994 and 1995 typically ranged between 14.5 and 79 pCi/L. A summary of more recent trends in uranium concentrations in the 200-UP-1 Groundwater OU is provided in Section 2.5.4.4.

2.5.4.3 Summary of Groundwater in the Vicinity of the 216-U-12 Crib

The status of groundwater contamination in the vicinity of the 216-U-12 Crib is described in PNNL-14187, and indicates that the site in the past was one of several contributing sources.

PNNL-14187 indicates that the 216-U-12 Crib is the source of elevated nitrate and Tc-99 that have been detected in downgradient wells. The regional nitrate and Tc-99 plumes are a co-mingled series of smaller plumes with sources from several cribs (216-U-1, 216-U-2, 216-U-8, and 216-U-12) in the U Plant area. Iodine-129 and tritium were detected repeatedly in several monitoring wells downgradient from the 216-U-12 Crib, but the sources appear to be the REDOX Plant effluent disposal cribs that are upgradient of the 216-U-12 Crib. Additional discussion of the trends of constituents associated with the plume beneath the 200-UW-1 OU are provided in Section 2.5.4.4.

2.6 EVALUATION OF THE ANALOGOUS WASTE SITES

DOE/RL-96-81, *Waste Site Grouping for 200 Areas Soil Investigations*, describes the grouping of Central Plateau waste sites based on process. Sites that received waste associated with a certain process were grouped by waste category (e.g., process condensate). The waste categories then were subdivided based on more specific process details (e.g., 200-PW-2: Uranium Rich

Process Waste Group; 200-LW-2: 200 Areas Chemical Laboratory Waste Group). This streamlining approach is employed to reduce the amount of characterization and evaluation required to support remedial action decision making. Application of the concept takes into account similarities between waste sites, such as waste stream type, discharge history, and geology, as well as the available characterization data, to assess the nature and extent of contamination. The concept builds on the knowledge gained from the characterization of a few waste sites (representative sites) that are indicative of typical OU conditions. Selection of representative sites generally is based on waste stream inventory, the volume of effluent discharged, and the amount of characterization performed before the RI. Because the U Plant Area incorporates waste sites from several waste category groups, the analogous site concept has been refined further to appropriately regroup these waste sites. The following general conclusions can be made about contaminant distribution at 200-UW-1 OU waste sites (primarily high-risk liquid waste sites) investigated to date.

- Effluents and contaminants typically were discharged within 6.1 m (20 ft) of the surface to cribs, French drains, septic systems, and trenches, which were designed to facilitate the infiltration of liquids into the vadose zone. The exceptions are the 216-U-8 Crib, which extends to 9.1 m (30 ft), and the 216-U-4 Reverse Well, which extends to 25 m (75 ft). The zone of highest overall contaminant concentrations generally occurs near the base of the structure. Very little lateral spreading of contamination in the vadose zone has been observed, which means that contamination only is expected beneath and adjacent to the footprint of the waste site.

- Maximum concentrations of contaminants with low mobility, such as cesium, are observed near the point of release (i.e., are associated with the bottom of the waste site). Concentrations generally decrease with depth and are not detected deep within the vadose zone. These contaminants generally are not associated with groundwater impacts.

- Contaminants that are highly mobile, such as Tc-99 and nitrate, generally have been flushed through the vadose zone to groundwater and have impacted groundwater. Residuals can be detected throughout the vadose zone, often in low concentrations. Vadose zone concentrations may increase with depth or may be higher locally, in fine-grained soil layers.

- Contaminants that are moderately mobile, such as strontium and uranium, have variable vadose zone distributions based on site-specific conditions and, in certain cases, have reached groundwater. Uranium often is observed to be concentrated near the bottom of the waste site, but also can be found at higher concentrations deeper in the vadose zone, particularly in association with fine-grained soil layers. At certain waste sites, uranium has reached and impacted groundwater. Similar to uranium, strontium often is observed to be concentrated near the bottom of the waste site, but can be found at higher concentrations deeper in the vadose zone. However, strontium is not known to have reached or impacted groundwater.

2.6.1 Analogous Site Assignment to Representative Sites

Figure 2-11 shows the process for evaluating the analogous sites against the representative sites for the RI/feasibility study (FS) process through the confirmatory and design sampling processes. This section documents this evaluation process and the assignment of waste sites to one of the five representative sites. Important considerations in determining the appropriate representative site for an analogous waste site include the following:

- Waste site configuration and construction (e.g., crib, trench, unplanned release), including method of discharge and purpose of waste site
- Volume of effluent received in relation to the available pore volume for the waste site
- Types and amounts of contaminants received; contaminant inventory
- Depth of waste discharge
- Expected distribution of contaminants, based on method of discharge and purpose of waste site
- Potential for hydrologic and contaminant impacts to groundwater.

The most important factors to consider in relation to the geologic setting as it pertains to the analogous site discussion are the thickness of the vadose zone and the relative depth of the confining layer (caliche layer). For the purposes of the analogous site groupings, these two factors remain relatively constant among the waste sites in the U Plant Area, as evidenced by the cross sections shown in Figures 2-2 through 2-4. The thickness of the vadose zone generally does not vary more than 1 m (3 ft), while the depth to the confining layer does not vary by more than approximately 10 m (33 ft) compared to a typical vadose zone thickness of 78 m (255 ft). Therefore, more subtle differences in the geologic setting of the waste sites are not discussed further in the analogous site rationale below.

In cases where characterization data are available from an analogous waste site, the data are evaluated for sufficiency to support a site-specific evaluation of risk. If the data are sufficient, a risk estimate for the analogous site is calculated and then used to support the evaluation and selection of the appropriate remedial action. If the data are insufficient to support a risk estimate, the data are used to support the comparison and assignment to an appropriate representative site. In most cases, little or no characterization data are available from the analogous sites. In these instances, existing information from the WIDS, discharge information, and general process information are used to make assignments.

It is assumed that the characterization data from representative sites will provide sufficient information to select remedies for the waste group. However, site-specific data also may be needed to verify that the selected remedial alternative is appropriate. Following the decision in the record of decision, additional sampling would be conducted as needed to confirm the selected remedy for the analogous waste sites and to collect data to support remedial design. Following remedial action, an additional data collection activity would be conducted as needed to verify the

achievement of remedial action objectives. A separate data quality objective and sampling analysis plan activity will address future data collection activities.

The risk analysis and data from the representative sites are used to support the risk evaluation and remedial decisions for those analogous sites that are without data to support a site-specific risk estimate. The use of the risk assessment from the representative sites presents some risk management decisions for the decision makers. If an analogous site is well represented by the representative site (i.e., the evaluation criteria of waste stream, size and construction, geology, waste inventory, and effluent volume received are similar or equal to the representative site), the decision to apply the representative site risk and preferred alternative poses minimal risk and minimal consequences of an incorrect decision.

Similarly, if the representative site bounds the contamination problem at an analogous site, the application of the representative site risk and remedial action pose minimal consequences from a human health and ecological risk standpoint, but may significantly impact costs through the potential application of an unnecessary remedy. In this situation, no confirmatory sampling or limited confirmatory sampling may be needed to confirm the nature of the contamination, the risk, and the appropriate remedial action. Design data may be needed, depending on the preferred alternative. If an analogous site is not bound by the representative site, because contamination may be greater at that analogous site, then application of the representative site risk estimate and preferred alternative poses the greatest decision risk and resulting consequences. In this case, confirmatory sampling would be required to ensure the selection of the appropriate alternative, based on a better understanding of the nature and risk of the analogous site. This last scenario is unlikely for most sites, because the analogous site approach tends to target waste sites that bound (e.g., have higher contaminant concentrations or greater risks) the contamination associated with a waste group.

There are situations, however, that may require special considerations as the analogous site approach is implemented in the U Plant Area. If a site does not fit or is not bounded by an existing representative site contaminant distribution model (i.e., data indicate that contaminant distribution may be more extensive or significantly different), a recommendation may be made to reclassify the waste site into a new or different waste group.

Another situation specific to the U Plant Area is that a number of the waste sites within the area do not have the previously assigned representative sites within the project boundary. For example, the 216-U-4 Reverse Well, 216-U-4A French Drain, and 216-U-4B French Drain are assigned to the 200-LW-2 200 Areas Chemical Laboratory Waste Group OU. DOE/RL-2001-66, *Chemical Laboratory Waste Group Operable Unit, RI/FS Work Plan, Includes: 200-LW-1 and 200-LW-2 Operable Units*, assigned two representative waste sites (216-Z-7 Crib and 216-S-20 Crib) for the 200-LW-2 OU. Therefore, a new analogous group and a different representative site within the U Plant Area is required for the FFS.

2.6.2 Analogous Site Groupings

The waste sites included in the 200-UW-1 OU include waste sites previously belonging to 8 of the 23 process-based OUs in the 200 Areas. Based on the analogous group assignment criteria above, six analogous groups have been developed, with representative waste sites assigned to

each group. The analogous waste groups are described in the following sections. Table 2-1 provides a list of the representative sites and analogous sites assigned to each representative site.

2.6.2.1 Process Waste Group

200-UW-1 OU waste sites formerly assigned to the Process Waste Group include sites in the following OUs:

- 200-PW-2: Uranium-Rich Process Waste OU
- 200-PW-3: Organic-Rich Process Waste OU
- 200-PW-4: General Process Waste OU.

These sites generally consist of engineered structures such as cribs, trenches, and settling tanks designed for disposal of liquid process wastes from the U Plant.

Because several waste sites within the Process Waste Group OUs were characterized during the 200-UP-2 Groundwater OU LFI, and the majority of these sites are high-risk waste sites in the U Plant Area, three waste sites have been selected as representative of this group; 216-U-1 and 216-U-2 Cribs, 216-U-8 Crib, and 216-U-12 Crib. The remaining waste sites in the Process Waste Group have been assigned to one of these three waste sites based on the criteria listed in Section 2.6.1.

Tables 2-3 through 2-5 provide descriptions of waste sites included in this group and the rationale for assigning analogous sites to the representative sites for the group.

Unplanned release UPR-200-W-163, which is associated with the 216-U-8 VCP (designated as the 200-W-42 VCP/UPR-200-W-163 site) has been identified as an analogous site for which sufficient data exist to perform risk assessment.

2.6.2.1.1 216-U-1 and 216-U-2 Cribs Representative Waste Site

The 216-U-1 and 216-U-2 Cribs have been selected as a representative waste site for the 241-U-361 Settling Tank. The following criteria were used to evaluate relationship between the representative site and those sites analogous to it.

1. *Waste site configuration and construction*: The 216-U-1 and 216-U-2 Cribs are below-grade timber structures constructed in an open excavation, which was backfilled with soil. The 241-U-361 Settling Tank is a circular reinforced concrete underground tank structure. This criterion is only partially applicable, because only the depth of the engineered structure for these sites is similar.

2. *Volume of effluent received in relation to the available pore volume*: The volume of effluent discharged from the 216-U-1 and 216-U-2 Cribs is significantly higher than the available soil pore volume (46,200 m^3 compared to 400 m^3). Because the volume and precise location of leakage from the 241-U-361 Settling Tank overflow (UPR-200-W-19) are unknown, a direct comparison cannot be made to the 216-U-1 and 216-U-2 Cribs. However, because the overflow was unplanned and not part of normal operation, it is

reasonable to assume that the volume of waste discharged to the cribs would be much higher than the amount of waste that overflowed from the tank.

3. *Contaminant inventory*: The contaminant type for the representative and analogous waste sites should be identical, because the 241-U-361 Settling Tank was not 100 percent efficient for removing solids, and the suspended and soluble contaminants were discharged to the cribs. The contaminant inventory in the 241-U-361 Settling Tank should be bounded by the 216-U-1 and 216- U-2 Cribs, because the tank only held a portion of the total waste stream.

4. *Depth of waste discharge*: The structure depths are similar for the representative and analogous sites; however, this criterion is only partially applicable, because the tank was not designed to discharge waste to the vadose zone, and only the unplanned tank overflow would have had the potential to follow the tank outside surface and reach the crib discharge depth.

5. *Expected distribution of contaminants*: The distribution of contaminants in the vadose zone is expected to be much higher for the 216-U-1 and 216-U-2 Cribs, compared to the 241-U-361 Settling Tank, because the cribs were designed to discharge liquid wastes and the tank was not.

6. *Potential for hydrologic and contaminant impacts to groundwater*: The 216-U-1 and 216-U-2 Cribs are known to have impacted groundwater. The 241-U-361 Settling Tank was not designed to discharge liquid waste to the vadose zone; however, the unplanned tank overflow would have had the potential to follow the tank outside surface and reach the crib discharge depth, so it has a small potential to have impacted groundwater. Therefore, the 216-U-1 and 216-U-2 Cribs would bound the 241-U-361 Settling Tank in terms of impacts to groundwater.

2.6.2.1.2 216-U-8 Crib Representative Waste Site

The following criteria were used to evaluate the suitability of the 216-U-8 Crib as a representative site for the 200-W-42 VCP/UPR-200-W-163 site.

1. *Waste site configuration and construction*: The 216-U-8 Crib consists of three wooden structures constructed in a 9 m (31 ft) deep open excavation that was backfilled with 1.3 cm (0.5-in.) crushed stone to the tops of the wooden structures and then to the existing grade with soil. The analogous site, 200-W-42 VCP/UPR-200-W-163, consists of a 15 cm (6–in.) diameter underground VCP buried approximately 3 to 4 m (10 to 12 ft) deep, and its associated surface unplanned release UPR-200-W-163. Although the structures are different, the representative site is deeper in the vadose zone and therefore bounds its analogous site in terms of depth.

2. *Volume of effluent received in relation to the available pore volume*: The volume of effluent discharged from the 216-U-8 Crib is significantly higher than the available soil pore volume (379,000 m^3 compared to 11,100 m^3). Because the volume and precise location of leakage from the 200-W-42 VCP/UPR-200-W-163 site pipeline are unknown, a direct comparison cannot be made to the 216-U-8 Crib. Because the pipeline

discharged to the 216-U-8 Crib, it is reasonable to assume that the volume of waste discharged to the crib would be much higher than the amount of waste that leaked from the pipeline. Therefore, the volume of effluent discharged to the 216-U-8 Crib is believed to bound the volume released from the 200-W-42 VCP/UPR-200-W-163 site pipeline.

3. *Contaminant inventory*: The contaminant inventory for the 216-U-8 Crib bounds the contaminant inventory for the 200-W-42 VCP/UPR-200-W-163 site pipeline, because only a portion of the waste was released from the pipeline. The pipeline did, however, carry the same uranium-rich waste stream that was discharged to the crib, so it is expected that the contaminants would be the same.

4. *Depth of waste discharge*: The 216-U-8 Crib discharged wastes at a depth of between 6 and 9 m (21 and 31 ft) (crib structure was 3 m [10 ft] tall) compared to the depth of the pipeline, which was 3 to 4 m (10 to 12 ft). The representative site bounds the analogous site in terms of discharge depth.

5. *Expected distribution of contaminants*: The expected distribution of contaminants in the vadose zone from the 216-U-8 Crib is expected to be similar to that of the 200-W-42 VCP/UPR-200-W-163 site pipeline, because the waste streams are the same, and the sites are located adjacent to each other. Less mobile contaminants, such as Cs-137, are found near the depth of release at both sites. The distribution of these contaminants is shallower at the 200-W-42 VCP/UPR-200-W-163 site because of the shallower discharge depth. Insufficient data exist to evaluate the distribution of contaminants deeper in the vadose zone beneath the 200-W-42 VCP/UPR-200-W-163 site pipeline.

6. *Potential for hydrologic and contaminant impacts to groundwater*: The 216-U-8 Crib is known to have impacted groundwater. The potential for contaminants to impact groundwater at the 216-U-8 Crib is expected to be greater than that of the 200-W-42 VCP/UPR-200-W-163 site pipeline, because the volume of waste discharged is believed to be greater than that of the 200-W-42 VCP/UPR-200-W-163 site, and the discharge depth of the crib was greater.

2.6.2.1.3 216-U-12 Crib Representative Waste Site

The following criteria were used to evaluate the suitability of the 216-U-12 Crib as a representative site for the sites listed in Table 2-1 (the 216-U-5, 216-U-6, and 216-U-15 Trenches and the 216-U-16 and 216-U-17 Cribs).

1. *Waste site configuration and construction*: The 216-U-12 Crib was constructed in a 5 m (15 ft) deep open excavation, which was backfilled with drainage layers of gravel, overlain by a polyethylene barrier and soil backfill. The 216-U-16 Crib and 216-U-17 Crib are constructed similarly with coarse drainage layers in the bottom of an unlined trench, overlain by an impermeable barrier (36 mil reinforced polyethylene for 216-U-16 Crib and 10 mil polyvinylchloride membrane for 216-U-17 Crib) and soil backfill. The 216-U-5, 216-U-6, and 216-U-15 Trenches were open excavations that were intended for short-term use. These trenches contained no structure and were backfilled with soil after use. The depths of the analogous sites range between 3 and 6 m (10 and 18 ft).

2. *Volume of effluent received in relation to the available pore volume*: The volume of effluent discharged to the 216-U-12 Crib is significantly greater than the soil pore volume beneath the site (150,000 m^3 compared to 1,400 m^3). The 216-U-12 Crib bounds the analogous sites, because it had a significantly higher ratio of effluent volume to soil pore volume compared to the 216-U-5 Trench, the 216-U-6 Trench, the 216-U-15 Trench, the 216-U-16 Crib, and the 216-U-17 Crib. The 216-U-16 Crib also had a significantly higher ratio of effluent volume to soil pore volume with 25 times the soil pore volume.

3. *Contaminant inventory*: The primary constituents in the 216-U-12 Crib waste inventory are uranium, Tc-99, and nitrate. Of these constituents, actual inventories for the 216-U-12 Crib were calculated only for uranium (2,010 kg). Total uranium, Tc-99, and nitrate inventories for the 216-U-16 Crib and 216-U-17 Crib are expected to be lower than those for the 216-U-12 Crib, because they received similar process condensate wastes from the 224-U Concentration Facility (UO_3 Plant) but received a smaller volume of waste. Because the 216-U-5 and 216-U-6 Trenches received unirradiated-fuel waste streams, no Tc-99 is expected to be present. The 216-U-15, 216-U-5, and 216-U-6 Trenches uranium inventories were estimated at 2.25 kg, 363 kg, and 363 kg, respectively. Nitrate inventories at the 216-U-5 and 216-U-6 Trenches were estimated at 200 kg for each trench. The 216-U-15 Trench received approximately 1 Ci of fission products (compared to about 6 Ci of fission products at the 216-U-12 Crib) and significant amounts of organic solution, whereas none of the other sites including the 216-U-12 Crib received significant amounts of organic solutions.

4. *Depth of waste discharge*: The 216-U-12 Crib is 5 m (15 ft), compared to a waste discharge depth range of 3 to 6 m (10 to 18 ft) for the analogous sites. The discharge depth for the representative site bounds the analogous sites.

5. *Expected distribution of contaminants*: The distribution of contaminants at the 216-U-12 Crib is representative of the analogous sites listed in Table 2-1 (the 216-U-5, 216-U-6, and 216-U-15 Trenches and the 216-U-16 and 216-U-17 Cribs). Immobile contaminants such as Cs-137 are found primarily near the point of release and are shallow within the vadose zone. Mobile contaminants were carried deep into the vadose zone or to groundwater. Although the data available from well 299-W22-78 indicate that little lateral spreading occurred, some lateral spreading may have occurred because of soil heterogeneities and naturally occurring capillary breaks across textural changes within single or across different geologic units. Because of the similarities in the contaminant inventories and release depths, similar distributions would be expected at the analogous sites.

6. *Potential for hydrologic and contaminant impacts to groundwater*: The 216-U-12 Crib is bounding, because it is known to have impacted groundwater, as evidenced by the presence of Tc-99 and nitrate in the groundwater. The 216-U-16 Crib also is known to have impacted groundwater, primarily through the lateral spreading of waste from the crib along the caliche to the 216-U-1 and 216-U-2 Cribs, where uranium and Tc-99 were mobilized and moved to groundwater through an improperly sealed well. No other analogous sites in this group impacted groundwater because of the limited discharge volumes from these sites.

2.6.2.2 Reverse Well/French Drain Group

200-UW-1 OU waste sites assigned to the Reverse Well/French Drain Group include sites formerly in the 200-LW-2, 200 Areas Chemical Laboratory Waste OU. These sites include one reverse well and two French drains that received laboratory waste from the 224-U Building (UO_3 Plant). Because of the proximity of the 216-U-4 Reverse Well and the 216-U-4A French Drain, they are considered together as one representative site. Table 2-6 provides the background and a description of the waste sites included in this group and the rationale for assigning analogous sites to the representative sites for the group. A general discussion of the rationale for the representative site and analogous groupings, based on the criteria established in Section 2.6.1, follows:

1. *Waste site configuration and construction*: The 216-U-4 Reverse Well is the only reverse well among the 200-UW-1 OU waste sites. The 216-U-4A French Drain and the 216-U-4B French Drain were constructed similarly (having similar materials, depth, and diameter).

2. *Volume of effluent received in relation to the available pore volume*: The volume of effluent discharged through the 216-U-4 Reverse Well and the 216-U-4A French Drain is 845 m^3 compared to a total of 33 m^3 for the 216-U-4B French Drain. Therefore, 216-U-4/216-U-4A bounds the analogous site.

3. *Contaminant inventory*: The 216-U-4 Reverse Well, the 216-U-4A French Drain, and the 216-U-4B French Drain all received waste from the 222-U Laboratory. The primary contaminants discharged to the 216-U-4 Reverse Well and the 216-U-4A French Drain are uranium (8.83 kg), plutonium (9.00 E-03 g), Cs-137 (1.85 E-01 Ci), Sr-90 (1.59 E-02 Ci), and nitrate (1,300 kg). The contaminant inventory for the 216-U-4B French Drain is higher in terms of plutonium (5.40 E-02 g), similar in terms of Cs-137 (1.97 E-01 Ci), lower in Sr-90 (1.65 E-03 Ci) and nitrate (10 kg), and lacks uranium altogether. Because uranium is the primary risk driver for protection of groundwater, 216-U-4/216-U-4A bound the 216-U-4B French Drain.

4. *Depth of waste discharge*: The depth of discharge is similar for the 216-U-4A French Drain and the 216-U-4B French Drain; however, the 216-U-4 Reverse Well is approximately 20 m (66 ft) deeper.

5. *Expected distribution of contaminants*: Because of the greater depth of the reverse well and much greater combined volume of discharge from the 216-U-4 Reverse Well and 216-U-4A French Drain, the contaminant distribution is expected to be significantly deeper for the representative site than for the analogous site (the 216-U-4B French Drain). Similar to other waste sites in the U Plant Area, immobile contaminants such as Cs-137 are found near the point of release, and more mobile contaminants such as nitrate migrate lower in the vadose zone. The representative site bounds the analogous site in terms of the depth of the contaminant distribution.

6. *Potential for hydrologic and contaminant impacts to groundwater*: Because of the depth of the 216-U-4 Reverse Well, the volume of effluent discharged in comparison to the soil pore volume, and the detection of uranium at the caliche layer in excess of the

background concentration, it is believed that contaminants from the representative site may have reached groundwater. Because the waste inventory for nitrate, the release depth, and the effluent volume are all significantly less for the 216-U-4B French Drain, the representative site is believed to bound it in terms of impacts to groundwater.

2.6.2.3 Septic System Group

200-UW-1 OU waste sites assigned to the Septic System Group include sites formerly in the 200-ST-1 Septic Tank and Drain Fields OU. These sites include two septic systems and their septic tanks, diversion boxes, and tile fields. These septic systems were intended to be used for sanitary effluent from the U Plant.

Because no characterization data are available for either of the septic systems located in the U Plant Area, it is necessary to select a representative site that bounds the septic systems in terms of contaminant inventory, distribution, and risk. Therefore, the representative site may not be analogous to the other sites in the group, but rather bounding.

These sites are considered bounded by the UPR-200-W-19 representative site, because they are adequately bounded in terms of waste inventory released to the site.

Table 2-7 provides the background and a description of the waste sites included in this group and the rationale for assigning analogous sites (2607-W5 and 2607-W7 Septic Tank and Tile Fields) to the representative sites for the group. General discussion of the rationale for assigning UPR-200-W-19 as a bounding site for this group is discussed in terms of the criteria established in Section 2.6.1. These criteria are evaluated as follows:

1. *Waste site configuration and construction*: The unplanned release has a different configuration than the septic systems because the unplanned release is not an engineered structure and was not built to accept sanitary effluent.

2. *Volume of effluent received in relation to the available pore volume*: The volume of effluent received is expected to exceed the soil pore volume for the septic systems. This is not the case for UPR-200-W-19; however, this may not be of significance, because the septic systems were intended to accept sanitary effluent, not contaminated effluents. Therefore the waste inventory transported with that liquid effluent is expected to be minimal.

3. *Contaminant inventory*: The waste inventory of the UPR-200-W-19 unplanned release and the septic systems is unknown; however, a known release of contaminants was documented at UPR-200-W-19, whereas no releases of radiological contaminants have been documented for the 2607-W5 and 2607-W7 Septic Systems, because they were intended for disposal of sanitary effluent.

4. *Depth of waste discharge*: The depth of discharge for the septic systems is considered similar to that of UPR-200-W-19, because the septic tanks and tile fields are near the surface.

5. *Expected distribution of contaminants*: The contaminant distribution is expected to be near the surface for immobile contaminants such as Cs-137 that may have been inadvertently released into the septic systems. More mobile contaminants inadvertently discharged into the septic systems could migrate deeper into the vadose zone; however, the amounts of these contaminants is expected to be small, because these contaminants were not purposely discharged into the septic systems, and no unplanned releases have been documented. Because surface contamination has been documented and characterized at UPR-200-W-19, it is believed that the representative site would bound the analogous sites in terms of risk.

6. *Potential for hydrologic and contaminant impacts to groundwater*: Because of the shallow nature of the representative and analogous sites, and the limited contaminant inventory released to the sites in comparison to other U Plant waste sites designed to accept liquid effluent, neither the representative site nor the analogous sites are expected to have impacted groundwater.

The 2607-W7 Septic System was removed from service in accordance with WAC 246-272-18501, "Department of Health," "On-Site Sewage Systems," "Abandonment." The 2607-W5 Septic System will be removed from service in a similar fashion as the closure progresses in the U Plant Area.

2.6.2.4 Solid Waste Group

200-UW-1 OU waste sites assigned to the Solid Waste Group include sites formerly belonging to the following OUs:

- 200-SW-1, Nonradioactive Landfills and Dumps OU
- 200-SW-2, Radioactive Landfills and Dumps OU.

These sites generally consist of unlined radioactive and nonradioactive dumps, burning grounds, and construction laydown areas. Because no characterization data exist for any similar sites within the U Plant Area, it is necessary to select a representative site that bounds these sites in terms of contaminant inventory, distribution, and risk. Therefore, the representative site may not be entirely analogous to the other sites in the group, but rather bounding.

Of the available representative sites, the UPR-200-W-19 representative site is the most similar site and is believe to adequately bound these sites in terms of waste inventory, contaminant distribution, and risk.

Table 2-7 provides the background and a description of the waste sites included in this group and the rationale for assigning analogous sites (200-W-56 Dump, 200-W-57 Dump, 200-W-71 Pit, and UPR-200-W-8 Pit or Burial Ground) to the representative sites for the group. General discussion of the rationale for assigning UPR-200-W-19 as a bounding site for this group is discussed in terms of the criteria established in Section 2.6.1. These criteria are evaluated as follows:

1. *Waste site configuration and construction*: The representative site and analogous sites are surface sites and therefore have little if any structure.

2. *Volume of effluent received in relation to the available pore volume*: UPR-200-W-19 had relatively low effluent volume, and the solid waste group sites received only solid waste.

3. *Contaminant inventory*: A documented release occurred at UPR-200-W-19, whereas no known contamination has been documented at the 200-W-56 and 200-W-57 Dumps, and contamination at the 200-W-8 Burial Ground is believed to have been cleaned up. Because contamination is known to exist at UPR-200-W-19, which is a documented release from a high-risk waste site, it is believed that the risk at this site would bound the analogous sites where contamination either has not been found or has been previously addressed at the analogous sites. It is believed that UPR–200-W-19 bounds these sites in terms of contaminant inventory, which is believed to be relatively small in comparison to other U Plant Area wastes sites such as cribs and trenches that were intended for disposal of significant inventory of contaminants.

4. *Depth of waste discharge*: The depth of release at UPR-200-W-19 is at the surface. Similarly, releases that may have occurred at the analogous sites, if any, also would have been at or near the surface.

5. *Expected distribution of contaminants*: The contaminant distribution at UPR-200-W-19 is expected to be near the surface contaminants, because the volume was relatively low and it was released at the surface. Because no contamination is known to exist at the analogous sites, and surface contamination has been documented and characterized at UPR-200-W-19, it is believed that the representative site bounds the analogous sites in terms of risk.

6. *Potential for hydrologic and contaminant impacts to groundwater*: It is hypothesized that the potential for contaminant impacts on groundwater is low for these sites because of the shallow nature of the representative and analogous sites and the limited contaminant inventory and liquid effluent volume released or potentially released to the sites.

2.6.2.5 Unplanned Release Group

200-UW-1 OU waste sites assigned to the Unplanned Release Group include sites formerly in the 200-UR-1 Unplanned Release OU. The unplanned release sites in this group are UPR-200-W-19 and UPR-200-W-118. Unplanned release UPR-200-W-19 has been selected as a representative site, based on characterization data near the release, and UPR-200-W-118 is believed to be analogous to, and bounded by, UPR-200-W-19 in terms of waste inventory, contaminant distribution, and risk. Table 2-7 provides the background and a description of the waste sites included in this group and the rationale for assigning analogous sites (UPR-200-W-118) to the representative sites for the group.

General discussion of the rationale for assigning UPR-200-W-19 as a bounding site for this group is discussed in terms of the criteria established in Section 2.6.1. These criteria are evaluated as follows:

1. *Waste site configuration and construction*: The representative site and the analogous site in this grouping are unplanned releases expected to be limited to surface soils within 3 m (10 ft) of the ground surface, based on the nature of the releases.

2. *Volume of effluent received in relation to the available pore volume*: This criterion is not applicable. The representative site and the analogous site in this grouping are unplanned releases and therefore the volumes of effluent discharged to these sites were low relative to cribs, trenches, and French drains.

3. *Contaminant inventory*: The representative site and the analogous site in this grouping are unplanned releases and therefore the contaminant inventory discharged to these sites was not documented. However, because surface contamination has been documented at UPR-200-W-19, and the release occurred from a high risk site, it is believed that the representative site would bound the analogous site in terms of risk.

4. *Depth of waste discharge*: Both the representative site UPR-200-W-19 and the analogous site UPR-200-W-118 were releases to surface soil and therefore have similar release depths.

5. *Expected distribution of contaminants*: Because the release depths are similar, it is anticipated that contaminant distributions at the representative site and the analogous site would be similar. The contaminant distribution at UPR-200-W-19 is expected to be near the surface for immobile contaminants such as Cs-137, with some lateral spreading caused by vegetation uptake of contaminants and subsequent wind-blown vegetation and soil. More mobile contaminants could migrate deeper into the vadose zone; however, the amounts of these contaminants are expected to be small because the contaminant inventory and effluent volume are believed to be relatively small in comparison to other 200-UW-1 OU waste sites such as cribs and trenches that were intended for disposal of liquid effluent. Spreading of more mobile contaminants deeper into the vadose zone is less likely because of the smaller volume of effluent released at these sites. Because surface contamination has been documented and characterized at UPR-200-W-19, and the release occurred from a high-risk waste site, it is believed that the representative site would bound the analogous site in terms of risk.

6. *Potential for hydrologic and contaminant impacts to groundwater*: It is hypothesized that the potential for contaminant impacts on groundwater is low for these sites because of the shallow nature of the representative and analogous sites.

2.6.2.6 Shallow/Surface Waste Site Group

200-UW-1 OU waste sites assigned to the Shallow/Surface Waste Site Group include sites formerly in the 200-UR-1 Unplanned Release OU. These sites include unplanned releases where contamination is expected to be limited to surface soils within 0.9 m (3 ft) of the ground surface, based on the nature of the release. These sites are considered analogous to, and adequately bounded by, the unplanned release UPR-200-W-19 representative site. Table 2-7 provides the background and a description of the waste sites included in this group and the rationale for assigning analogous sites (200-W-89 Foundation and the UPR-200-W-33, UPR-200-W-48,

UPR-200-W-55, UPR-200-W-60, 200-W-77, UPR-200-W-78, 200-W-85, 200-W-87, and UPR-200-W-117 Unplanned Releases) to the representative sites for the group.

General discussion of the rationale for assigning UPR-200-W-19 as a bounding site for this group is discussed in terms of the criteria established in Section 2.6.1. These criteria are evaluated as follows:

1. *Waste site configuration and construction*: The representative site and the analogous sites in this grouping are unplanned releases expected to be limited to surface soils within 3 m (10 ft) of the ground surface for the representative site and within 1 m (3 ft) of the ground surface for the analogous sites of the ground surface based on the nature of the releases.

2. *Volume of effluent received in relation to the available pore volume*: The representative site and the analogous sites in this grouping are unplanned releases, and therefore the volume of effluent discharged to these sites was low relative to cribs, trenches, and French drains. The volume of effluent at these sites is expected to be small, because the nature of the releases is that they are from small surface spills and leaks. The volume of effluent discharged to UPR-200-W-19 is expected to bound these sites, because it is a larger spill from a high-risk waste site. Several of the analogous sites had no liquid effluent associated with them.

3. *Contaminant inventory*: The representative site and the analogous sites in this grouping are unplanned releases, and therefore the contaminant inventory discharged to these sites was not documented. However, because surface contamination has been documented at UPR-200-W-19, and the release occurred from a high risk site, it is believed that the representative site would bound the analogous sites in terms of risk.

4. *Depth of waste discharge*: The representative site UPR-200-W-19 and the analogous sites were releases to surface soil and therefore have similar release depths.

5. *Expected distribution of contaminants*: Because the release depths are similar, is anticipated that contaminant distributions at the representative site and the analogous sites would be similar and would be bounded by UPR-200-W-19. The contaminant distribution at UPR-200-W-19 is expected to be near the surface for immobile contaminants such as Cs-137, with some lateral spreading caused by vegetation uptake of contaminants and subsequent wind blown vegetation and soil. More mobile contaminants could migrate deeper into the vadose zone; however, the amounts of these contaminants are expected to be small, because the contaminant inventory and effluent volume are believed to be relatively small in comparison to other U Plant Area wastes sites such as cribs and trenches that were intended for disposal of liquid effluent. Spreading of more mobile contaminants deeper into the vadose zone is less likely because of the smaller volume of effluent released at these sites. Because surface contamination has been documented and characterized at UPR-200-W-19, and the release occurred from a high-risk waste site, it is believed that the representative site would bound the analogous sites in terms of risk.

6. *Potential for hydrologic and contaminant impacts to groundwater*: It is hypothesized that the potential for contaminant impacts on groundwater is low for these sites because of the shallow nature of the representative site and the analogous sites.

2.7 SUMMARY OF RISK ASSESSMENT

The DOE, U.S. Environmental Protection Agency (EPA), and Ecology (Tri-Parties) recently undertook the task of developing a risk framework to support risk assessments in the Central Plateau. This included a series of workshops with representatives from DOE, EPA, Ecology, the Hanford Advisory Board (HAB), the Tribal Nations, the State of Oregon, and other interested stakeholders. The workshops focused on the different programs involved in activities in the 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 advice #132 (HAB 132, "Exposure Scenarios Task Force on the 200 Area"), in the Tri-Parties response to the HAB advise (Klein et al. 2002, "Consensus Advice #132: Exposure Scenarios Task Force on the 200 Area"). The following items summarize the risk framework description from the Tri-Parties response to the HAB.

1. The core zone (Central Plateau including B Pond [main pond] and S Ponds) will have an industrial scenario for the foreseeable future.

2. 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 waste 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.

3. DOE will follow the required regulatory processes for groundwater remediation (including public participation) to establish the points of compliance and remedial action objectives. 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 yr). It is assumed that the tritium and iodine-129 plumes beyond the core zone boundary will exceed the drinking water standards for the period of the next 150 to 300 yr (less for the tritium plume). It is expected that other groundwater contaminants will remain below, or be restored to, drinking water levels outside the core zone.

4. 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.

5. Waste sites outside the core zone but within the Central Plateau (200 North Area, Gable Mountain Pond, BC 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.

6. 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 following:
   - The post-institutional controls period (>150 yr)
   - Sites near the core zone perimeter, to analyze opportunities to "shrink the site"
   - Early (precedent-setting) closure/remediation decisions.
7. This framework does not address the tank retrieval decision.

This description serves as the basis for the risk assessment activities performed as part of this FFS. The human health and ecological risk assessments can be found in Appendix C of this document and are summarized in the following subsections and in Table 2-8.

2.7.1 Human Health Risk Assessment

The human health risk assessment (HHRA) (see Appendix C) includes the evaluation of nonradiological and radiological constituents from the six representative waste sites. Analytical data used in the HHRA include shallow zone (0 to 4.6 m [0 to 15 ft] bgs) and deep-zone soil (0 to the groundwater table) samples and were screened in accordance with EPA, Ecology, and DOE guidance to identify the contaminants of potential concern (COPC). The purpose of the HHRA is to identify and prioritize the COPCs that are estimated to pose an unacceptable risk (or dose) and should be addressed by the FFS.

All of the representative waste sites are located in the industrial (exclusive) land-use boundary (core zone). All shallow-zone soil samples were evaluated under an industrial exposure scenario. A hypothetical Native American subsistence scenario also was evaluated, to provide a basis of comparison (assuming unrestricted land use) to the site-specific industrial exposure scenario. Ecology, the EPA, and the DOE have interacted with the stakeholder Tribes over the past several years to obtain their input on developing a Native American exposure scenario or scenarios, including key parameters for the Central Plateau risk assessment models. The Tribes were involved in the risk assessment framework workshops during the summer of 2002; in October 2002, they were asked to provide written suggestions on specific risk assessment parameters (exposure assumptions) for tribal use scenarios (DOE-RCA-2002-0584, 2002a; 2002b; 2002c [contain no titles]). This request culminated in a workshop in December 2002 that included Ecology, the EPA, the DOE, and representatives from the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes and Bands of the Yakama Nation, and the Nez Perce Tribe. The Yakamas and the Nez Perce participated in the workshop, but felt they needed additional time to provide input. The Umatillas asked that the information from "A Native American Exposure Scenario" (Harris and Harper 1997) be used to calculate risk estimates for a Native American subsistence scenario. Additional discussion regarding the hypothetical Native American scenario is provided in Appendix C of this report.

Local groundwater is not a current source of drinking water and is being addressed under the 200-UP-1 Groundwater OU. However, the potential for contaminants to migrate from soil to groundwater was evaluated.

2.7.1.1 Nonradiological Results

The *Comprehensive Environmental Response, Compensation and Liability Act of 1980* (CERCLA) prescribes a risk range of 10^{-6} to 10^{-4} for evaluating the need for remedial action for carcinogens and noncarcinogenic constituents that pose a chronic toxic effect to human health; noncarcinogenic constituents that pose a chronic toxic effect to human health shall not exceed a hazard quotient of 1.0. Risk-based standards based on an industrial scenario are identified in WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties," that equate to a risk of 1×10^{-5}; these standards are evaluated in the risk assessment. A summary of the HHRA results for nonradiological constituents is presented below.

Shallow Zone[3]

All nonradiological COPCs from the shallow zone were compared to the WAC 173-340-745(5)(b)(iii)(B), "Soil Cleanup Standards for Industrial Properties," "Method C Industrial Soil Cleanup Levels," "Standard Method C Industrial Soil Cleanup Levels," "Human Health Protection," "Soil Direct Contact," and the WAC 173-340-750(4), "Cleanup Standards to Protect Air Quality," "Method C Air Cleanup Levels," ambient air cleanup levels (CUL) for the industrial exposure scenario. The sample mean concentrations of all shallow-zone COPCs from each representative waste site were less than their respective direct-contact and ambient-air Method C CULs. A summary of these comparisons is provided in Appendix C, Tables C-29 through C-34 and Tables C-41 through C-46, respectively.

Deep Zone[4]

All nonradiological COPCs from the deep zone were compared to the WAC 173-340-747, "Deriving Soil Concentrations for Ground Water Protection," Method B CULs for the groundwater protection pathway. Except for concentrations of antimony, arsenic, nitrate, nitrogen in nitrite and nitrate, and uranium, the sample mean concentrations for all constituents were less than their respective groundwater protection WAC 173-340-747, Method B CUL at all representative waste sites. Summaries of these comparisons are provided in Appendix C, Tables C-35 through C-40.

Sample mean concentrations of nitrate (as NO_3) at the 216-U-8 Crib, sample mean concentrations of nitrogen in nitrite and nitrate at the 216-U-8 Crib, 216-U-12 Crib, and 200-W-42 VCP/UPR-200-W-163 site, and sample mean concentrations of total uranium at the 216-U-8 Crib, 216-U-4 Reverse Well/216-U-4A French Drain, and the 216-U-1/216-U-2 Cribs exceeded their respective WAC 173-340-747 Method B CULs and site background concentrations. These constituents are considered contaminants of concern for the groundwater protection pathway and should be considered in the FFS. Antimony at the 216-U-8 Crib, UPR-200-W-19, and the 216-U-1/216-U-2 Cribs, arsenic at the 216-U-12 Crib and 200-W-42 VCP/UPR-200-W-163 site, and mercury at the 216-U-4 Reverse Well/216-U-4A French Drain

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[3] Shallow zone soils are defined as those collected from zero to 15 ft bgs.

[4] Deep zone soils are defined as those collected from the soil surface to the groundwater table.

failed the three-part test as described in WAC 173-340-740(7), "Unrestricted Land Use Soil Cleanup Standards," "Compliance Monitoring"; therefore these constituents also are considered contaminants of concern for the groundwater protection pathway and should be considered in the FFS.

2.7.1.2 Radiological Results

The HHRA for radiological constituents was performed using the RESidual RADioactivity (RESRAD) code Version 6.2 analysis (ANL 2002, *RESRAD for Windows*, Version 6.21). The RESRAD model was used to obtain risk and dose estimates from direct-contact exposure to radiological constituents present in the shallow zone under an industrial-exposure scenario. Risk and dose estimates also were determined for a hypothetical Native American subsistence scenario; however, the focus of this summary is on industrial exposure.

Radiological constituents in the shallow zone are evaluated using two different methods. The first evaluation method is considered representative of current site conditions, because it accounts for the depth of clean cover that is currently over the representative waste site. Radiological constituents are encountered only at depths greater than the clean cover, which accounts for protective shielding effects. It is assumed that a minimum of 0.45 m (1.5 ft) of clean material covers the 216-U-8 Crib and UPR-200-W-19, 0.53 m (1.7 ft) of clean material covers the UPR-200-W-19 site, and 0.61 m (2 ft) of clean material covers the 216-U-1 and 216-U-2 Cribs. No clean material covers the 216-U-12 Crib or the 200-W-42 VCP/UPR-200-W-163 site; therefore, this scenario was not considered for these waste sites.

The second evaluation method is considered representative of worst case conditions, because it assumes that there is no clean cover over the representative waste site. The absence of clean cover assumes that the radiological constituents are distributed evenly throughout the shallow zone and that there are no protective effects from shielding. As described in the HHRA, the exposure-point concentrations for each of the radiological constituents were calculated as the lesser of either the maximum value or the 95th percentile upper confidence limit (UCL) of all results.

The RESRAD model (ANL 2002) was used to obtain risk and dose estimates for the groundwater protection pathway for deep zone soils. However, the model is limited to screening purposes, and the results were used to focus the appropriate fate and transport model used in the FFS.

For comparative purposes, risk and dose estimates are discussed relative to the following exposure times:

- 50 years is the estimated time that the DOE will have an on-site presence
- 150 years is the estimated time that institutional controls are assumed to be effective.

For this remedial action, the radiation dose limit for the industrial and hypothetical Native American subsistence exposure scenarios evaluated is 15 mrem/yr (10 CFR 835, "Occupational Radiation Protection"). This dose limit is developed for members of the public who are unknowingly exposed to radiation, and it is approximately equivalent to an excess lifetime cancer risk (ELCR) of 1×10^{-4}. For the groundwater protection pathway, the average annual

activity of beta particles and photon radioactivity from manmade radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ of greater than 4 mrem/yr (40 CFR 141.66, "National Primary Drinking Water Regulations," "Maximum Contaminant Levels for Radionuclides").

Shallow Zone[5] – Industrial Scenario - Clean Cover

Except for the 200-W-42 VCP/UPR-200-W-163 site, the total dose from each of the representative waste sites does not exceed the target dose level of 15 mrem/yr at any of the exposure times evaluated. Similarly, the ELCR does not exceed 1×10^{-5} at any of the exposure times evaluated. With the exception of the 200-W-42 VCP/UPR-200-W-163 site, the ELCR for all sites is also within the CERCLA target risk range of 1×10^{-6} to 1×10^{-4}. The results of this evaluation are provided in Appendix C, Tables C-47 and C-48.

At the 200-W-42 VCP/UPR-200-W-163 site, the total dose is less than 15 mrem/yr through 150 years, 21 mrem/yr at 450 years, 19 mrem/yr at 500 years, and less than 15 mrem/yr at 1,000 years. The primary radionuclides associated with the maximum total dose include Am-241, Th-232, Ra-226, and Pu-239. The maximum ELCR is 1.8×10^{-4} at 450 yr. The ELCR under this exposure scenario exceeds the target risk level of 1.0×10^{-5} at all exposure times evaluated. With the exception of the 50- and 150-year exposure times, the ELCR also exceeds the CERCLA upper target risk threshold of 1×10^{-4}.

No radiological constituents were identified as COPCs in shallow zone soil from the 216-U-12 Crib; therefore the industrial exposure scenario was not evaluated.

Shallow Zone – Industrial Scenario - Without Clean Cover

216-U-8 Crib (Representative Site). The total dose at the 216-U-8 Crib is 83 mrem/yr at 50 years, and a total dose of less than 15 mrem/yr is achieved at exposure times evaluated before 150 years. The ELCR is 1.1×10^{-3} at 50 years and 1.1×10^{-4} at 150 years. The ELCR under this exposure scenario is less than the target risk level of 1.0×10^{-5} after 150 years. Additionally, the ELCR under this scenario is within or less than the CERCLA target risk range of 1×10^{-6} to 1×10^{-4} after 150 years. The primary contributor to total dose and risk is Cs-137. The results of this evaluation are provided in Appendix C, Tables C-49 and C-50.

216-U-4 Reverse Well/216-U-4A French Drain (Representative Site). The total dose at the 216-U-4 Reverse Well/216-U-4A French Drain is 37 mrem/yr at 50 years, and a total dose of less than 15 mrem/yr is achieved at exposure times evaluated before 150 years. The ELCR is 5.0×10^{-4} at 50 years and 1.0×10^{-4} at 150 years. The ELCR under this exposure scenario slightly exceeds the target risk level of 1.0×10^{-5} after 150 years. Additionally, the ELCR under this scenario is within the CERCLA target risk range of 1×10^{-6} to 1×10^{-4} after 150 years. The primary contributor to total dose and risk is Cs-137. The results of this evaluation are provided in Appendix C, Tables C-49 and C-50.

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[5] Shallow zone soils are defined as those collected from zero to 15 ft bgs.

UPR-200-W-19 (Representative Site). The total dose at UPR-200-W-19 is 52 mrem/yr at 50 years, and a total dose of less than 15 mrem/yr is achieved at exposure times evaluated before 150 years. The ELCR is 6.9×10^{-4} at 50 years and 7.0×10^{-5} at 150 years. The ELCR under this exposure scenario is less than the target risk level of 1.0×10^{-5} after 150 years. Additionally, the ELCR under this scenario is within or less than the CERCLA target risk range of 1×10^{-6} to 1×10^{-4} after 150 years. The primary contributor to total dose and risk is Cs-137. The results of this evaluation are provided in Appendix C, Tables C-49 and C-50.

216-U-1/216-U-2 Cribs (Representative Site). The total dose at the 216-U-1/216-U-2 Cribs is 50 mrem/yr at 50 years, and a total dose of less than 15 mrem/yr is achieved at exposure times evaluated before 150 years. The ELCR is 6.7×10^{-4} at 50 years and 6.7×10^{-5} at 150 years. The ELCR under this exposure scenario is less than the target risk level of 1.0×10^{-5} after 150 years. Additionally, the ELCR under this scenario is within or less than the CERCLA target risk range of 1×10^{-6} to 1×10^{-4} after 150 years. The primary contributor to total dose and risk is Cs-137. The results of this evaluation are provided in Appendix C, Tables C-49 and C-50.

200-W-42 VCP/UPR-200-W-163 (Analogous Site). The total dose at the 200-W-42 VCP/UPR-200-W-163 site is 7,820 mrem/yr at 50 years, 799 mrem/yr at 150 years, 19 mrem/yr at 500 years, 15 mrem/yr at 831 years, and less than 15 mrem/yr after 831 years. The ELCR is 1.1×10^{-1} at 50 years, 1.1×10^{-2} at 150 years, 1.7×10^{-4} at 500 years, and 1.3×10^{-4} at 1,000 years. The ELCR under this exposure scenario exceeds the target risk level of 1.0×10^{-5} at all exposure times evaluated. Additionally, the ELCR under this scenario exceeds the CERCLA target risk threshold of 1×10^{-4} at all exposure times evaluated. The primary radionuclide associated with the total dose and risk at 50 years and 150 years is Cs-137, and the primary radionuclides are Am-241, Th-232, Ra-226, and Pu-239 at 500 years. The results of this evaluation are provided in Appendix C, Tables C-49 and C-50.

No radiological constituents were identified as COPCs in the shallow zone from the 216-U-12 Crib; therefore, risk and dose estimates were not calculated for the direct-contact industrial-exposure scenario.

Deep Zone[6] – Groundwater Protection

At the 216-U-12 Crib and the 216-U-4 Reverse Well/216-U-4A French Drain, , the total dose is less than the target dose level of 4 mrem/yr, and the ELCR is less than the target risk level of 1.0×10^{-6} at all exposure times evaluated. The analytical data available for 216-U-12 Crib are not considered spatially representative, and it is likely that radiological contaminants are present in the vadose zone that would impact the groundwater protection pathway.

Exposure point concentrations (EPC) of radiological constituents in the shallow zone were evaluated separately for the groundwater protection pathway. The purpose of this evaluation was to determine if the concentrations of radiological constituents for the shallow zone (zero to 4.6 m [0 to 15 ft] bgs) are underestimated when they are combined with the concentrations of the remaining soil column. The results of this evaluation indicate that the deep zone soil (that is, soil

[6] Deep zone soils are defined as those collected from the soil surface to the groundwater table.

surface to the groundwater table) EPCs adequately represent the contribution of contaminants in the shallow zone. Shallow zone dose and risk estimates for the groundwater protection pathway are equal to or less than the dose and risk estimates provided for the deep zone evaluation.

216-U-8 Crib. The total dose at 126 years is 106 mrem/yr, which also is the maximum dose. The total dose is less than the target dose level of 4 mrem/yr at all exposure times beyond 126 years. The ELCR is 3.8×10^{-4} at 126 years and 4.0×10^{-7} at 150 years. The ELCR under this exposure scenario does not exceed the target risk level of 1.0×10^{-6} after 150 years. The primary contributors to dose and risk include Se-79 and Tc-99. The results of this evaluation are provided in Appendix C, Tables C-55 and C-56.

UPR-200-W-19. The total dose at 76 years is 67 mrem/yr, which also is the maximum dose. The total dose is less than the target dose level of 4 mrem/yr at all exposure times beyond 76 years. The ELCR is 2.2×10^{-4} at 76 years. The ELCR under this exposure scenario does not exceed the target risk level of 1.0×10^{-6} after 76 years. The primary contributors to dose and risk at 76 years include Se-79.

216-U-1/216-U-2 Cribs. The total dose at 76 years is 194 mrem/yr, which also is the maximum dose from zero to 1,000 years. The total dose is less than the target dose level of 4 mrem/yr from 150 to 500 years. The total dose slightly increases to .33 mrem/yr at 14, 000 years and decreases to zero at 10,000 years. The ELCR is 6.1×10^{-4} at 76 years and decreases to less than 1×10^{-6} from 150 to 500 years. The ELCR increases to 5.2×10^{-6} at 14,000 years and decreases to less than 1.0×10^{-6} thereafter. The primary radionuclides associated with the maximum total dose and risk at 76 years include Se-79 and Tc-99, and the radionuclide associated with total dose at 14,000 years is I-129.

2.7.2 Ecological Risk Assessment

For the ecological risk assessment (ERA), the eight-step ERA process developed for the Superfund program in EPA/540/R-97/006, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (Interim Final)*, was followed (see Appendix C). The process starts with a screening-level ERA (SLERA), which uses conservative screening values provided by Ecology (WAC-173-340-900, "Tables") for nonradionuclides and by the Biota Dose Assessment Committee (BDAC) in DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*, for radionuclides. This corresponds to Steps 1 and 2 of the EPA guidance (EPA/540/R-97/006). The SLERA process followed is as described in DOE/RL-2001-54 and is further outlined in Appendix C. The U Plant Area SLERA intentionally is conservative and serves to eliminate analytes and sites from further evaluation that do not pose a risk to the environment despite the SLERA's bias toward overestimating risk. The SLERA is used to determine whether further evaluation (i.e., baseline ERA) or remedial actions are necessary. The results of the screening are presented separately in the following subsections for nonradionuclides and radionuclides.

2.7.2.1 Results of the Screening-Level Ecological Risk Assessment

Nonradionuclides

For each of the representative sites, EPCs for each nonradionuclide constituent were screened against the wildlife screening values presented in WAC 173-340-900, Table 749-3, to determine if any chemical concentrations exceeded their respective screening values. The waste sites had the following nonradionuclides exceed their respective terrestrial wildlife screening values.[7]

- 216-U-8 Crib: none
- 216-U-12 Crib: arsenic (1.22) and barium (1.01)
- UPR-200-W19: none
- 216-U-1/216-U-2 Cribs: none
- 200-W-42 VCP/UPR-200-W-163: arsenic (1.25).

Radionuclides

For each of the representative waste sites, the exposure point concentration of each radionuclide was screened against biota concentrations guides (BCG) proposed by the BDAC (DOE-STD-1153-2002). The waste sites had the following individual radionuclides exceed their respective terrestrial wildlife BCGs at these waste sites:[8]

- 216-U-8 Crib: Cs-137 (21/4.2) and Sr-90 (1.5/<1)
- 216-U-12 Crib: none
- UPR-200-W19: Cs-137 (12/2.7) and Sr-90 (1.9/<1)
- 216-U-1/216-U-2 Cribs: Cs-137 (12/2.3)
- 200-W-42 VCP/UPR-200-W-163: Cs-137 (1,900/250) and Sr-90 (6.5/<1).

For each of the 200-UW-1 OU waste sites except for the 216-U-12 Crib, the total risk estimate (sum of all radionuclide fractions) exceeded 1.0 for terrestrial wildlife. The individual radionuclides identified above were the major contributors to the sum of fraction exceedances. Cesium-137 contributes greater than 70 percent of the total sum of fractions at each waste site with Level 2 exceedances.

2.7.3 Evaluation of Ecological significance

Step 1 (preliminary problem formulation) of the EPA ERA process revealed that ecological receptors and sufficient habitat are present or potentially present at the U Plant Area. The results of Step 2 (ecological risk-based screening) are provided in Appendix C, Section C2.7.2.1, and indicate that at least one screening value has been exceeded at each representative waste site

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[7]Values in parentheses represent the factor of exceedance (EPC divided by the screening level) above the wildlife screening value.

[8]Values in parentheses represent the factor of exceedance (maximum detect divided by BCG/mean detected concentration divided by BCG) above the wildlife screening value.

evaluated. This section provides a qualitative and quantitative evaluation of the ecological significance of the Step 2 exceedances. More realistic assumptions (versus the defaults used during Step 2) and consideration of background concentrations are used to provide a perspective on the ecological significance of the Step 2 exceedances. This discussion is provided separately for nonradionuclides and radionuclides in the following sections.

2.7.3.1 Nonradionuclides

For terrestrial wildlife, only arsenic and barium at the 216-U-12 Crib and arsenic at UPR-200-W19 exceeded their respective wildlife screening levels. Sitewide soil background levels have been established for metals at the Hanford Site and are compared with site-specific concentrations in Appendix C, Tables C-12 through C-17. The EPC for barium at the 216-U-12 Crib of 104 mg/kg is below the 90th percentile background concentration of 132 mg/kg. The EPCs for arsenic at the 216-U-12 Crib and UPR-200-W19 are 8.6 mg/kg and 8.8 mg/kg, respectively. The 90th percentile background concentration for arsenic is 6.5 mg/kg. Collectively considering the low magnitude of each exceedance of the arsenic screening value (1.22 and 1.25), conservative assumptions implied in the SLERA (e.g., no area use factor applied, 100 percent bioavailability, focused sampling at known contaminant areas), and levels attributable to naturally occurring metal concentrations, these exceedances are not expected to be biologically significant.

2.7.3.2 Radionuclides

Level 1 and 2 risks to terrestrial wildlife from contamination in surface soil were estimated using a highly conservative model (see Appendix C, Sections C4.5.1.2 and C4.6). For example, exposure and toxicity estimations for the most radiosensitive species (primarily small mammals) tested were used to conservatively estimate the risks to wildlife. Additionally, the model used did not account for home range (i.e., area use factor (AUF) = 1 was assumed), availability of higher quality habitat for foraging in nearby areas, and the clean cover soil at some waste sites. The model assumes that a small mammal resides and forages exclusively at each waste site evaluated and that these small mammal populations and their food items are continuously exposed to high-end levels of radionuclides that have been measured at each waste site, sometimes at soil depths of up to 15 ft bgs. The ecological significance of the risks to wildlife potentially exposed at each area evaluated are discussed below for the four U Plant Area representative waste sites at which radionuclide levels exceeded screening levels during the Level 2 screening.

- **216-U-8 Crib.** Mean Cs-137 concentrations exceeded the wildlife BCG by a factor of 4.2. Using the mean concentrations, the sum of all fractions for all radionuclides was 5.3. Clean stabilization cover with a minimum depth of 1.5 ft exists at the 216-U-8 Crib. Cesium-137 levels exceed the BCG at 2 of 5 sample locations (B0BKM1 and B0BKM2), with the shallowest exceedance occurring from 0.5 ft below the stabilization cover. The waste site is approximately 0.6 acre and contains limited vegetation. Considering the conservative exposure and effect assumptions described in Appendix C, Sections C4.5.1.2 and C4.6, used in the Level 2 screening for radionuclides, the magnitude of the exceedance of the screening level, and reduced direct exposure with the stabilization

cover, the ecological significance of these exceedances to terrestrial wildlife populations likely is low.

- **UPR-200-W19**. Mean Cs-137 concentrations exceeded the wildlife BCG by a factor of 2.7. Using the mean concentrations, the sum of all fractions for all radionuclides was 3.7. Clean stabilization cover with a minimum depth of 1.75 ft exists at UPR-200-W19. Cesium-137 levels exceed the BCG at 5 of 7 sample locations, with the shallowest exceedance occurring from 0.5 ft below the stabilization cover. Considering the conservative exposure and effect assumptions described in Appendix C, Sections C4.5.1.2 and C4.6, used in the Level 2 screening for radionuclides, the magnitude of the exceedance of the screening level, and reduced direct exposure with the stabilization cover, the ecological significance of these exceedances to terrestrial wildlife populations likely is low.

- **216-U-1 and 216-U-2 Cribs**. Mean Cs-137 concentrations exceeded the wildlife BCG by a factor of 2.3. Using the mean concentrations, the sum of all fractions for all radionuclides was 3.2. Clean stabilization cover with a minimum depth of 2 ft exists at the 216-U-1 and 216-U-2 Cribs. Cesium-137 levels exceed the BCG at 7 of 9 sample locations, with the shallowest exceedance occurring from 0.5 ft below the stabilization cover. Again, considering the conservative exposure and effect assumptions described in Appendix C, Sections C4.5.1.2 and C4.6, used in the Level 2 screening for radionuclides, the magnitude of the exceedance of the screening level, and reduced direct exposure with the stabilization cover, the ecological significance of these exceedances to terrestrial wildlife populations likely is low.

- **200-W-42 VCP/UPR-200-W-163**. Mean Cs-137 concentrations exceeded the wildlife BCG by a factor of 250. Using the mean concentrations, the sum of all fractions for all radionuclides was 250. Clean stabilization cover with a minimum depth of 1.5 ft exists at the 200-W-42 VCP/UPR-200-W-163 site. Cesium-137 levels exceed the BCG at six of 11 sample locations, with the shallowest exceedance occurring from 7.5 ft below the stabilization cover. Concentrations of Cs-137 were below the wildlife BCG in each of the four shallow surface soil samples collected at depths between 5 and 6 ft below the stabilization cover. Even considering the conservative methods employed in this SLERA, the magnitude of the Cs-137 exceedance indicates that adverse effects to terrestrial wildlife potentially exposed at the 200-W-42 VCP/UPR-200-W-163 site are possible; however, the depth of the contamination likely significantly reduces or eliminates the amount of direct exposure to radionuclides for terrestrial wildlife species. Therefore, the most plausible exposure and risk is to wildlife that consume deep-rooted vegetation (e.g., big sagebrush, Russian thistle, antelope bitterbrush).

Because initial screening risk estimates resulted in Cs-137 concentrations that exceed a ratio of 1.0 at these four representative waste sites, further evaluation was warranted for Cs-137 to provide an additional evaluation on ecological significance of the exceedances. The results of this evaluation are presented in the following section, and the entire process and assumptions are provided in Appendix C.

2.7.3.2.1 Results of Additional Screening for Cesium-137

A screening value for Cs-137 was calculated using the RESRAD-BIOTA model, following the assumptions listed in Appendix C, Section C4.5.1.2. Two modifications to the exposure model used in the previous screening resulted in a slightly less conservative screening to provide a more realistic perspective on the potential for risk to terrestrial wildlife.

For the 216-U-8 Crib, UPR-200-W19, the 216-U-1 and 216-U-2 Cribs, and the 200-W-42 VCP/UPR-200-W-163 waste sites, mean Cs-137 concentrations in surface soil were screened against the Cs-137 BCG. The results of the terrestrial wildlife screening for Cs-137 were as follows:

- **216-U-8 Crib**: factor of exceedance = 0.76
- **UPR-200-W-19**: factor of exceedance = 0.50
- **216-U-1 and 216-U-2 Cribs**: factor of exceedance = 0.42
- **200-W-42 VCP/UPR-200-W-163**: factor of exceedance = 45.

Although the RESRAD-BIOTA model used for this screening is in draft form and currently is undergoing validation, the inputs and equations are based on the guidance provided in DOE-STD-1153-2002. This additional line of evidence is intended to provide support for the remedial decision-making process. The model was used to evaluate the potential effects under more realistic exposure assumptions that serve to provide a perspective on the conservatism inherent in the results of the initial screening. Application of additional modifications (e.g., area use factors, finite body size for external radiation exposure) based on potential site-specific receptors would be anticipated to further lower the risk estimates.

2.7.3.2.2 Conclusions/Recommendations

This ERA (see Appendix C) assesses the potential impacts on terrestrial wildlife from past releases to soil at the 200-UW-1 OU waste sites, and was conducted in accordance with EPA, Ecology, and DOE guidance. The resulting characterization of potential risk is expected to provide enough information that informed decisions can be made about these waste sites. The primary decision for which the results of the SLERA provide input is whether to address any areas and site-related constituents at the waste site because of the potential threat to the environment. Therefore, results of an ERA are used to determine which of the following recommendations can be made:

- No further ecological investigations at the waste site
- Continuation of the risk assessment process at the next level
- Undertake a removal or remedial action.

Based on the nature and extent of constituent concentrations observed during the waste site investigation, and considering ecosystem characteristics, the following conclusions are made.

- On the basis of considering the background concentrations for metals at the Hanford Site and the screening levels for nonradionuclides, soil concentrations for nonradionuclides are not considered high enough to pose unacceptable risk to terrestrial wildlife at any of the U Plant Area representative waste sites evaluated.

- Radionuclide levels in soil exceed available Level 1 and 2 screening concentration for terrestrial wildlife at the 216-U-8 Crib, UPR-200-W19, 216-U-1 and -2 Cribs, and the 200-W-42 VCP/UPR-200-W-163 site.

- However, a closer evaluation (including Level 3) indicates that detected radionuclide concentrations (except at the 200-W-42 VCP/UPR-200-W-163 site) likely are not high enough to pose unacceptable risk to terrestrial wildlife populations or to any Federally- or state-listed threatened or endangered terrestrial wildlife species in the area.

Based on the results of this risk analysis, the constituent with the highest potential for ecological exposure is Cs-137 at the 216-U-8 Crib, UPR-200-W19, the 216-U-1 and 216-U-2 Cribs, and the 200-W-42 VCP/UPR-200-W-163 site. However, risks to terrestrial wildlife using the U Plant Area are considered marginal to low at all of the waste sites except the 200-W-42 VCP/UPR-200-W-163 site. Decisions on whether to undertake remedial actions are discussed in Chapter 4.0.[9]

2.8 SUMMARY OF GROUNDWATER PROTECTION FATE AND TRANSPORT MODELING

Fate and transport modeling (see Appendix D) was conducted for the 216-U-1/216-U-2 Cribs, 216-U-4 Reverse Well/216-U-4A French Drain, 216-U-8 Crib, 216-U-12 Crib, and the 200-W-42 VCP/UPR-200-W-163 Site. Modeling was performed because the risk assessment (see Section 2.7 and Appendix C) identified the potential for groundwater impact above groundwater MCLs. The fate and transport modeling was accomplished using the STOMP model (PNNL-12034, *STOMP, Subsurface Transport Over Multiple Phases, Version 2.0, User's Guide*) developed by Pacific Northwest National Laboratory. The model is used to simulate existing contaminant soil concentrations and predict future migration of contaminants and concentrations through the soil column into groundwater.

The criteria specified in WAC 173-340-747(8), "Deriving Soil Concentrations for Ground Water Protection," "Overview of Methods," "Alternative Fate and Transport Models," also were evaluated in Appendix D. The criteria specify the procedures and requirements for using alternative fate and transport models. Based on this evaluation, it is concluded that the models developed using the STOMP code and their application within the 200-UW-1 OU are appropriate and meet the requirements as set forth in WAC-173-340-747(8).

Conceptual models were developed for each waste site based on site-specific information (e.g., contaminant and soil property data) and translated into numerical form. These data and model assumptions provide the framework for the simulations and the confidence that predictions of fate and transport are appropriate.

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[9] RESRAD-BIOTA results will be reevaluated in the event that updates to the beta version could increase the risk estimates, although waste sites where the selected remedy involves removal and disposal would not need reevaluation because the exposure pathway would be eliminated.

A simulation was run for each site using input that simulates present day hydrologic conditions and contaminant distributions. The results of this modeling were used to evaluate and identify remedial strategies for the U Plant Area by predicting waste sites with the potential to impact groundwater. Waste sites with the potential to impact groundwater are considered for placement of an engineered barrier as a remedial alternative.

Results of the modeling indicate that four sites (216-U-1/216-U-2 Cribs, 216-U-8 Crib, and 216-U-12 Crib) have contaminant inventories sufficient to pose a threat to groundwater above MCLs within a thousand years. Those sites and contaminants are listed below:

- Tc-99 may impact groundwater and exceed the MCL at the 216-U-1 and 216-U-2 Cribs
- Uranium and nitrogen (as nitrate and nitrite) may impact groundwater and exceed MCLs at the 216-U-8 Crib
- Nitrogen (as nitrate and nitrite) may impact groundwater and exceed the MCL at the 216-U-12 Crib.

Results of the modeling also indicate that contaminants beneath the 216-U-4 Reverse Well/216-U-4A French Drain and the 200-W-42 VCP/UPR-200-W-163 site are not expected to impact groundwater within 1,000 years.

An additional simulation was run for the 216-U-1 and 216-U-2 Cribs to evaluate the effects of placing an engineered barrier over the waste site as a proposed remedy. The STOMP simulation, with conditions representing placement of an engineered barrier over the 216-U-1 and 216-U-2 Cribs, resulted in peak groundwater concentrations below the MCLs for Tc-99. This modeling simulation suggests that groundwater will not be impacted if an engineered surface barrier is placed over the waste sites. On the basis of the 216-U-1/216-U-2 Cribs barrier modeling, similar barriers over the 216-U-8 and 216-U-12 Cribs are expected to reduce the flux of contaminants at those sites such that remedial action objectives are met in the future. The other waste sites (216-U-4 Reverse Well/216-U-4A French Drain and the 200-W-42 VCP/UPR-200-W-163 site) currently meet the groundwater protection remedial action objectives and, as such, are not evaluated further for MCLs..

Appendix D contains a more detailed description of the model, sites and parameters, and discussion of modeling results.

2.9 DATA INTEGRATION WITH HANFORD SITE COMPOSITE ANALYSIS EFFORT

Analyses of risk and impact at the Hanford Site are conducted and reported on a site-wide scale via a composite analysis. DOE Order 435.1, *Radioactive Waste Management*, requires a composite analysis that is a site-wide assessment of the public exposure and risk from all onsite discharges and disposals following site closure. The composite analysis is prepared and maintained by the Hanford Site-Wide Assessments Project conducted by Pacific Northwest National Laboratory as part of the Fluor Hanford, Inc., Groundwater Remediation Project that is managed by DOE. The composite analysis is being prepared using PNNL-14027, *An Initial*

Assessment of Hanford Impact Performed with the System Assessment Capability; PNNL-13932, *User Instructions for the Systems Assessment Capability, Rev. 0, Computer Codes, Vol. 1 and 2*, the Systems Assessment Capability for Integrated Groundwater/Vadose Zone (SAC) computer model and database developed by Pacific Northwest National Laboratory; this model considers cumulative impacts to groundwater attributable to a variety of sources across the entire Hanford Site. The SAC simulates contaminant release to and transport through the vadose zone underlying waste sites, within the unconfined aquifer, and the contaminants discharged to the Columbia River. In addition to exposure scenarios in the upland area surrounding the Central Plateau, the SAC simulates risk in the riparian zone and Columbia River from all contamination remaining at the Hanford Site after site closure. Because the SAC simulates up to 1,000 waste sites simultaneously, the groundwater and riparian zone contamination simulated is the composite impact of all releases. The impact to groundwater from individual facilities or operable units is addressed in RI/FS reports, FFS documents (such as this document), remedial field investigation/corrective measures studies, or performance assessments conducted by the program managing the waste.

At the site-wide scale, the composite analysis presents a holistic view of contaminant release and migration and evaluates the impacts of alternate disposals and remedial actions at the Hanford Site. For the cumulative release of all wastes, the composite analysis reports (1) allowable risk, (2) groundwater contaminant concentrations at the core-zone boundary and river shore, (3) risk to riparian zone receptors, (4) groundwater flux into the Columbia River, and (5) risk to river receptors (ecological and human health). At this time the composite analysis does not address groundwater remediation actions, including pump-and-treat remedial actions on the Central Plateau and the River Corridor and the in situ remediation of chromium. Accordingly, risk and contamination level associated with groundwater remediation at the site-wide scale are not presently represented in the composite analysis. Future composite analyses will address the pump-and-treat actions.

The composite analysis is the starting point for a tool that will maintain a comprehensive "risk baseline" for all of the Hanford Site. This baseline will be updated periodically as detailed risk assessments are conducted for individual waste sites and projects. The composite analysis will identify the total impacts from all sources to the groundwater and to the River Corridor and will identify areas where "overlapping" impacts could occur. Impacts to the River Corridor identified through the composite analysis will be fed back to the 200 Areas remedial action and remedial design process. It is anticipated that, after source control remedial actions are implemented and their positive impacts demonstrated through monitoring, the appropriate source elimination from the specific operable unit will be incorporated into the sitewide composite analysis.

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FIGURES

Figure 2-1. U Plant Area Geologic Cross Section Index. 2-71

Figure 2-2. U Plant Area Geologic Cross Section A-A' 2-72

Figure 2-3. U Plant Area Geologic Cross Section B-B'. 2-73

Figure 2-4. U Plant Area Geologic Cross Section C-C'. 2-74

Figure 2-5. 216-U-12 Crib Construction Diagram (DOE/RL-2000-60, Rev. 0). 2-75

Figure 2-6. 216-U-1 and 216-U-2 Cribs Conceptual Contaminant Distribution Model 2-76

Figure 2-7. 216-U-8 Crib Conceptual Contaminant Distribution Model (modified from DOE/RL-2000-60) 2-77

Figure 2-8. 216-U-12 Crib Conceptual Contaminant Distribution Model (modified from DOE/RL-2000-60) 2-78

Figure 2-9. 216-U-4 Reverse Well / 216-U-4A French Drain Conceptual Contaminant Distribution Model. 2-79

Figure 2-10. UPR-200-W-19 Unplanned Release Conceptual Contaminant Distribution Model 2-80

Figure 2-11. Application of Analogous Site Approach. 2-81

2.0 BACKGROUND FIGURES

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Figure 2-1. U Plant Area Geologic Cross Section Index.

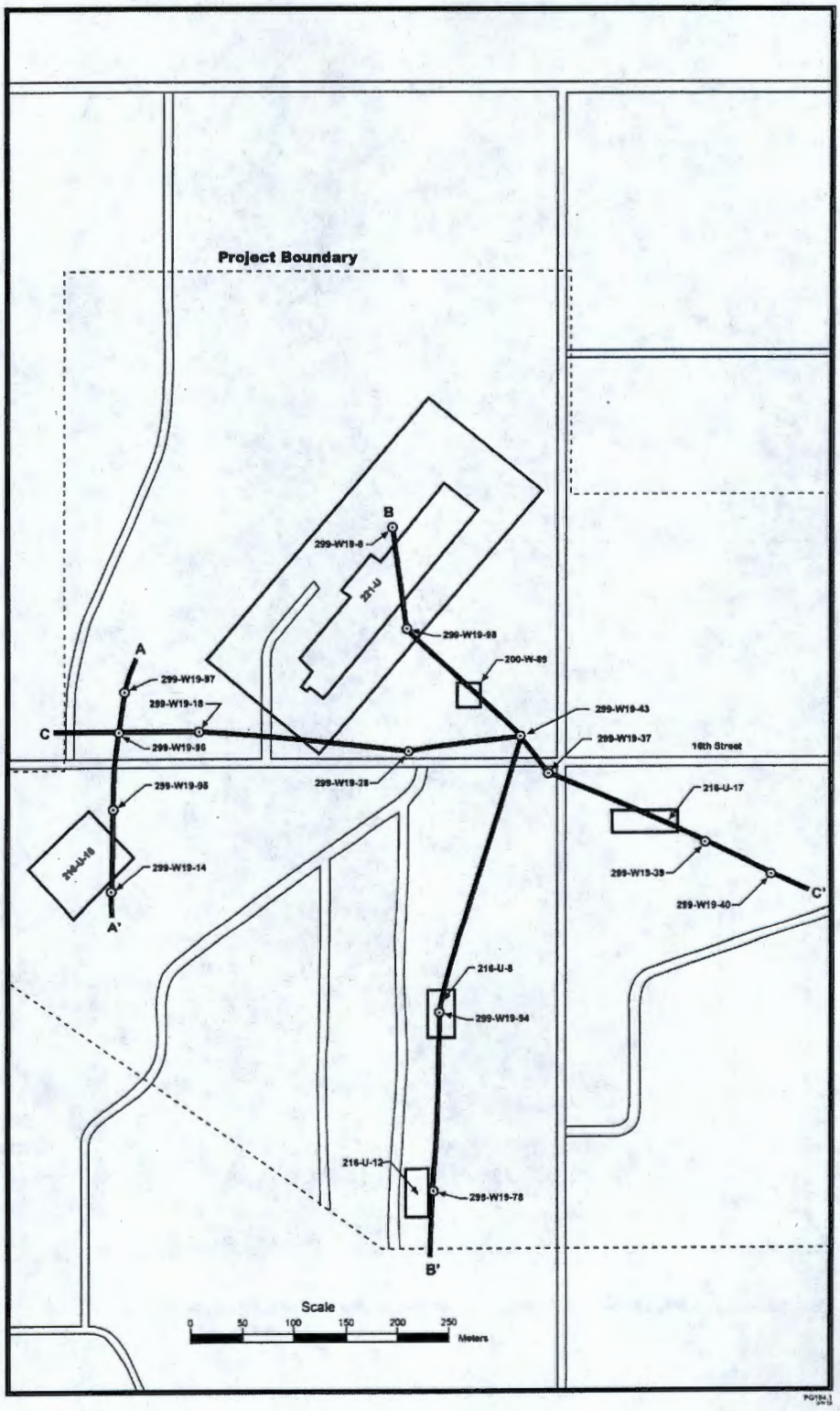
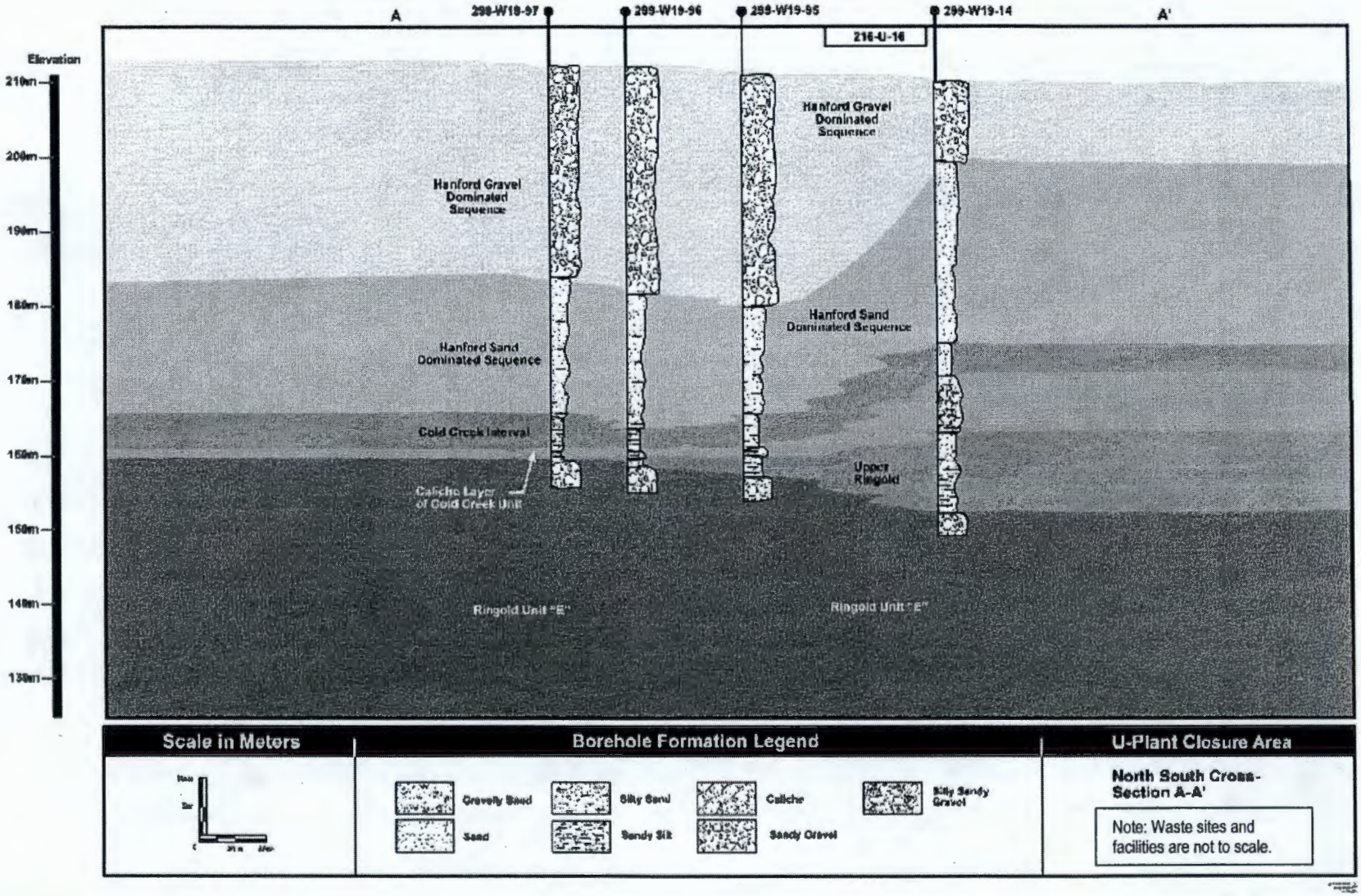


Figure 2-2. U Plant Area Geologic Cross Section A-A'.



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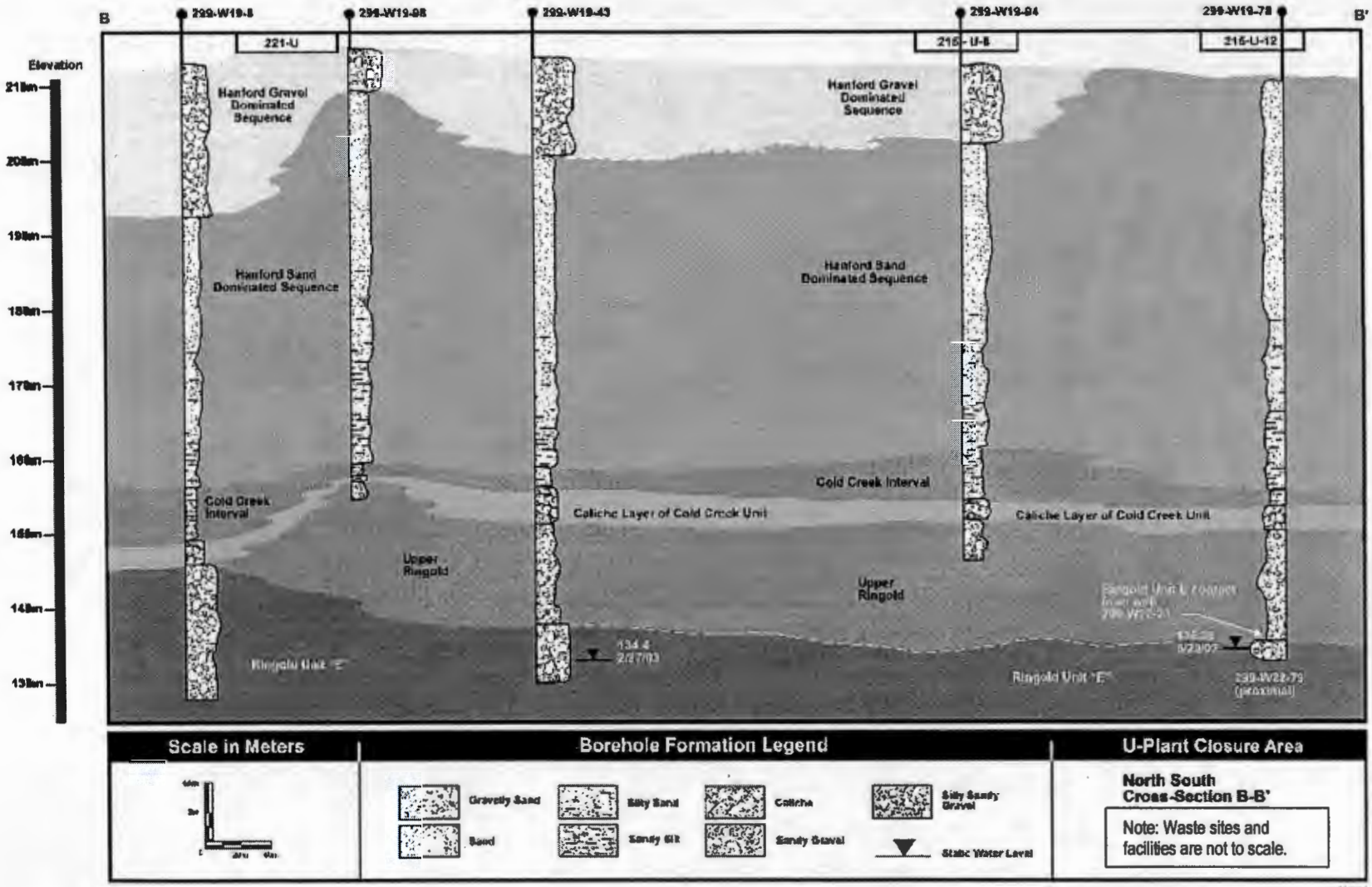

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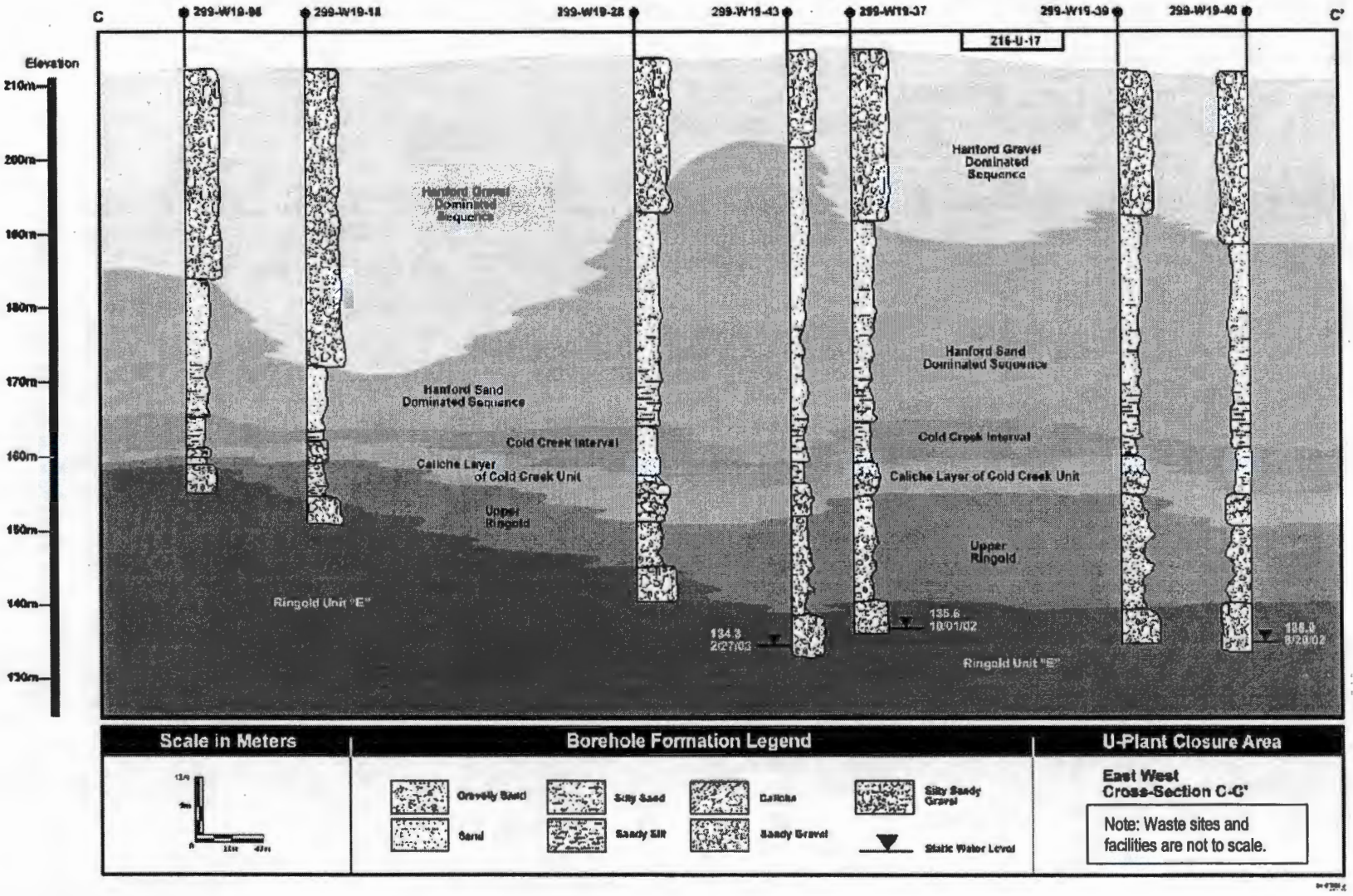


Figure 2-5. 216-U-12 Crib Construction Diagram (DOE/RL-2000-60, Rev. 0).

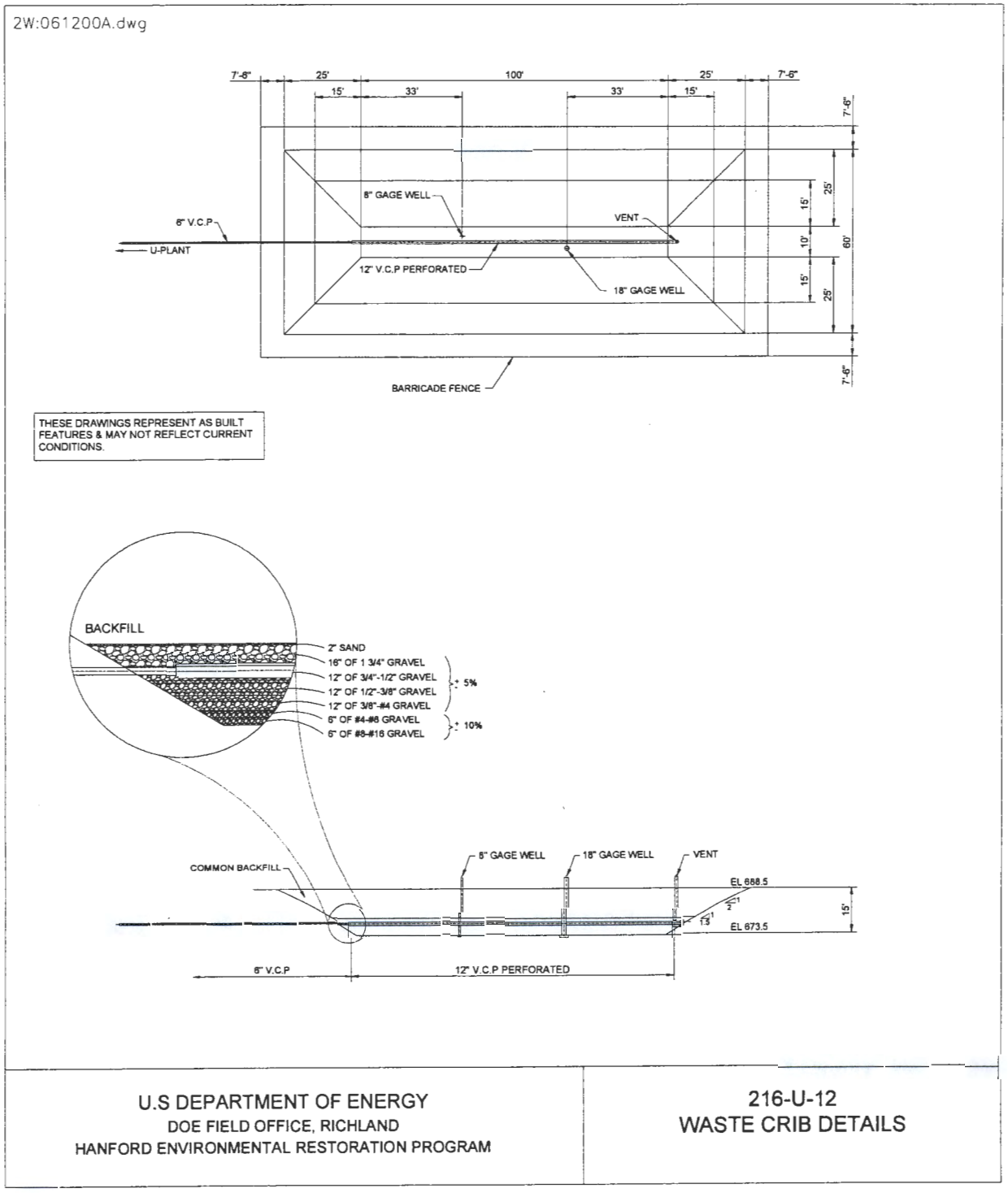
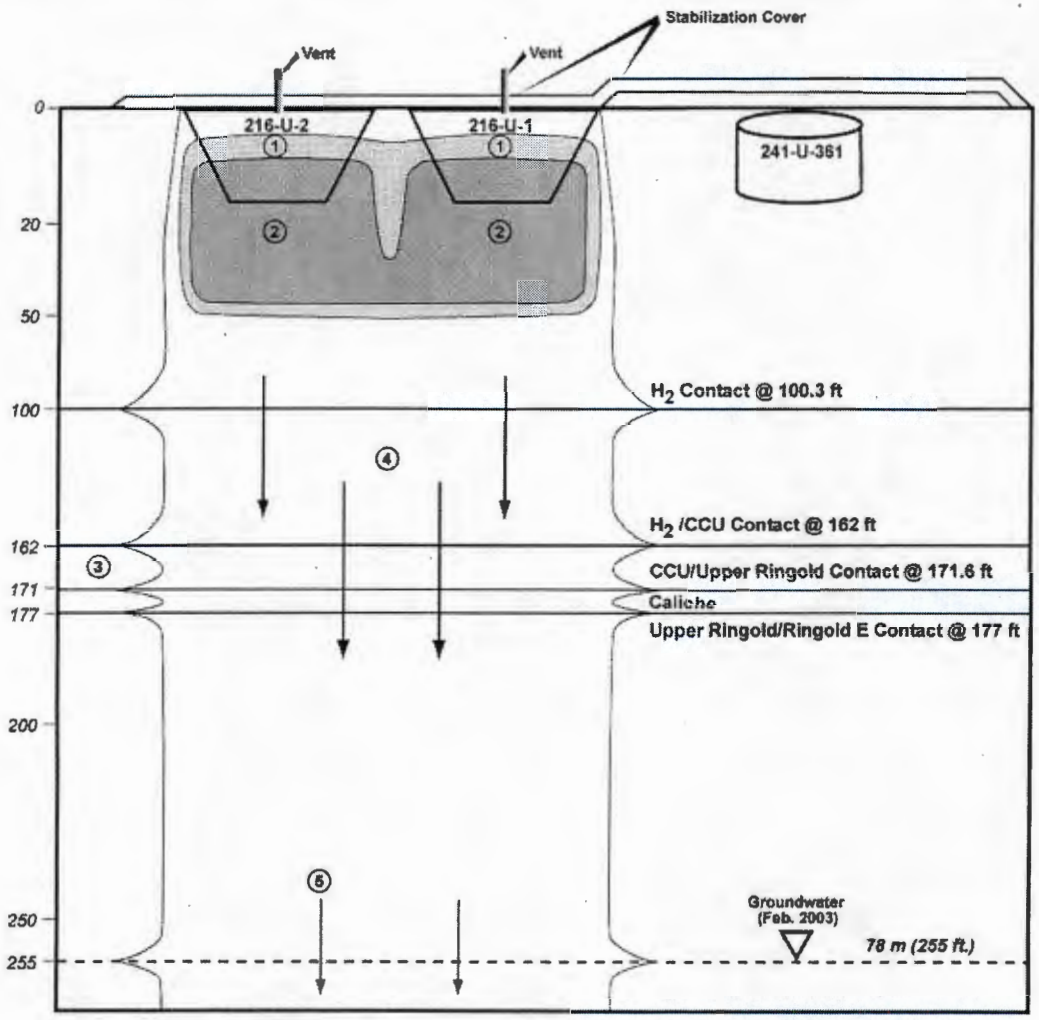


Figure 2-6. 216-U-1 and 216-U-2 Cribs Conceptual Contaminant Distribution Model.



① Uranium rich process wastes were discharged to the 216-U-1 and 216-U-2 cribs until 1967. The wooden crib structures received a total of 4.62 x 10^7 liters (16.2 x 10^8 gallons) of wastewater. The effluent contained uranium, cesium-137, plutonium, and, strontium-90. The crib was stabilized with 0.46 m to 0.61 m (1.5 to 2 ft) of clean fill. Effluent was released to the environment at the bottom of the crib structure within the H1 formation. The wetting front and contaminants moved vertically down beneath the crib.

② The distributions of Am-241, Co-60, Cs-137, and Sr-90 (maximum concentration of 33 pCi/g, 10.6 pCi/g, 1,700,000 pCi/g, and 2,400,000 pCi/g, respectively) are primarily limited to 6 to 12 m (20 to 40 ft) bgs.

③ Uranium was detected through the vadose zone with peak values at 12 m (40 ft) (maximum concentration for U-233/234 of 1400 pCi/g and for U-238 of 10,080 pCi/g at 12 m [40 ft]) and within the Cold Creek unit (32 pCi/g for U-233/234 and 32 pCi/g for U-238). Spectral gamma borehole logging indicated a maximum U-238 activity of 5000 pCi/g at 12 m (39.5 ft).

④ Little lateral spreading is believed to have occurred within the vadose zone as evidenced by near background levels of contaminants in boreholes 299-W22-95 and 299-W22-97 located adjacent to the cribs. However, Some lateral spreading may have occurred because of soil heterogeneities and naturally occurring capillary breaks across textural changes within single or across different geologic units.

⑤ Wastewater and mobile contaminants are known to have impacted groundwater beneath the cribs. Effluent volume discharged to the soil column (42,600 m^3) is much greater than the soil pore volume (400 m^3). Significant amounts of uranium are believed to have reached groundwater through an improperly sealed well, after acidic process wastes discharged from the 216-U-16 crib formed a perched groundwater zone at the caliche layer. This acidic process waste is believed to have mobilized uranium from the 216-U-1 and 216-U-2 cribs within the vadose zone.

Contamination

- High (>1,000 pCi/g)
- Medium (100-1,000 pCi/g)
- Low (0-100 pCi/g)

*Contamination from UPR-200-W-19 Not Shown

H_1 Hanford formation: Gravel Dominated Sequence

H_2 Hanford formation: Sand Dominated Sequence

CCU Cold Creek Unit

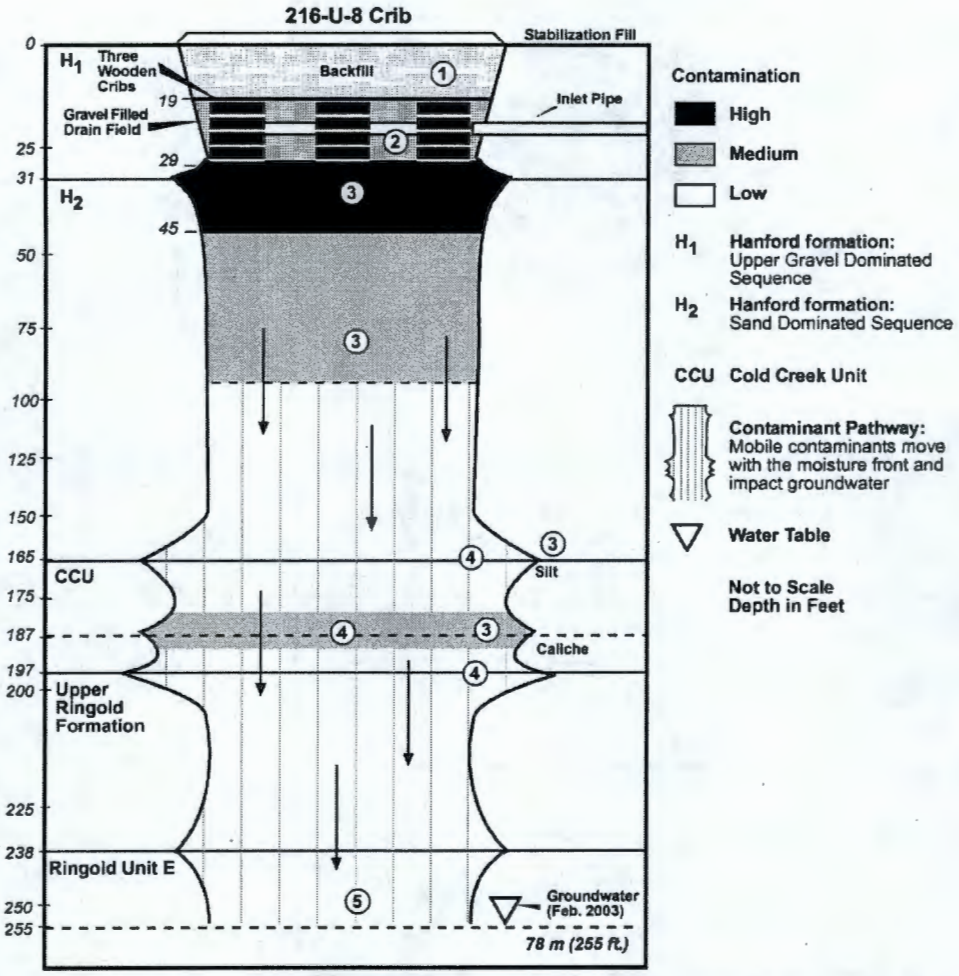
Water Table

Not to Scale

Depth in Feet

FG300.1a

Figure 2-7. 216-U-8 Crib Conceptual Contaminant Distribution Model (modified from DOE/RL-2000-60).



① Uranium rich process wastes were discharged to the 216-U-8 Crib between 1952 and 1960. The wooden crib structures received a total volume of 3.7×10^8 liters (1.0×10^8 gallons) of wastewater. The effluent contained uranium, cesium-137, plutonium, strontium-90, and nitric acid. The crib was stabilized with 0.3-0.6 m (1-2 ft) of clean fill in 1994. The pipeline leading to the crib was known to have leaked contamination into near-surface soils.

② Effluent and contaminants were released to the environment at the bottom of the wooden structure near the contact between H1 and H2. The wetting front and contaminants moved vertically down beneath the crib. There is little or no lateral spreading. (Low levels (<1 pCi/g) of cesium-137 contamination were intermittently detected in borehole 299-W19-2 approximately 15.2 m (50 ft) east of the waste site).

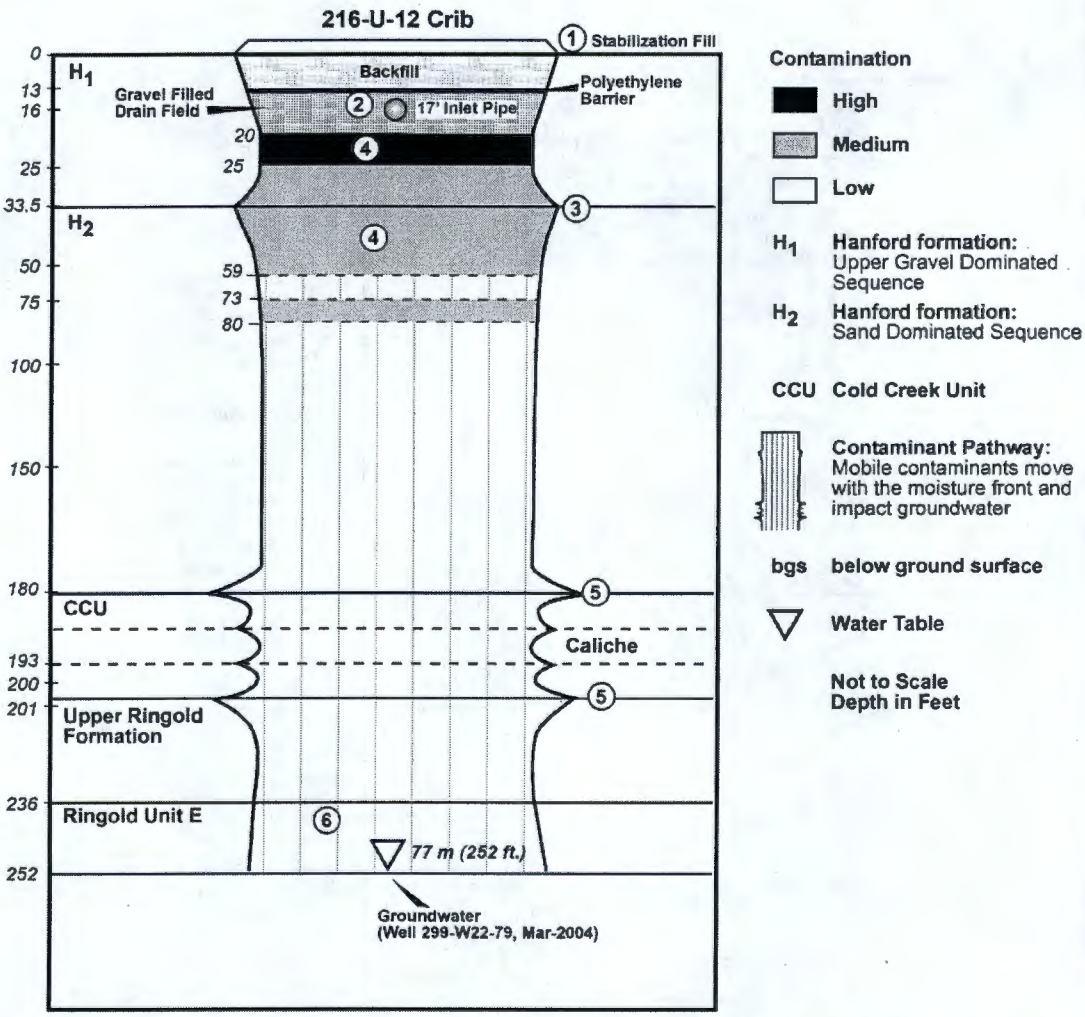
③ The zone of greatest contamination is detected from the bottom of the crib to a depth of 12.8 m (42 ft). Contaminants that are immobile, such as cesium-137, sorb to soils near the bottom of the trench. Cesium-137 concentrations are highest at depths less than 12.8 (42 ft); they decreased with depth to 30.5 m (100 ft) where they become undetectable. Contaminants that are moderately mobile, such as strontium-90 and uranium, are present deeper in the vadose zone. Uranium-238 concentrations were highest at the base of the crib and at a depth of 56.4 m (185 ft). Strontium-90 was detected in the vadose zone to a depth of at least 61 m (199 ft). The maximum concentration was detected at the interface between H2 and the CCU at 50.3 m (165 ft). The most mobile contaminants, such as nitrate, move with the moisture front and are present in trace amounts in the vadose zone.

④ If significant lateral spreading occurs within the vadose zone, it is associated with the upper Ringold Formation and the Cold Creek Unit. However, Some lateral spreading may have occurred because of soil heterogeneities and naturally occurring capillary breaks across textural changes within single or across different geologic units.

⑤ Wastewater and mobile contaminants are likely to have impacted groundwater since the effluent volume discharged to the soil column (380,000 m^3) is much greater than the soil pore volume (11,100 m^3) and as evidenced by the uranium, tritium, and nitrate in downgradient well 299-W19-2.

FG300.4
21145

Figure 2-8. 216-U-12 Crib Conceptual Contaminant Distribution Model (modified from DOE/RL-2000-60).



1. Uranium rich process wastes (pH-1) were discharged to the 216-U-12 Crib between 1960 and 1988. The crib received a total of 1.5×10^8 liters (4.0×10^7 gal) of waste water. The low pH of the process water is supected to have significantly increased the mobility of uranium beneath the crib.

2. Effluent and contaminants were released to the environment from a vitrified clay pipe approximately 17 ft bgs within a gravel filled drain field.

3. The wetting front and contaminants moved vertically down beneath the crib.

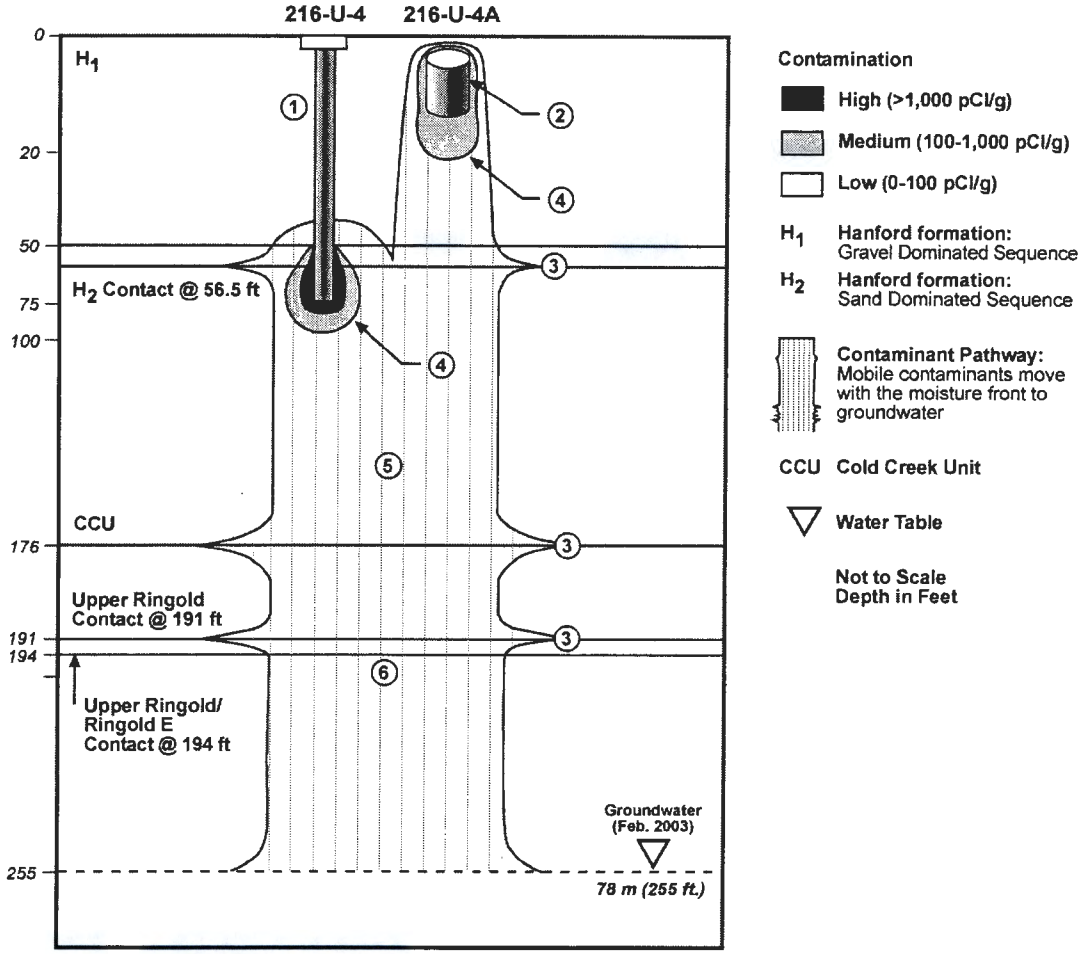
4. Contaminants such as cesium-137 have large contaminant distribution coefficients and sorb more readily to soils. Higher concentrations of cesium-137 are found within 5 feet of the bottom of the crib, generally decrease with depth, and were not detected greater than 59 ft bgs. Uranium, which can have small to moderate contaminant distribution coefficients was the only other contaminant detected beneath the crib. It is present to a depth of 80 ft and contaminant concentration generally increase with depth. The 216-U-12 crib is considered analogous to the 216-U-8 Crib, and therefore uranium may be present associated with the Cold Creek Unit (caliche layer) and may be distributed throughout the vadose zone with strontium-90, a moderately mobile contaminant. Contaminants with distribution coefficients of zero move with the moisture front and may be present in trace amounts throughout the vadose zone.

5. If spreading occurs within the vadose zone, it is associated with the Cold Creek Unit and the upper Ringold Formation. However, Some lateral spreading may have occurred because of soil heterogeneities and naturally occurring capillary breaks across textural changes within single or across different geologic units.

6. Wastewater and contaminants with moderate to very low contaminant distribution coefficients impact groundwater. The effluent volume discharged to the soil column (150,000 m^3) is greater than the soil pore volume (1,400 m^3) as evidenced by the tritium, and nitrate in the groundwater in the vicinity of the crib.

FG300.3
2/11/05

Figure 2-9. 216-U-4 Reverse Well / 216-U-4A French Drain Conceptual Contaminant Distribution Model.



① Acidic, low salt, low organic liquid waste containing 400 kg of nitrate, and other contaminants were discharged to the 216-U-4. Reverse Well from March 1947 to July 1955. The reverse well received a total volume of 300,000 L (78,000 Gallons).

② Acidic, low salt, low organic liquid waste containing 8.83 kg of uranium, 0.009 g of plutonium, 0.185 Ci of cesium-137, 0.0159 Ci of strontium-90, 900 kg of nitrate, and other contaminants were discharged to the 216-U-4A french drain from July 1955 to July 1970. The french drain received a total volume of 545,000 L (141,700 Gallons).

③ Once discharged wastewater and contaminants migrate vertically downward beneath the reverse well and french drain. Lateral spreading of wastewater and contaminants is expected as this point of discharge due to the small diameter of the structures, and at the contacts of the H2, CCU, and Ringold E formations.

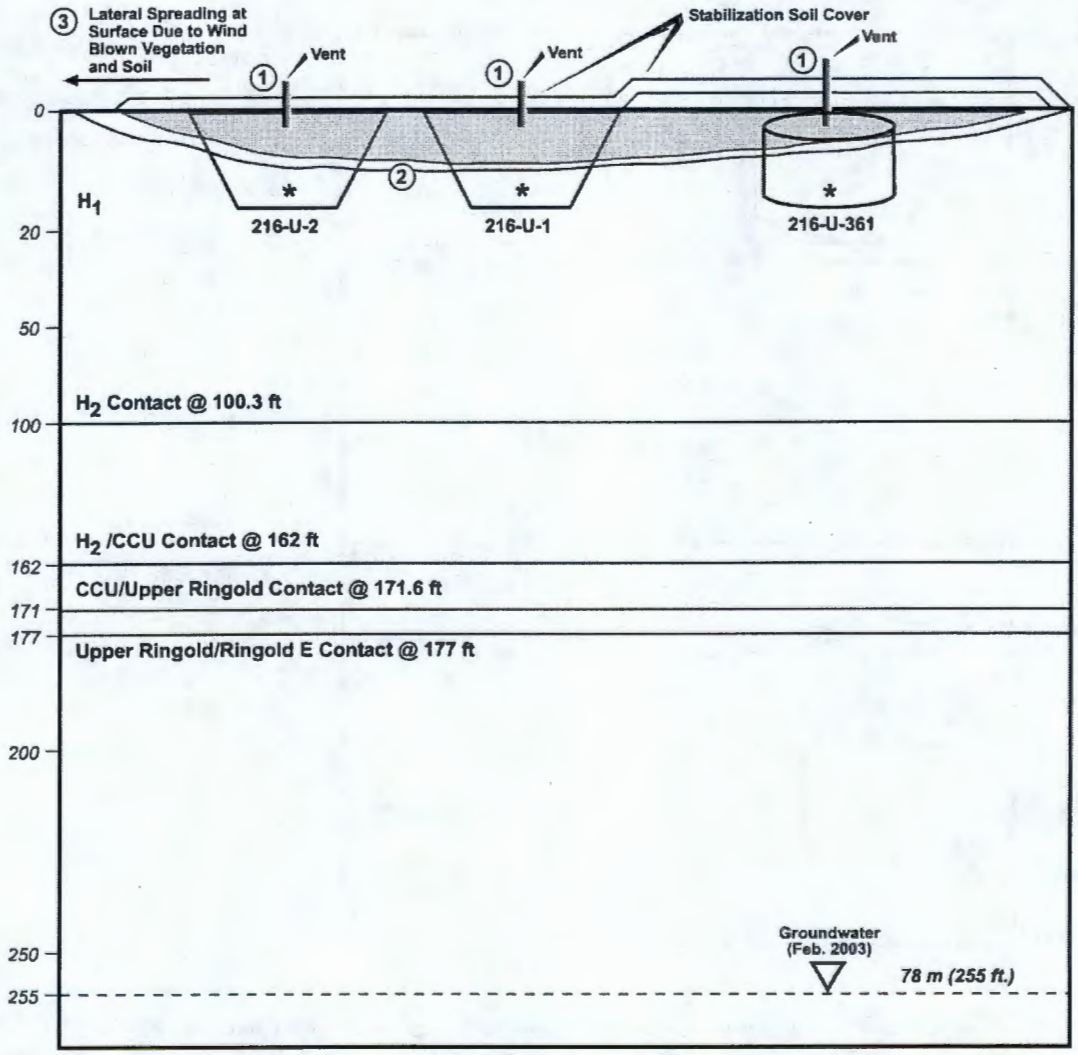
④ Immobile contaminants such as cesium-137 normally sorb to soils near the point of release of high concentrations. Maximum cesium-137 concentration of 420 pCi/g were located near the top of the 218-U-4A french drain and 1980 pCi/g near the midpoint of the screened interval of the 216-U-4 reverse well and decrease to non-detect within 20 feet in both cases.

⑤ Mobile contaminants like nitrate migrate with the moisture front and may be detected in low concentrations to the water table.

⑥ Wastewater and mobile contaminants have likely reached groundwater since the effluent volume discharged to the soil column is much greater than the soil column pore volume for both the reverse well and french drain.

FG300.2
11/22/04

Figure 2-10. UPR-200-W-19 Unplanned Release Conceptual Contaminant Distribution Model.



① Uranium rich process wastes overflowed from the 216-U-1 & 2 Cribs and 241-U-361 vent risers.

② Contaminants released to surface soils are expected remain close to the surface. Immobile contaminants such as cesium-137 normally sorb to soils near the point of release of high concentrations. Maximum cesium-137 and strontium-90 concentrations of 259 pCi/g and 42 pCi/g respectively were located at 4-6 ft below ground surface in soil boring 299-W-19-96 near the 216-U-1 Crib. Deeper sample intervals in soil boring 299-W-19-96 correspond to contaminant distribution from the 216-U--1&2 Cribs and are not included in this conceptual contaminant distribution model.

③ Some lateral spreading is possible due to windblown soil and vegetation uptake. Maximum concentrations of cesium-137 and strontium-90 associated with boring 299-W-19-97 showed maximum concentrations of 18 pCi/g and 3.3 pCi/g respectively at 4-6 ft below ground surface. Concentrations decreased to non-detect in the 10-12.5 ft sample interval. Surface soil samples associated with UPR-200-W-19 showed maximum concentrations of cesium-137 and strontium-90 of 53 pCi/g and 7.6 pCi/g respectively.

Contamination

- **High (>1,000 pCi/g)**
- **Medium (100-1,000 pCi/g)**
- **Low (0-100 pCi/g)**

***Contamination from 216-U-1&2 and 241-U-361 Not Shown**

H_1 **Hanford formation:** Gravel Dominated Sequence

H_2 **Hanford formation:** Sand Dominated Sequence

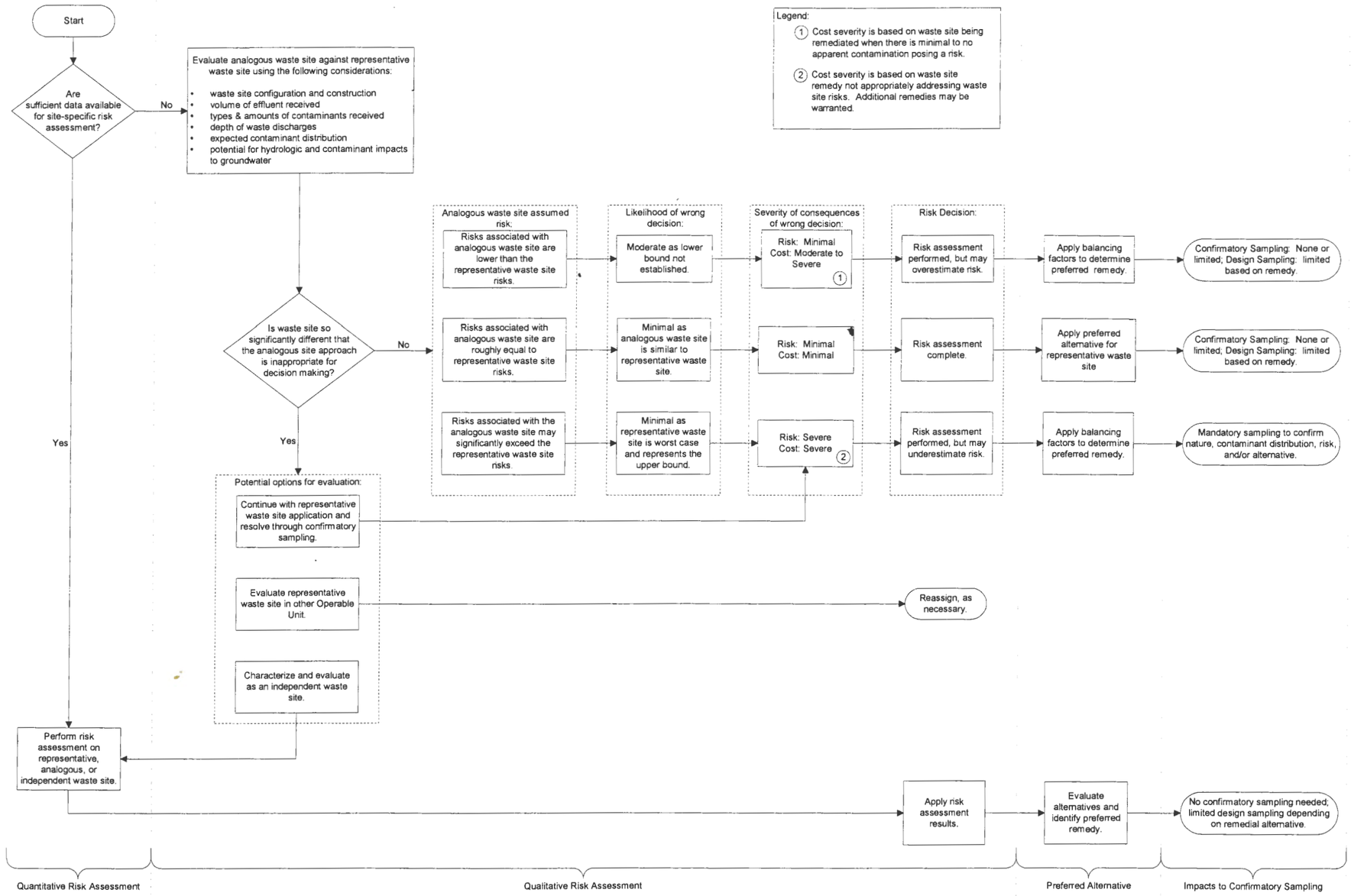
CCU **Cold Creek Unit**

Water Table

Not to Scale
Depth in Feet

FG300.1
3/18/04

Figure 2-11. Application of Analogous Site Approach.



TABLES

Table 2-1. Application of Analogous Site Approach to 200-UW-1 Operable Unit Representative Waste Sites. 2-85

Table 2-2. U Plant Area Groundwater Contaminant Trends (Modified from DOE/RL-2003-58)..... 2-86

Table 2-3. 216-U-1 and 216-U-2 Crib and Associated Analogous Waste Sites..... 2-87

Table 2-4. 216-U-8 Crib and Associated Analogous Waste Sites..... 2-89

Table 2-5. 216-U-12 Crib and Associated Analogous Waste Sites..... 2-92

Table 2-6. 216-U-4 Reverse Well/216-U-4A French Drain and Associated Analogous Waste Sites. 2-98

Table 2-7. Unplanned Release UPR-200-W-19 and Associated Analogous Waste Sites..... 2-100

Table 2-8. Waste Site Risk Summary..... 2-111

2.0 BACKGROUND TABLES

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Table 2-1. Application of Analogous Site Approach to 200-UW-1 Operable Unit Representative Waste Sites.

Representative Site
216-U-1 and 216-U-2 Cribs
Process Waste Group analogous wastes sites to be evaluated by the 216-U-1 and 216-U-2 Cribs model
241-U-361 Settling Tank
Representative Site
216-U-8 Crib
Process Waste Group analogous wastes sites to be evaluated by the 216-U-8 Crib model
200-W-42 Vitrified Clay Pipeline and UPR-200-W-163 Unplanned Release
Representative Site
216-U-12 Crib
Process Waste Group analogous wastes sites to be evaluated by the 216-U-12 Crib model
216-U-5 Trench
216-U-6 Trench
216-U-15 Trench
216-U-16 Crib
216-U-17 Crib
Representative Site
216-U-4 Reverse Well and 216-U-4A French Drain
Reverse Well/French Drain Group analogous wastes sites to be evaluated by the 216-U-4 Reverse Well/ 216-U-4A French Drain model
216-U-4B French Drain
Representative Site
UPR-200-W-19 Unplanned Release
Septic System Group analogous wastes sites to be evaluated by the UPR-200-W-19 model
2607-W5 Septic System
2607-W7 Septic System
Solid Waste Group analogous wastes sites to be evaluated by the UPR-200-W-19 model
200-W-56 Dump
200-W-57 Dump
200-W-71 Pit
UPR-200-W-8 Burial Ground
Unplanned Release Group analogous wastes sites to be evaluated by the UPR-200-W-19 model
UPR-200-W-118 Unplanned Release
Shallow/Surface Waste Site Group analogous wastes sites to be evaluated by the UPR-200-W-19 model
UPR-200-W-33 Unplanned Release
UPR-200-W-48 Unplanned Release
UPR-200-W-55 Unplanned Release
200-W-77 Unplanned Release
UPR-200-W-78 Unplanned Release
200-W-85 Unplanned Release
200-W-87 Unplanned Release
200-W-89 Foundation
UPR-200-W-117 Unplanned Release
UPR-200-W-60 Unplanned Release

Table 2-2. U Plant Area Groundwater Contaminant Trends (Modified from DOE/RL-2003-58).

Well	Technetium-99 (ρCi/L)		Uranium (μg/L)	
	Fiscal Year 02	Fiscal Year 03	Fiscal Year 02	Fiscal Year 03
299-W19-20	1,140	838	581	459
299-W19-35	568	795	41.4	42.7
299-W19-36	8,915	4,600	995	453
299-W19-37	605	436 and 808	261	249 and 284
299-W19-39	1,160	952	134	223
299-W19-40	219	170	150	127
299-W19-43	22,400	18,200 and 3,390	1,560	1,190 and 480
299-W19-46[a]	N/A	163, 154, 174, and 139	N/A	131, 168, 164, and 105

Note:

[a] For well 299-W19-46, the first value for each analyte concentration is from the undeveloped well during vertical profile sampling.

DOE/RL-2003-58, *Fiscal Year 2003 Annual Summary Report for 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations*.

Table 2-3. 216-U-1 and 216-U-2 Crib and Associated Analogous Waste Sites. (2 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Current Waste Site Cover/Vegetation	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)	Co-60 (Ci)	CCl_4 (kg)	Ferro-Cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
Representative site																			
216-U-1 and 216-U-2 Cribs	The site is north of 16th Street, west of the 221-U Facility and east of the 207-U Retention Basin. The cribs are collocated in a radiologically controlled area that is posted with Underground Radioactive Material Area signs. Each crib is delineated with posts and chain with Cave-In Potential signs. The cribs consist of two wooden structures, each measuring 3.6 by 3.6 by 1.2 m (12 by 12 by 4 ft). The cribs are constructed of 0.15 by 0.15 by 3.7 m (0.5 by 0.5 by 12 ft) timbers and are open at the bottom. Each wooden structure is located on a 4.3 by 4.3 m (14 by 14 ft) area at the bottom of a 6.1 m (20 ft) deep excavation with 1:1 side slopes. The wooden structures rest on the underlying native soil. The wooden structures are spaced 18 m (60 ft) apart and are connected by an 8.9 cm (3.5 in.) diameter stainless steel pipeline. Gravel fill was not used in the cribs. A 2-in. stainless steel vent pipe was installed but blanked off and replaced with a ¼ in. stainless steel line that extends from the surface to within 1 ft of the crib bottom. An 8-in. black iron test well casing extends from the surface through the center of each crib to a depth of 21 m (70 ft). U Plant wastes flowed from the 241-U-361 Settling Tank, which lies approximately 26 m (85 ft) east of the 216-U-1 Crib post and chain boundary, and then to the 216-U-2 Crib.	Gravel and soil.	The U Plant wastes included, from 1952 to 1957, cell drainage from the 5-6 tank in the 221-U Facility and waste from the 224-U Building, until the Uranium Recovery Process operations were shut down and, from July 1957 through May 1967, 224-U Building and equipment decontamination waste and reclamation waste from the 221-U Facility. In the spring of 1953, organic wastes and cell drainage from the tributyl phosphate process in 221-U and waste from 224-U overflowed to the ground by way of the 241-U-361 Settling Tank risers and 216-U-1 and 216-U-2 Crib vents. Contamination readings of 11.5 rad/h at a distance of 7.6 cm (3 in.) were reported over an area of approximately 4.6 m^2 (50 ft^2). In 1953, decontamination was attempted. The area was backfilled, delineated by a wooden fence, and posted with Radiation Zone signs. In 1992, the area was surface stabilized by scraping the contaminated surface soil and consolidating it near the 241-U-361 Settling Tank. The contaminated soil was covered with 46 to 61 cm (18 to 24 in.) of clean backfill. The surface surrounding the 241-U-361 Settling Tank was covered with shotcrete. In 1994, contamination was found on the surface again, presumably caused by insect intrusion. In January 1985, groundwater samples taken from wells 299-W19-03 and 299-W19-11 indicated 60,000 and 85,000 pCi/L of uranium. Previous routine samples averaged less than 500 pCi/L. An investigation revealed that liquid waste from the 216-U-16 Crib, located south of the 216-U-1&2 Cribs, had migrated north along a subsurface caliche layer. Existing groundwater monitoring wells around the 216-U-1&2 Cribs provided a pathway for the contamination to reach the groundwater. Remedial action included pumping approximately 30 million liters (8 million gallons) of contaminated groundwater and processing it to recover the uranium. The remedial action was initiated on June 13, 1985, and continued until November 26, 1985. An estimated 687 kg of uranium were removed. Portions of existing wells (299-W19-3, 299-W19-9, and 299-W19-11) were grouted to prevent vertical communication with the groundwater, and four new monitoring wells (299-W19-15, 299-W19-16, 299-W19-17, and 299-W19-18) were installed to characterize the uranium plume.	4.00 E+03	4.26 E+01	-	4.36 E+00	2.11 E+00	1.57 E-03	-	-	-	1,200,000	-	-	-	46,200	400	The 216-U-1 and 216-U-2 Cribs have been selected as a representative site because of the amount of available characterization data, their significant impact to groundwater, and their direct association with the 241-U-361 Settling Tank. The criteria considered to evaluate the suitability of this site as representative are: (1) *Waste site configuration and construction*: The 216-U-1 and 216-U-2 Cribs are below-grade timber crib structures constructed in an open excavation, which was backfilled with soil. The 241-U-361 Settling Tank is a circular reinforced concrete underground tank structure. This criterion is only partially applicable, because only the depth of the engineered structure for these sites is similar; (2) *Volume of effluent received in relation to the available pore volume:* This criterion is not applicable, because the 241-U-361 Settling Tank was not designed to discharge waste to the vadose zone; (3) *Contaminant inventory*: The contaminant type for the representative and the analogous waste sites should be identical, because the 241-U-361 Settling Tank was not 100% efficient for removing solids, and the suspended and soluble contaminants were discharged to the cribs. The contaminant inventory in the 241-U-361 Settling Tank should be bounded by the 216-U-1 and 216- U-2 Cribs, because the tank only held a portion of the total waste stream; (4) *Depth of waste discharge:* The structure depths are similar for the representative and analogous sites; however, this criterion is not applicable, because the tank was not designed to discharge waste to the vadose zone; (5) *Expected distribution of contaminants:* The distribution of contaminants in the vadose zone is expected to be much higher for the 216-U-1 and 216-U-2 Cribs as compared to the 241-U-361 Settling Tank, because the cribs were designed to discharge liquid wastes and the tank was not; (6) *Potential for hydrologic and contaminant impacts to groundwater:* The 216-U-1 and 216-U-2 Cribs are known to have impacted groundwater. The zone of highest contamination is at the base of the crib from 6 to 12 m (20 to 40 ft) below ground surface. Maximum concentrations in this interval includes Sr-90 at 2,380,000 pCi/g; Cs-137 at 1,758,000 pCi/g; uranium was detected through out the vadose zone with peak values around 12 m (40 ft) (maximum concentration for U-233/234 of 1400 pCi/g, for U-235 of 148 pCi/g, and for U-238 of 10,080 pCi/g) and within the Cold Creek unit (32 pCi/g for U-233/234, 2.2 pCi/g for U-235, and 10,080 pCi/g for U-238). Spectral gamma borehole logging indicated a maximum U-238 activity of 5,000 pCi/g at 12 m (39.5 ft). The 241-U-361 Settling Tank was not designed to discharge liquid waste to the vadose zone; however, the unplanned tank overflow would have had the potential to follow the tank outside surface and reach the crib discharge depth, so it has a small potential to have impacted groundwater. Therefore, the 216-U-1 and 216-U-2 Cribs would bound the 241-U-361 Settling Tank in terms of impacts to groundwater.

Table 2-3. 216-U-1 and 216-U-2 Crib and Associated Analogous Waste Sites. (2 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Current Waste Site Cover/Vegetation	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)	Co-60 (Ci)	CCl_4 (kg)	Ferro-Cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
Process Waste Group analogous sites to be evaluated using the 216-U-1 and 216-U-2 Cribs model																			
241-U-361 Settling Tank	The 241-U-361 Settling Tank is located southwest of the 221-U Facility, north of 16th Street. The 216-U-1 and 216-U-2 Cribs and the 241-U-361 Settling Tank are collocated in a common radiologically controlled area that is posted with Underground Radioactive Material Area signs. The tank is posted with Inactive Miscellaneous Underground Storage Tank signs. The 241-U-361 Settling Tank was constructed in 1944-1945 and had an adjacent reverse well. However, the reverse well was never used and, in December 1949, the inlet lines to the well were cut and plugged. The 241-U-361 Settling Tank waste line was then extended to the 216-U-1 and 216-U-2 Cribs. The 241-U-361 Settling Tank is a circular underground settling tank 6 m (20 ft) in diameter by 6 m (19 ft) in height, constructed of 15 cm (6 in.) steel reinforced prestressed concrete. The top of the tank is approximately 2 m (6 ft) below grade, and several vents and risers penetrated the ground surface. The bottom of the tank is located approximately 7.6 m (25 ft) below grade. U Plant wastes flowed from the 241-U-361 Settling Tank to the 216-U-1 Crib (which lies 26 m [85 ft] to the west), and then to the 216-U-2 Crib. The surface surrounding the settling tank has been covered with shotcrete to cover an unplanned release (UPR-200-W-19).	Gravel and shotcrete	The U Plant wastes included, from 1952 to 1957, cell drainage from the 5-6 tank in the 221-U Facility and waste from the 224-U Building until the Uranium Recovery Process operations were shut down and, from July 1957 through May 1967, 224-U Building and equipment decontamination waste and reclamation waste from the 221-U Facility. In the spring of 1953, organic wastes and cell drainage from the tributyl phosphate process in 221-U and waste from 224-U overflowed to the ground by way of the 241-U-361 Settling Tank risers and 216-U-1 and 216-U-2 Crib vents. Contamination readings of 11.5 rad/h at a distance of 7.6 cm (3 in.) were reported over an area of approximately 4.6 m^2 (50 ft^2). In 1953, decontamination was attempted. The area was backfilled, delineated by a wooden fence, and posted with Radiation Zone signs. In 1992, the area was surface stabilized by scraping the contaminated surface soil and consolidating it near the 241-U-361 Settling Tank. The contaminated soil was covered with 46 to 61 cm (18 to 24 in.) of clean backfill. The surface surrounding the 241-U-361 Settling Tank was covered with shotcrete. In 1994, contamination was found on the surface again, presumably caused by insect intrusion. Approximately 106,000 L (28,000 gal) of waste sludge are believed to remain in the tank.	4.00 E+03	-	-	-	-	-	-	-	-	-	-	-	-	104	-	This settling tank is analogous to the 216-U-1 and 2 Cribs because: (1) *Waste site configuration and construction*: The 216-U-1 and 216-U-2 Cribs and the 241-U-361 Settling Tank are associated structures. This criterion is only partially applicable, because only the depth of the engineered structure for these sites is similar; (2) *Volume of effluent received in relation to the available pore volume:* The volume of effluent discharged from the 216-U-1 and 216-U-2 Cribs is significantly higher than the available soil pore volume (46,200 m^3 compared to 400 m^3). Because the volume and precise location of leakage from the 241-U-361 Settling Tank overflow (UPR-200-W-19) are unknown, a direct comparison cannot be made to the 216-U-1 and 216-U-2 Cribs. However, since the overflow was unplanned and not part of normal operation, it is reasonable to assume that the volume of waste discharged to the crib would be much higher than the amount of waste that overflowed from the tank.; (3) *Contaminant inventory:* The contaminant type for the representative and the analogous waste sites should be identical, because the 241-U-361 Settling Tank was not 100% efficient for removing solids, and the suspended and soluble contaminants were discharged to the cribs. The contaminant inventory in the 241-U-361 Settling Tank should be bounded by the 216-U-1 and 216- U-2 Cribs, because the tank only held a portion of the total waste stream; (4) *Depth of waste discharge:* The structure depths are similar for the representative and analogous sites; however, this criterion is only partially applicable, because the tank was not designed to discharge waste to the vadose zone and only the unplanned tank overflow would have had the potential to follow the tank outside surface and reach the crib discharge depth; (5) *Expected distribution of contaminants:* The distribution of contaminants in the vadose zone is expected to be much higher for the 216-U-1 and 216-U-2 Cribs compared to the 241-U-361 Settling Tank, because the cribs were designed to discharge liquid wastes and the tank, except for the unplanned tank overflow, was not; (6) *Potential for hydrologic and contaminant impacts to groundwater:* The 216-U-1 and 216-U-2 Cribs are known to have impacted groundwater. The 241-U-361 Settling Tank was not designed to discharge liquid waste to the vadose zone; however, the unplanned tank overflow would have had the potential to follow the tank outside surface and reach the crib discharge depth, so it has a small potential to have impacted groundwater. Therefore, 216-U-1 and 216-U-2 Cribs would bound the 241-U-361 Settling Tank in terms of impacts to groundwater.

NPH = normal paraffin hydrocarbon.
TBP = tributyl phosphate.

Table 2-4. 216-U-8 Crib and Associated Analogous Waste Sites. (3 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Current Waste Site Cover/Vegetation	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)	Co-60 (Ci)	CCl_4 (kg)	Ferro-Cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)				
Representative site																				
216-U-8 Crib	The site is located approximately 137 m (450 ft) west of Beloit Avenue and 229 m (750 ft) south of 16th Street. The crib consists of three wooden structures set in series at the bottom of a trench that measures 48 by 15 by 9 m (160 by 50 by 31 ft). Each wooden structure is 4.9 by 4.9 by 3.0 m deep (16 by 16 by 10 ft deep) and is open at the bottom. The trench was filled with 1.3 cm (0.5-in.) crushed stone to the tops of the wooden structures and then backfilled to the existing grade. The crib received U Plant waste via the 15.2 cm (6-in.) diameter 200-W-42 Vitrified Clay Pipeline (VCP).	Gravel	The crib received acidic process condensate from the 221-U and 224-U Buildings along with drainage from the 291-U-1 Stack. The crib was in operation from June 1952 to March 1960. When ground settling occurred around the crib vent risers in 1960, the site was deactivated by blanking the pipeline approximately 18 m (60 ft) north of the unit. The effluents were rerouted to the 216-U-12 Crib. In 1995, the area over the crib and a portion of the 200-W-42 VCP was stabilized. Approximately 8 to 10 cm (3 to 4 in.) of contaminated soil were removed from the area above the VCP (200-W-42 VCP/ UPR-200-W-163) and consolidated over the top of the 216-U-8 Crib. The area over the crib and consolidated soils was covered with about 0.5 to 0.6 m (1.5 to 2 ft) of soil.	2.39 E+04	3.70 E+02	-	4.55 E-02	4.31 E-02	2.04 E-03	-	-	-	-	-	-	-	379,000	11,100	The criteria considered to evaluate the suitability of the 216-U-8 Crib as representative of the analogous sites assigned to it are: (1) *Waste site configuration and construction:* The 216-U-8 Crib consists of three wooden structures constructed in a 9 m (31 ft) deep open excavation, which was backfilled with 1.3-cm (0.5-in.) crushed stone to the tops of the wooden structures and then to the existing grade with soil. The analogous site, 200-W-42 VCP, consists of a 15 cm (6 in.) diameter underground VCP buried approximately 3 to 4 m (10 to 12 ft) deep, and its associated surface unplanned release UPR-200-W-163. Although the structures are different, the representative site is deeper within the vadose zone and therefore bounds its analogous site in terms of depth. (2) *Volume of effluent received in relation to the available pore volume:* The volume of effluent discharged from the 216-U-8 Crib is significantly higher than the available soil pore volume (379,000 m^3 compared to 11,100 m^3). Because the volume and precise location of leakage from the 200-W-42 VCP pipeline are unknown, a direct comparison cannot be made to the 216-U-8 Crib. Because the pipeline discharged to the 216-U-8 Crib, it is reasonable to assume that the volume of waste discharged to the crib would be much higher than the amount of waste that leaked from the pipeline. Therefore, the volume of effluent discharged to the 216-U-8 Crib is believed to bound the volume released from the 200-W-42 VCP. (3) *Contaminant inventory:* The contaminant inventory for the 216-U-8 Crib bounds the contaminant inventory for the 200-W-42 VCP, because only a portion of the waste was released from the pipeline. The pipeline did, however, carry the same uranium-rich waste stream that was discharged to the crib, so it is expected that the contaminants would be the same. (4) *Depth of waste discharge:* The 216-U-8 Crib discharged wastes at a depth of between 6 and 9 m (21 and 31 ft) (crib structure was 3 m [10 ft] tall) compared to the depth of the pipeline, which was 3 to 4 m (10 to 12 ft). The representative site bounds the analogous site in terms of discharge depth. (5) *Expected distribution of contaminants:* The expected distribution of contaminants in the vadose zone from the 216-U-8 Crib is expected to be similar to that of the 200-W-42 VCP, because the waste streams are the same, and the sites are located adjacent to each other. Less mobile contaminants, such as Cs-137, are found near the depth of release at both sites. The distribution of these contaminants is shallower at 200-W-42 VCP because of the shallower discharge depth. Insufficient data exist to evaluate the distribution of contaminants deeper in the vadose zone beneath the 200-W-42 VCP.

Table 2-4. 216-U-8 Crib and Associated Analogous Waste Sites. (3 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Current Waste Site Cover/Vegetation	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)	Co-60 (Ci)	CCl_4 (kg)	Ferro-Cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
Representative site																			
216-U-8 Crib (cont)																			(6) *Potential for hydrologic and contaminant impacts to groundwater:* The 216-U-8 Crib is known to have impacted groundwater. The potential for contaminants to impact groundwater at the 216-U-8 Crib is expected to be greater than that of the 200-W-42 VCP, because the volume of waste discharged is believed to be greater than that of the 200-W-42 VCP, and the discharge depth of the crib was greater. Significant zones of contamination are at the base of the crib (9 m [31 ft] bgs) to 13 m [42 ft] bgs and in the deep vadose zone (50 m [165 ft] to 61 m [199 ft]. Cs-137 concentrations are highest from 9 to 13 m (30 to 42 ft) bgs (max value of 91,190 pCi/g at 9 m [30 ft] bgs) with no detectable concentrations below 30 m (100 ft). Sr-90 was detected from 9 to 61 m [31 to 199 ft] with peak values near the base of the crib (130 pCi/g) and between 35 and 50 m (115 and 165 ft) (max value of 520 pCi/g at 35 and 50 m [115 and 165 ft] bgs). Uranium peaks near the base of the crib (28 pCi/g U-233/234 and 94 pCi/g U-238) and within the Cold Creek unit (max values of 140 pCi/g U-233/234 and 150 pCi/g U-238 at 56 m [185 ft] bgs) with concentrations generally <20 pCi/g between 12 to 50 m (40 to 165 ft). Spectral gamma borehole logging indicated a maximum U-238 activity of 831 pCi/g at 12 m [38 ft]. Levels of Tc-99, Am-241, plutonium, and Np-237 are less than 1 pCi/g.

Table 2-4. 216-U-8 Crib and Associated Analogous Waste Sites. (3 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Current Waste Site Cover/Vegetation	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)	Co-60 (Ci)	CCl_4 (kg)	Ferro-Cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
Process Waste Group analogous sites to be evaluated using the 216-U-8 Crib model																			
200-W-42 VCP/ UPR-200-W-163	The 200-W-42 VCP site is located is located south of the U Plant and extends from the 221-U Building under 16th Street to 216-U-8 Crib and to the 216-U-12 Crib. UPR-200-W-163 is the contaminated surface soil above the pipeline from the 2715-UA Building to the 216-U-8 Crib. The release consisted of radiologically contaminated vegetation growing above the 200-W-42 VCP, the underground pipeline to the 216-U-8 Crib. The underground VCP transferred U Plant waste to the 216-U-8 Crib and, after 1960, to the 216-U-12 Crib. The area currently is posted with Underground Radioactive Material Area signs. The 15.2 cm (6 in.) diameter VCP runs from a neutralization tank located beneath the 2715-UA Building south to the 216-U-8 Crib. The pipeline is buried 3 to 4 m (10 to 12 ft) below grade. The pipeline was blanked off when the 216-U-8 Crib was deactivated, and it was extended approximately 225 m (738 ft) south to the 216-U-12 Crib. The pipeline is buried approximately 3 m (10 ft) below grade for the segment between the 216-U-8 and 216-U-12 Cribs.	Gravel	The VCP transferred acidic process condensate from the 221-U and 224-U Buildings along with drainage from the 291-U-1 Stack to the 216-U-8 Crib from June 1952 to March 1960. From April 1960 to May 1967, the VCP transferred 291-U-1 Stack drainage, 241-WR Vault waste, and 224-U Building process condensate to the 216-U-12 Crib. UPR-200-W-163 occurred over time, as leaking waste from the underground VCP contaminated the soil. Vegetation absorbed some of the radioactive contaminants. Broken pieces of contaminated vegetation scattered in the wind and caused the size of the surface-posted contamination area to be increased. The site, south of 16th Street and north of the 216-U-8 Crib, encompassed 1.8 hectares (4.5 acres) at one time; however 1.4 hectares (3.5 acres) were stabilized and down posted to no posting in 1994. The site currently consists of 0.4 hectare (1 acre) of soil above the underground pipeline that is marked and posted with Underground Radioactive Material Area signs. The posted area over the pipeline on the north side of 16th Street was stabilized in October 2001.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	This VCP/unplanned release is considered to be analogous to the 216-U-8 Crib, because: (1) *Waste site configuration and construction:* This criterion is partially applicable. Although the crib and pipeline structures are different, the representative site is deeper within the vadose zone and therefore bounds its analogous site in terms of depth. (2) *Volume of effluent received in relation to the available pore volume:* Because the section of pipeline associated with the unplanned release discharged to the 216-U-8 Crib and only a portion of the effluent volume leaked from the pipeline, the volume of effluent discharged to the 216-U-8 Crib is believed to bound the volume released from the 200-W-42 VCP. (3) *Contaminant inventory:* The contaminant inventory for the 216-U-8 Crib bounds the contaminant inventory for the 200-W-42 VCP, because only a portion of the waste was released from the pipeline. (4) *Depth of waste discharge:* The representative site bounds the analogous site in terms of discharge depth; (5) *Expected distribution of contaminants:* The distribution of less mobile contaminants is expected to be shallower at the 200-W-42 VCP than at the 216-U-8 Crib because of the shallower discharge depth. Insufficient data exist to evaluate the distribution of contaminants deeper in the vadose zone beneath the 200-W-42 VCP. (6) *Potential for hydrologic and contaminant impacts to groundwater:* The potential for contaminants to impact groundwater at the 216-U-8 Crib is expected to be greater than that of the 200-W-42 VCP, because the volume of waste discharged is believed to be greater than that of 200-W-42 VCP, and the discharge depth of the crib was greater. Surface soil samples collected in 1994 during the VCP limited field investigation typically showed low levels of activity for analyzed constituents. However the highest Sr-90 and Tc-99 activities were detected in adjacent vegetation samples at 1,380 pCi/g for Sr-90 and 117 pCi/g Tc-99. Significantly higher levels of contamination (maximums of 426 pCi/g Am-241, 49,100 pCi/g Cs-137, 180 pCi/g of Sr-90, 50 pCi/g of Tc-99, 43 pCi/g of U-238, 3.3 pCi/g of U-235, and 38 pCi/g of U-233/234) were detected throughout the 4 m (12-ft) depth of the investigation above the pipeline. The data also suggested that minor lateral spreading (no more than 1 to 2 m [3 to 5 ft]) was apparent.

bgs = below ground surface.
NPH = normal paraffin hydrocarbon.
TBP = tributyl phosphate.
VCP = vitrified clay pipeline.

Table 2-5. 216-U-12 Crib and Associated Analogous Waste Sites. (6 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Current Waste Site Cover/ Vegetation	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)	Co-60 (Ci)	CCl_4 (kg)	Ferro-Cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
Representative site																			
216-U-12 Crib	The 216-U-12 Crib is located in the 200 West Area about 650 m (2,130 ft) south of the 221-U Facility and 140 m (460 ft) north of Beloit Avenue. It is south of the 216-U-8 Crib. The 216-U-12 Crib was built in 1960 to replace the 216-U-8 Crib when it showed signs of cave-in potential. It was designed to receive mixed waste (corrosive, D002) from the U Plant via a 15 cm (6 in.) vitrified clay pipeline for approximately 5 minutes every hour, at the rate of 378 L/min (100 gal/min), and to dispose of the process condensate by percolation into the soil column.	Gravel	From April 1960 to May 1967, the site received 291-U-1 Stack drainage; 241-WR Vault waste; and 224-U Building process condensate via the C-5 Tank. Contaminated water from the 241-WR Vault was discharged to the crib in October 1965 that included 3.14 kg (6.9 lb) thorium. From May 1967 to September 1972, the site received the above wastes (excluding the 241-WR Vault waste) plus occasional waste via the C-7 Tank in the 224-U Building. From September 1972 to November 1981, the site was taken out of service. From November 1981 to January 1987, the site received corrosive process condensate (corrosive: [D002] typical pH range is 0.5-1.5) from the 224-U Building. The 216-U-12 Crib was operational until 1988, when the pipeline was cut and capped. The 216-U-12 Crib was replaced by the 216-U-17 Crib. In 1992, the site surface was radiologically surveyed and downposted from a Surface Contamination Area to an Underground Radioactive Material Area.	2.01 E+03	1.00 E+00	6.45 E-03	5.66 E-02	5.59 E+01	-	-	-	-	-	-	-	-	150,000	1,400	The criteria considered to evaluate the suitability of the 216-U-12 Crib as representative of the analogous sites assigned to it are: (1) *Waste site configuration and construction:* The 216-U-12 Crib was constructed in a 5 m (15 ft) deep open excavation which was backfilled with drainage layers of gravel, overlain by a polyethylene barrier and soil backfill. The 216-U-16 Crib and 216-U-17 Crib are constructed similarly, while the 216-U-5, 216-U-6, and 216-U-15 Trenches were open excavations that were intended for short-term use, contained no structure, and were backfilled with soil after use. The depths of the analogous sites range between 3 and 6 m (10 and 18 ft). (2) *Volume of effluent received in relation to the available pore volume:* The volume of effluent discharged to the 216-U-12 Crib is significantly greater than the soil pore volume beneath the site (150,000 m^3 compared to 1400 m^3). The 216-U-12 Crib bounds the analogous sites, because it had a significantly higher ratio of effluent volume to soil pore volume compared to analogous sites. (3) *Contaminant inventory:* The primary constituents in the 216-U-12 Crib waste inventory are uranium, Tc-99, and nitrate. Of these constituents, actual inventories for the 216-U-12 Crib were calculated only for uranium (2,010 kg). Total uranium, Tc-99, and nitrate inventories for the 216-U-16 Crib and 216-U-17 Crib are expected to be lower than for the 216-U-12 Crib, because they received similar process condensate wastes from 224-U but received a smaller volume of waste. Because the 216-U-5 and 216-U-6 Trenches received unirradiated fuel waste streams, no Tc-99 is expected to be present. The 216-U-15, 216-U-5, and 216-U-6 Trenches uranium inventories were estimated at 2.25 kg, 363 kg, and 363 kg, respectively. Nitrate inventories at the 216-U-5, and 216-U-6 Trenches were estimated at 200 kg for each trench. The 216-U-15 Trench received approximately 1 Ci of fission products (compared to about 6 Ci of fission products at the 216-U-12 Crib) and significant amounts of organic solution, whereas none of the other sites including the 216-U-12 Crib did. (4) *Depth of waste discharge:* The 216-U-12 Crib is 5 m (15 ft) deep compared to a range of 3 to 6 m (10 to 18 ft) for the other sites. The discharge depth for the representative site bounds the analogous sites. (5) *Expected distribution of contaminants:* The distribution of contaminants at the 216-U-12 Crib in the vadose zone is expected to bound the distribution of mobile contaminants at the 216-U-15, 216-U-5, and 216-U-6 Trenches. Immobile contaminants are found primarily near the point of release, shallow within the vadose zone. Mobile contaminants were carried deep into the vadose zone or to groundwater, but with little lateral spreading. Because of the similarities in the contaminant inventories and release depths, similar distributions would be expected at the analogous sites; (6) *Potential for hydrologic and contaminant impacts to groundwater:* The 216-U-12 Crib is bounding, because it is known to have impacted groundwater as evidenced by the presence of Tc-99 and nitrate in the groundwater. The 216-U-16 Crib also is known to have impacted groundwater, primarily through the lateral spreading of waste from the crib along the caliche to the 216-U-1 and 216-U-2 Cribs where uranium and Tc-99 was mobilized and moved to groundwater through an improperly sealed well.

Table 2-5. 216-U-12 Crib and Associated Analogous Waste Sites. (6 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Current Waste Site Cover/ Vegetation	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)	Co-60 (Ci)	CCl_4 (kg)	Ferro-Cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
Representative site																			
216-U-12 Crib (cont)																			No other analogous sites in this group impacted groundwater, because of the limited volumes of waste discharged to these sites. Limited characterization data are available for the crib from a 1994 borehole placed adjacent to the crib footprint, but spectral gamma borehole logging of a borehole throughthe crib to 53 m [175 ft] bgs indicates Cs-137 from 5 to 18 m (16 to 59 ft) (maximum activity of 16,100 pCi/g at 7 m [23 ft]) and U-238 from 5 to 24 m (17 to 80 ft) (maximum activity of 500 pCi/g at 23 m [76 ft] bgs). U-235 was detected by Radionuclide Logging System at 20 pCi/g between 22 m and 24 m (73 ft and 80 ft). Levels of Am-241, plutonium, and Np-237 are less than 1 pCi/g.
Process Waste Group analogous sites to be evaluated using the 216-U-12 Crib model																			
216-U-5 Trench	The site is located northwest of the 221-U Facility. The site consists of an unlined trench (12 by 12 m [40 by 40 ft] at the base of the excavation). The trench was 3 m (10 ft) deep. The above-ground piping was removed and the trench was backfilled with 3 m (10 ft) of clean soil immediately after receiving waste. No structures exist in the trench, which is posted with Underground Radioactive Material Area signs.	Gravel	This site was used as a liquid disposal site for unirradiated uranium waste from the cold start-up run at the 221-U Facility. The site was active only during March 1952. It was deactivated when the start-up waste disposal operation was complete. The aboveground piping was removed and the trench was backfilled. The site was interim stabilized in 1994 with 0.61 m (2 ft) of clean soil.	3.63 E+02	5.00 E-02	-	2.07 E-02	1.95 E-02	6.00 E-04	-	-	-	200	-	-	-	4,500	3,300	This trench is considered to be analogous to the 216-U-12 Crib based on the following criteria: (1) *Waste site configuration and construction.* The site is an inactive unlined trench; however, it lacks drainage layers and an impermeable barrier; (2) *Volume of effluent received in relation to the available pore volume.* The trench received a volume of effluent comparable to the soil pore volume (4500 m^3 compared to 3300 m^3, which is significantly less than the 216-U-12 Crib); (3) *Contaminant inventory.* The trench received a uranium-rich waste stream estimated to contain approximately 300 kg of uranium and 200 kg of nitrate; (4) *Depth of waste discharge.* The trench was constructed to a depth similar to that of the 216-U-12 Crib; (5) *Expected distribution of contaminant.* The trench has primary contaminants of uranium and nitrate and is expected to have similar contaminant distributions with maximum concentrations expected at the base of the trench (3 to 6 m [10 to 12 ft] bgs) and little lateral spreading; and (6) *Potential for hydrologic and contaminant impacts to groundwater.* The site is not believed to have impacted groundwater because of the limited discharge volumes from the site. This site is bound by the 216-U-12 Crib; however, contaminant concentrations, vertical distribution, and risks likely are lower than those of the crib, based on: (1) the site receiving orders of magnitude less wastewater than 216-U-12 Crib (4,500 m^3 compared to 150,000 m^3); (2) the site receiving a smaller inventory of contaminants (an order of magnitude less uranium, which was unirradiated); (3) the site receiving a single short-duration discharge (lacks a persistent driving source of wastewater), which likely would further limit the vertical movement of contaminants from the point of discharge; and (4) the mobile contaminants (uranium and nitrate) have not impacted the underlying groundwater.

Table 2-5. 216-U-12 Crib and Associated Analogous Waste Sites. (6 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Current Waste Site Cover/Vegetation	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)	Co-60 (Ci)	CCl_4 (kg)	Ferro-Cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
216-U-6 Trench	The site is located northwest of the 221-U Facility. This site consists of a backfilled trench that is posted with Underground Radioactive Material Area signs. The site consists of an unlined trench (3 by 25 m [10 by 75 ft] at the base of the excavation). The trench was 3 m (10 ft) deep. The above- ground piping was removed and the trench was backfilled. No structures exist in the trench.	Gravel	This site was used as a liquid disposal site for unirradiated uranium waste from the cold start-up run at the 221-U Facility. The site was active only during March 1952. It was deactivated when the start-up waste disposal operation was complete. In 1994, the crib surface was interim stabilized with 0.46 to 0.61 m (18 to 24 in.) of uncontaminated backfill. An additional contaminated zone, located south of crib, was stabilized at the same time.	3.63 E+02	5.00 E-02	-	2.07 E-02	1.95 E-02	6.00 E-04	-	-	-	200	-	-	-	4,500	3,300	This trench is considered to be analogous to the 216-U-12 Crib based on the following criteria: (1) *Waste site configuration and construction.* The site is an inactive unlined trench; however, it lacks drainage layers and an impermeable barrier; (2) *Volume of effluent received in relation to the available pore volume.* The trench received a volume of effluent comparable to the soil pore volume (4,500 m^3 compared to 3,300 m^3) and significantly less than the 216-U-12 Crib; (3) *Contaminant inventory.* The trench received a uranium-rich waste stream estimated to contain 363 kg of uranium and 200 kg of nitrate; (4) *Depth of waste discharge.* The trench was constructed to a depth similar to that of the 216-U-12 Crib; (5) *Expected distribution of contaminant.* The trench has primary contaminants of uranium and nitrate and is expected to have similar contaminant distributions with maximum concentrations expected at the base of the trench (3 to 6 m [10 to 12 ft] bgs) and little lateral spreading; and (6) *Potential for hydrologic and contaminant impacts to groundwater.* The site is not believed to have impacted groundwater because of the limited discharge volumes from the site. This site is bound by the 216-U-12 Crib; however, contaminant concentrations, vertical distribution, and risks likely are lower than those of the crib, based on: (1) the site receiving orders of magnitude less wastewater than 216-U-12 (4,500 m^3 compared to 150,000 m^3); (2) the site receiving a smaller inventory of contaminants (an order of magnitude less uranium, which was unirradiated); (3) the site receiving a single short-duration discharge (lacks a persistent driving source of wastewater), which likely would further limit the vertical movement of contaminants from the point of discharge; and (4) the mobile contaminants (uranium and nitrate) have not impacted the underlying groundwater.

Table 2-5. 216-U-12 Crib and Associated Analogous Waste Sites. (6 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Current Waste Site Cover/Vegetation	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)	Co-60 (Ci)	CCl_4 (kg)	Ferro-Cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
216-U-15 Trench	The site is located approximately 170 m north of 16th Street and 150 m west of the 271-U Building. The exact location is unknown. The site consists of an unlined trench 6.1 by 6.1 by 4.6 m (20 by 20 by 15 ft) deep (PNL-6456). The aboveground piping was removed and the trench was backfilled after the one-time waste water disposal. No structures exist in the trench.	Rabbit brush, tumble weed, and cheat grass.	The site is the result of a deliberate, one-time discharge of liquid waste into a hole in the ground that was immediately backfilled. The waste consisted of 26,500 L (7,000 gal) of interface crud, activated charcoal, and diatomaceous earth containing approximately 1 Ci of fission products. The site is associated with the 388-U Tank and the 276-U Solvent Storage Tank. No surface markers exist to identify the exact location of this waste unit. Exploratory core samples were taken in 1970 at the point of listed coordinates. No radioactivity was detected (RHO-CD-673).	2.25 E+00	1.00 E-01	-	4.65 E-02	4.42 E-02	2.33 E-03	-	-	40,000	-	-	-	13,000	68	560	This trench is considered to be analogous to the 216-U-12 Crib because: (1) *Waste site configuration and construction.* The site is an inactive unlined trench; however, it lacks drainage layers and an impermeable barrier; (2) *Volume of effluent received in relation to the available pore volume.* The trench received a volume of effluent less than the soil pore volume (volume (68 m^3 compared to 560 m^3); (3) *Contaminant inventory.* The trench received an inventory of fission products (approximately 1 Ci) less than that of the 216-U-12 Crib (approximately 6 Ci); however, it is reported that this trench received organic solutions containing TBP; (4) *Depth of waste discharge.* The trench was constructed to a depth similar to that of the 216-U-12 Crib; (5) *Expected distribution of contaminant.* The trench is expected to have similar contaminant distributions, with maximum concentrations expected at the base of the trench (3 to 6 m [10 to 12 ft] bgs) and little lateral spreading; and (6) *Potential for hydrologic and contaminant impacts to groundwater.* The site is not believed to have impacted groundwater because of the limited discharge volumes from the site. This site is bound by the 216-U-12 Crib; however, radionuclide contaminant concentrations, vertical distribution, and risks likely are lower than those of the crib based on: (1) the site receiving several orders of magnitude less wastewater (68 m^3 compared to 150,000 m^3); (2) the site receiving a smaller inventory of radionuclides (3 orders of magnitude less uranium); (3) the site receiving a single short-duration discharge (lacks a persistent driving source of wastewater), which likely would have further limited the vertical movement of contaminants from the point of discharge; and (4) mobile contaminants have not impacted the underlying groundwater. The 216-U-12 Crib, however, does not bound the chemical inventory of the 216-U-15 Trench, which received organics including tributyl phosphate and normal paraffin hydrocarbon. No analytical data are available for this site other than a report of core samples taken in 1970, where no radioactivity was detected. There is some uncertainty of the exact location of this site. Confirmatory sampling may be used to confirm the nature of contamination and the risk associated with this site, with a focus on the organics as well as to confirm the site location.

Table 2-5. 216-U-12 Crib and Associated Analogous Waste Sites. (6 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Current Waste Site Cover/Vegetation	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)	Co-60 (Ci)	CCl_4 (kg)	Ferro-Cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
216-U-16 Crib	The crib is located south of 16th Street, between Beloit and Cooper Avenues, southwest of the 224-U Building. The crib is identified with concrete markers and is posted with Underground Radioactive Material Area signs. The site consists of a trench with bottom dimensions of 58 by 80 m (191 by 262 ft). The bottom of the trench is approximately 5 m (17 ft) below grade. The bottom is filled with 1.5 m (5 ft) of gravel that is covered by a 36 mil reinforced polyethylene liner. Above the liner is select backfill to grade. The distribution system for the crib consists of two 8-in. diameter polyvinylchloride header pipes (reducing to 6 in.) set 0.9 m (3 ft) above the trench bottom and running on opposite sides of the crib. The header pipes are connected by a series of 4-in. perforated polyvinyl chloride pipes on 3 m (10 ft) centers that run across the crib. Each header pipe and cross line has a vent pipe. Three gage wells also are shown on plans for the crib–one at each end and in the middle. A 6-in. diameter subdrainage pipe runs the length of the west side of the crib.	Gravel	The crib was built to receive waste from the 224-U Uranium Oxide (UO_3) Processing Facility. Because of plans to deactivate the 216-U-14 Ditch and stabilize the 216-U-10 Pond, the 216-U-16 Crib was constructed. In 1984, the original 46 cm (18 in.) diameter, vitrified clay pipeline was connected to the 216-U-16 Crib via a 30 cm (12 in.) diameter polyvinyl chloride pipeline, and flow to the 216-U-14 Ditch was shut off. The pipeline transported 224-U steam condensate, 224-U chemical sewer waste, 271-U compressor cooling water, 221-U chemical sewer waste, and 224-U process condensate to the 216-U-16 Crib, while it was in operation from 1984 until February 1985, when liquid discharges to this crib were ended. When 216-U-16 Crib was shut down, the waste streams were rerouted to the 216-U-14 Ditch via the 207-U Retention Basin. Annual surface radiological surveys are performed; no signs of contamination have been located to date. In 1986, monitoring well 299-W19-13 showed elevated levels of uranium and alpha radiation. By 1994, the uranium levels had decreased considerably, but remain greater than the proposed maximum contaminant level. In 1996, the crib was permanently isolated by filling marhole #1 with concrete. In 2000, the vent risers were cut off below grade and the opening was sealed with a polyvinyl chloride cap.	1.76 E+01	-	-	1.65 E-02	9.20 E-03	-	-	-	-	-	-	-	-	409,000	16,500	This crib is considered to be analogous to the 216-U-12 Crib. The following criteria were used to evaluate this relationship: (1) *Waste site configuration and construction.* The site is an inactive gravel-filled crib similar in construction to the 216-U-12 Crib; (2) *Volume of effluent received in relation to the available pore volume.* Although the site received large volumes of effluent (409,000 m^3 compared to 150,000 m^3 for the 216-U-12 Crib) its pore volume was significantly larger (16,500 m^3 compared to 1,400 m^3) and therefore is bounded by the 216-U-12 Crib in terms of effluent volume in relation to pore volume; (3) *Contaminant inventory.* The site received a dilute uranium-bearing process waste stream; (4) *Depth of waste discharge.* The crib was constructed to a depth similar to that of the 216-U-12 Crib; (5) *Expected distribution of contaminants.* The primary radionuclide contaminants (uranium, Tc-99, and nitrate) are similar, and the site is expected to have a similar contaminant distribution with maximum concentrations at the base of the crib (5 m [17 ft] bgs); and (6) *Potential for hydrologic and contaminant impacts to groundwater.* The 216-U-16 Crib is known to have affected groundwater, primarily through the lateral spreading of waste from the crib along the caliche to the 216-U-1 and 216-U-2 Cribs, where uranium and Tc-99 were mobilized from beneath the 216-U-1 and 216-U-2 Cribs and moved to groundwater through an improperly sealed well near the 216-U-1 Crib. Characterization is limited to geophysical well logs. The site operated for only 3 years, but received a high enough rate of effluent to create a perched groundwater table. This site is bound by the 216-U-12 Crib; however, contaminant concentrations and risks likely are lower based on: (1) the site receiving a smaller inventory of contaminants (2 orders of magnitude less uranium); (2) wastewater was distributed over a much larger crib-base area.

Table 2-5. 216-U-12 Crib and Associated Analogous Waste Sites. (6 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Current Waste Site Cover/Vegetation	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)	Co-60 (Ci)	CCl_4 (kg)	Ferro-Cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
216-U-17 Crib	The site is located south of 16th Street and east of Beloit Avenue inside the 200 West Area. It is southeast of the 221-U Facility. The crib was built to replace the 216-U-12 Crib. The crib is marked and posted with Underground Radioactive Material Area signs. The site consists of a trench with bottom dimensions of 3 m by 46 m (10 ft by 150 ft). The trench was approximately 5 m (18 ft) deep with an original sideslope of 1:1.5. A single perforated distribution pipe runs down the centerline of the trench approximately 1.5 m (5 ft) above the trench bottom. The trench was backfilled with 2.0 m (6.5 ft) of clean, coarse gravel. This gravel was covered with a 10 mil polyvinyl chloride membrane, which then was covered with approximately 3 m (10 ft) of earth backfill. A 15 cm (6 in.) polyethylene pipeline connects the distribution pipe in the crib to the 224-U Building. Two vent risers on the distribution pipe and three sealed gauge wells are shown on the plans for this crib.	Gravel	The crib received effluent from the 224-U Uranium Trioxide (UO_3) calcining operations. The 216-U-17 Crib and pipeline were constructed in 1987 and became operational on January 31, 1998, as a replacement for the 216-U-12 Crib. Discharge to the crib was suspended in July 1989. Flow to the crib was resumed in August 1992 following approval of a sampling and analysis plan. Between July 1989 and August 1992, wastewater was stored at the UO_3 Plant. The UO_3 Plant process condensate originates in the off-gas condensers in Building 224-U, which processes contributor streams from throughout the UO_3 Plant Complex. From these condensers, the process condensate drains to a surge tank in the 203-U Enclosure. The process condensate is neutralized in Building 224-U and is pumped to the 216-U-17 Crib for disposal. A surface radiological survey in 1997 found no contamination. The vent risers were sealed in 2000 as a preventive measure for potential passive radioactive emission.	1.42 E+00	-	5.30 E-05	-	-	-	-	-	-	-	-	-	-	2,110	2,100	This crib is considered to be analogous to the 216-U-12 Crib. The following criteria were used to evaluate this relationship: (1) *Waste site configuration and construction.* It is an inactive crib of similar construction (drainage layers and overlain by an impermeable barrier) that was built to replace the 216-U-12 Crib; (2) *Volume of effluent received in relation to the available pore volume.* The 216-U-17 Crib received a liquid effluent equal to its pore volume; (3) *Contaminant inventory.* The crib received a uranium-rich waste steam, although significantly less inventory than the 216-U-12 Crib; (4) *Depth of waste discharge.* The 216-U-17 Crib was constructed to a depth similar to that of the 216-U-12 Crib; (5) *Expected distribution of contaminant.* It is expected to have similar contaminant distributions with maximum concentrations expected at the base of the crib and little lateral spreading; and (6) *Potential for hydrologic and contaminant impacts to groundwater.* The 216-U-17 Crib and 216-U-12 Crib have similar hydrogeology and thick vadose zone; however, the volume of effluent discharged is equal to the soil pore volume. Therefore, it is not believed that the contaminants from the crib significantly impacted groundwater. Radionuclide Logging System logging of six boreholes in the 216-U-17 Crib was completed in May 1993 after the crib received approximately 1.12×10^6 L, and no man-made radionuclides were detected in the vadose zone beneath the crib. In addition, sampling of the UO_3 Facility process condensate discharged to the crib detected only low concentrations of tritium, uranium, Tc-99, nitrate, and fluoride (WHC-EP-0664). Risks associated with this site are expected to be bounded by those of the 216-U-12 Crib, because the waste inventory and volume is significantly less than at the 216-U-12 Crib, and because of the Radionuclide Logging System logging results.

- = not detected or not analyzed.
bgs = below ground surface.
NPH = normal paraffin hydrocarbon.
TBP = tributyl phosphate.

PNL-6456, *Hazard Ranking System Evaluation of CERCLA Inactive Waste Sites at Hanford*, Vol. 2.
RHO-CD-673, *Handbook 200 Area Waste Sites*, Volumes I & II.
WHC-EP-0664, *Groundwater Impact Assessment for the 216-U-17 Crib.*

Table 2-6. 216-U-4 Reverse Well/216-U-4A French Drain and Associated Analogous Waste Sites. (2 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Current Waste Site Cover/ Vegetation	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)	Co-60 (Ci)	CCl_4 (kg)	Ferro-Cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
Representative site																			
216-U-4 Reverse Well	This site is located 5.2 m west and 0.6 m north of the 222-U Laboratory. The well is located inside the fence of the UO_3 exclusion area. This site consists of a deactivated reverse well. The site is marked with a small cement cover and a bronze medallion. It is posted as an Underground Radioactive Material Area. The well consists of a 7.6 cm (3 in.) diameter pipe installed 23 m (75 ft) into the ground with the bottom 8 m (25 ft) of pipe perforated. The end of the pipe is nearly closed by flattening. An overflow pipe connects the 216-U-4 Reverse Well with the 216-U-4A French Drain. No stabilization cover exists over the 216-U-4 Reverse Well.	Concrete	The site received acidic decontamination waste containing fission products from the 222-U Laboratory hood sinks. The site began to receive waste in March 1947 and retired when the unit was plugged in July 1955. The site was deactivated by installing an overflow line to the new 216-U-4A French Drain.	-	-	-	-	-	-	-	-	-	400	-	-	-	300	0.4	Because of the proximity of the 216-U-4 Reverse Well and 216-U-4A French Drain sites, they have been combined into one conceptual contaminant distribution model. The 216-U-4 Reverse Well and 216-U-4A French Drain were selected as a representative site based on the following criteria: (1) *Waste site configuration and construction.* The 216-U-4 Reverse Well is the only reverse well among the 200-UW-1 Operable Unit waste sites, and the 216-U-4A French Drain and the 216-U-4B French Drain were constructed similarly (having similar materials and depth); (2) *Volume of effluent received in relation to the available pore volume.* The volume of effluent discharged through the 216-U-4 Reverse Well and the 216-U-4A French Drain is 845 m^3 compared to a total of 33 m^3 for the 216-U-4B French Drain; (3) *Contaminant inventory.* The 216-U-4 Reverse Well, the 216-U-4A Drain, and the 216-U-4B French Drain all received waste from the 222-U Laboratory. The primary contaminants discharged to the 216-U-4 Reverse Well and the 216-U-4A French Drain are uranium (8.83 kg), plutonium (9.00 E-03 g), Cs-137 (1.85 E-01 Ci), Sr-90 (1.59 E-02 Ci), and nitrate (1,300 kg). The contaminant inventory for the 216-U-4B French Drain is higher in terms of plutonium (5.40 E-02 g), similar in terms of Cs-137 (1.97 E-01 Ci), lower in Sr-90 (1.65 E-03 Ci), and nitrate (10 kg), and lacks uranium altogether; (4) *Depth of waste discharge.* The depth of discharge is similar for the 216-U-4A French Drain and 216-U-4B French Drain; however, the 216-U-4 Reverse Well is approximately 20 m (66 ft) deeper; (5) *Expected distribution of contaminant.* Because of the greater depth of the reverse well and much greater combined volume of discharge from the 216-U-4 Reverse Well and 216-U-4A French Drain, the contaminant distribution is expected to be significantly deeper for the representative site than for the analogous site (the 216-U-4B French Drain). Similar to other waste sites in the 200-UW-1 Operable Unit, immobile contaminants such as Cs-137 are found near the point of release, and more mobile contaminants such as nitrate are migrating lower in the vadose zone. The representative site bounds the analogous site in terms of the depth of the contaminant distribution; (6) *Potential for hydrologic and contaminant impacts to groundwater.* Because of the depth of the 216-U-4 Reverse Well, the volume of effluent discharged in comparison to the soil pore volume, and the detection of uranium at the caliche layer in excess of the background concentration, it is believed that contaminants from the representative site may have reached groundwater. Because the waste inventory for nitrate, the release depth, and effluent volume are all significantly less for the 216-U-4B French Drain, *the representative site is believed to bound it in terms of impacts to groundwater.*

Table 2-6. 216-U-4 Reverse Well/216-U-4A French Drain and Associated Analogous Waste Sites. (2 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Current Waste Site Cover/Vegetation	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)	Co-60 (Ci)	CCl_4 (kg)	Ferro-Cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
Representative site																			
216-U-4A French Drain	This site is located at the southwest corner of the 222-U Laboratory. The 216-U-4A French Drain was installed 2.4 m north of the 216-U-4 Reverse Well. This site is posted as an Underground Radioactive Material Area. The top of the drain is painted yellow and has a removable lid. The site consists of a 1.3 m (51 in.) diameter concrete pipe placed vertically in the ground. The pipe extends downward a minimum of 1.2 m (4 ft) and its top is 1.5 m (5 ft) below grade. The pipe is not gravel filled and is covered by a 12.7 cm (5 in.) thick wooden lid. The drain rests on undisturbed soil. A 7.6 cm (3 in.) stainless steel pipe runs from the 216-U-4 Reverse Well to the 216-U-4A French Drain a few centimeters below its lid.	Concrete and manhole cover	The site operated from July 1955 to July 1970. From July 1955 to January 1965 the site received acidic decontamination waste containing fission products from hood sinks in the 222-U Laboratory. Waste flowed to the 216-U-4A French Drain via the overflow line from the 216-U-4 Reverse Well. From January 1965 to July 1970 the site received Pacific Northwest Laboratory operations decontamination waste from a hood sink in the 222-U Laboratory. The site has been inactive since Pacific Northwest Laboratory operations in the 222-U Laboratory were shut down.	8.83 E+00	9.00 E-03	-	1.85 E-01	1.59 E-02	-	-	-	-	900	-	-	-	545	20	See discussion above under 216-U-4 Reverse Well.
Reverse Well/French Drain Group analogous sites to be evaluated using the 216-U-4 Reverse Well/216-U-4A French Drain model																			
216-U-4B French Drain	This site is located 9.1 m (30 ft) south of the 222-U Laboratory. The French drain consists of a 0.9 m (36 in.) concrete pipe placed vertically below grade. The pipe extends 3 m (10 ft) downward. The pipe is located under a cement pad with a 2.5 cm (1 in.) diameter steel riser pipe, which has been capped. The vent riser extends approximately 1.2 m (4 ft) above the surface.	Concrete	The French drain is a Washington State-registered underground injection well. It is posted with Underground Radioactive Material Area signs. The site operated from January 1960 to July 1970. The unit was deactivated when Pacific Northwest Laboratory operations in the 222-U Laboratory were shut down. From January 1960 to July 1970, the site received waste from a hot cell and hood in the 222-U Laboratory. From January 1965 to July 1970, the site received waste from hoods and hot cells in the 222-U Laboratory from Pacific Northwest Laboratory work.	-	5.40 E-02	-	1.97 E-01	1.65 E-03	-	-	-	-	10	-	-	-	33	11	This site is analogous to the 216-U-4A French Drain based on the following criteria: (1) *Waste site configuration and construction.* It is an inactive French drain of construction similar to the 216-U-4A French Drain; (2) *Volume of effluent received in relation to the available pore volume.* It received a smaller effluent volume than the 216-U-4A French Drain and therefore is bounded by it; (3) *Contaminant inventory.* It received a similar contaminant inventory (see discussion under 216-U-4 Reverse Well). (4) *Depth of waste discharge.* The 216-U-4A and 216-U-4B French Drains have similar structure depths; (5) *Expected distribution of contaminant.* The contaminant distribution is expected to be similar to that of the 216-U-4A French Drain, although bounded by it because of smaller release volume and inventory; (6) *Potential for hydrologic and contaminant impacts to groundwater.* The site has a thick vadose zone and depth similar to the caliche layer of the representative ste because of the proximity of the two sites. The risk associated with the 216-U-4B French Drain is expected to be bounded by the 216-U-4A French Drain, because the waste liquid volume discharged to the 216-U-4B French Drain is an order of magnitude less than that discharged to the 216-U-4A French Drain.

-- = not detected or not analyzed.
NPH = normal paraffin hydrocarbon.
TBP = tributyl phosphate.

Table 2-7. Unplanned Release UPR-200-W-19 and Associated Analogous Waste Sites. (11 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Current Waste Site Cover/Vegetation	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)	Co-60 (Ci)	CCl_4 (kg)	Ferro-Cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
Representative site																			
UPR-200-W-19	The UPR-200-W-19 site is located north of 16th Street, west of the 221-U Facility, and east of the 207-U Retention Basin. The area where the release occurred and subsequent spread of contamination is marked as an Underground Radioactive Material Area, which also contains the 216-U-1 Crib, the 216-U-2 Crib, and the 241-U-361 Settling Tank. A portion of the 2607-W5 Septic Tank and Tile Field also is included in the Underground Radioactive Material Area.	Gravel, soil, bunch grass, some rabbit brush, tumble weed, and cheat grass	In the spring of 1953, organic wastes and cell drainage from the tributyl phosphate process in the 221-U Facility and waste from the 224-U Building (UO_3) overflowed to the ground from the 241-U-361 Settling Tank and the 216-U-1 and 216-U-2 Crib vents. Contamination readings of 11.5 rad/h at a distance of 7.6 cm (3 in.) were reported over an area of approximately 4.6 m^2 (50 ft^2). In 1953, decontamination was conducted and the area was backfilled, delineated by a wooden fence, and posted with Radiation Zone signs. In 1992, surface contaminated soil in the vicinity of the 216-U-1 and 216-U-2 Cribs was scraped and consolidated near the 241-U-361 Settling Tank. The surface surrounding the 241-U-361 Settling Tank was surface stabilized with shotcrete. The contaminated soil was covered with 45 to 61 cm (18 to 24 in.) of clean backfill. The area was downposted from a Surface Contamination Area to an Underground Radioactive Material Area. In 1994, contamination specks were found on the surface again, presumably caused by insect intrusion. Approximately 63 m^2 (700 ft^2) of contamination was covered with clean dirt to restore the area to an Underground Radioactive Material Area.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	The criteria considered to evaluate the suitability of UPR-200-W-19 as a representative of the sites assigned to it are: (1) *Waste site configuration and construction.* UPR-200-W-19 is an unplanned release site where contaminated liquid from a high-risk waste site was known to have been released to the ground; (2) *Volume of effluent received in relation to the available pore volume:* This criterion is applicable only when a known volume of waste is released to a site of defined size. Because the volume of the release for UPR-200-W-19 is unknown, the relationship to pore volume cannot be determined; (3) *Contaminant inventory*: Because UPR-200-W-19 was an unplanned release, contaminant inventory is not known; (4) *Depth of waste discharge*: UPR-200-W-19 was a surface release of liquid that was later spread to a wider area by plant and animal/insect intrusion. The depth of the release is expected to be 1-2 m below the clean backfill; (5) *Expected distribution of contaminants:* Immobile contaminants from UPR-200-W-19 have remained near the surface and have been spread laterally by windblown soil and vegetation. More mobile contaminants are anticipated to be relatively shallow, because the effluent volume released was small relative to the volume discharged to the cribs; (6) *Potential for hydrologic and contaminant impacts to groundwater*: No impacts to groundwater are anticipated because of the small effluent volume believed to have been released to thesite compared to high-risk waste sites.

Table 2-7. Unplanned Release UPR-200-W-19 and Associated Analogous Waste Sites. (11 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Current Waste Site Cover/Vegetation	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)	Co-60 (Ci)	CCl_4 (kg)	Ferro-Cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
Septic System Group analogous sites to be evaluated using the UPR-200-W-19 model																			
2607-W5 Septic Tank and Tile Field	This unit lies 122 m (400 ft) southwest of the 221-U Facility and east of the 207-U Retention Basin. It is north of the 241-U-361 Settling Tank. The 2607-W5 Septic Tank is a single-compartment tank constructed of concrete and has three entry openings on the top, each protected by a wooden cover. The tank is a buried concrete box that measures 9 m (30 ft) long, 4 m (13 ft) wide, and 3 m (11 ft) deep. Waste enters the tank through an 8-in. diameter VCP. A similar pipe connects the septic tank to a concrete diversion box (measuring 1.5 m [5 ft] long, 1.2 m [4 ft] wide, and 3 m [9 ft] deep), and then to a second concrete diversion box (measuring 2 m [7 ft] long, 1.5 m [5 ft] wide, and 3 m [9 ft] deep) before entering the tile field. The tops of the septic tank and both diversion boxes are located at ground level. The current tile field measures 41 by 30 m (136 by 100 ft). The tile field consists of 41 m (135 ft) lengths of 8-in. diameter perforated pipe spaced 6 m (20 ft) apart. The pipes are underlain by a gravel bed extending 0.6 m (2 ft) below the pipes. The tile field is backfilled 0.76 m (2.5 ft) above the pipes. The surface of the backfill is 0.9 m (3 ft) below the original grade. A second, abandoned tile field lies immediately west of the current tile field and is larger than the current tile field. The 2607-W5 Septic Tank and Tile Fields were scheduled to be abandoned in 2000. Some components of the existing system may have been reused (e.g., septic tank). The old tile field was replaced in 1954. The 2607-W5 Septic Tank and associated Tile Field are designed to accept sanitary sewer effluent from U Plant facilities. In 1998, the system was being used by MO-107 and MO-419. The operational status needs to be verified. For this focused feasibility study, it is assumed that these structures will be inactive because of the disposition of the 221-U Facility.	Concrete over septic tank, bunch grass on tile field	The 2607-W5 Septic Tank and associated Tile Field are designed to accept sanitary sewer effluent from U Plant facilities. The original design capacity for the system was 292 persons. The septic tank and diversion boxes are currently located in an Underground Radioactive Material Area related to the 216-U-1 and 216-U-2 Cribs and the 241-U-361 Settling Tank. The tile field is located outside the Underground Radioactive Material Area boundary. Only the south slope of the tile field is inside the boundary. Stabilization actions conducted at the site in 1991 included removing approximately 15 to 30 cm (6 to 12 in.) of soil from the active tile field, consolidating soils southeast of the 241-U-361 Settling Tank, and placement of 46 to 61 cm (18 to 24 in.) of stabilization cover over the area including the 2607-W5 Septic Tank and Diversion Boxes and 216-U-1 and 216-U-2 Cribs. Because radiological contamination was found at the surface within the tile field, and a portion of the tile field was decontaminated by scraping off surface soils, it is not clear that the contamination originated from the septic system effluent. Another possible source of this contamination could be from wind blown soil and vegetation from other sources, because the tile field is located in a surface depression. NOTE: MO-107 and MO-419 are located near the 224-U Building (UO_3).	-	-	-	-	-	-	-	-	-	-	-	-	-	12.1/day	-	This site is considered to be similar to and bounded by UPR-200-W-19 based on the following criteria: (1) *Waste site configuration and construction*: The unplanned release has a different configuration than the septic systems, because the unplanned release is not an engineered structure compared to the 2607-W5 Septic System, which was designed to accept sanitary effluent. (2) *Volume of effluent received in relation to the available pore volume:* The volume of effluent received at the 2607-W5 Septic System is expected to exceed the soil pore volume. This is not the case for UPR-200-W-19; however, this may not be of significance, because the septic system was intended to accept sanitary effluent, not contaminated effluents. Therefore, the waste inventory transported with that liquid effluent is expected to be minimal; (3) *Contaminant inventory:* The waste inventory of the septic systems is unknown but is believed to be bounded by the contaminant inventory released to UPR-200-W-19, where known release of contaminants from a high-risk waste site was documented and confirmed through characterization. No releases of radiological contaminants have been documented for the 2607-W5 Septic System, because it was not intended for disposal of sanitary effluent. (4) *Depth of waste discharge*: The depth of discharge for the septic system is considered similar to that of UPR-200-W-19, because the septic tank and tile fields are near the surface; (5) *Expected distribution of contaminants:* The contaminant distribution is expected to be near the surface for immobile contaminants such as Cs-137 that may have been inadvertently released into the septic system. More mobile contaminants inadvertently discharged into the septic system could migrate deeper into the vadose zone; however, the amounts of these contaminants are expected to be small, because these contaminants were not purposely discharged into the septic system, and no unplanned releases have been documented. Because surface contamination has been documented and characterized at UPR-200-W-19, it is believed that the representative site would bound the analogous sites in terms of risk; (6) *Potential for hydrologic and contaminant impacts to groundwater:* Because of the shallow nature of the site, and the limited contaminant inventory released to the sites in comparison to other 200-UW-1 Operable Unit waste sites designed to accept liquid effluent, the site is not believed to have impacted groundwater. Characterization data in the tile fields from borehole 299-W19-97 placed adjacent to the south west corner of the tile fields as part of the 1994 limited field investigation showed no evidence of impact to the vadose zone from the tile field. Low levels of Cs-137 associated with UPR-200-W-19 were detected near the surface.

Table 2-7. Unplanned Release UPR-200-W-19 and Associated Analogous Waste Sites. (11 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Current Waste Site Cover/Vegetation	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)	Co-60 (Ci)	CCl_4 (kg)	Ferro-Cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
2607-W7 Septic Tank and Tile Field	This unit lies 14 m (45.9 ft) north of the northernmost corner of the 221-U Facility. The 2607-W7 Septic Tank was a small, 950 L (350 gal) tank constructed of reinforced concrete. The 2607-W7 Septic Tank and associated Tile Field were designed to accept sanitary waste sewer effluent from a single restroom located in the 221-U Facility. It had a design capacity for eight persons. Radioactive materials were handled in the 221-U Facility.	Gravel	This system lies in between two Underground Radioactive Material Areas; however, no radionuclides or hazardous chemicals are known to have been associated with this system. This system was abandoned in 1999. The septic system was abandoned in 1999 per the requirements of WAC 246-272-18501. All septage inside the tank was removed, and the empty tank was filled to eliminate void spaces. Per an agreement with the Washington Department of Health, the septic system lids were left in place. WIDS does not indicate that any stabilization cover has been placed over this site. Previous documentation stated that the 2607-W7 Septic System includes a septic tank and tile field that lie in a radiation zone. A site visit made in 1999 found the septic tank to be located between two Underground Radioactive Material Areas. The location of the drain field was not visually apparent. WIDS indicates that the tile field may be west of the septic tank.	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0/day	-	This site is considered to be similar to and bounded by UPR-200-W-19 based on the following criteria: (1) *Waste site configuration and construction:* The unplanned release has a different configuration than the septic systems, because the unplanned release is not an engineered structure compared to the 2607-W7 Septic System, which was designed to accept sanitary effluent. (2) *Volume of effluent received in relation to the available pore volume:* The volume of effluent received at the 2607-W7 Septic System is expected to exceed the soil pore volume. This is not the case for UPR-200-W-19; however, this may not be of significance, because the septic system was intended to accept sanitary effluent, not contaminated effluents. Therefore, the waste inventory transported with that liquid effluent is expected to be minimal; (3) *Contaminant inventory:* The waste inventory of the septic systems is unknown but is believed to be bounded by the contaminant inventory released to UPR-200-W-19, where known release of contaminants from a high-risk waste site was documented and confirmed through characterization. No releases of radiological contaminants have been documented for the 2607-W7 Septic System, because it was not intended for disposal of sanitary effluent. (4) *Depth of waste discharge*: The depth of discharge for the septic system is considered similar to that of UPR-200-W-19, because the septic tank and tile fields are near the surface; (5) *Expected distribution of contaminants:* The contaminant distribution is expected to be near the surface for immobile contaminants such as Cs-137 that may have been inadvertently released into the septic system. More mobile contaminants inadvertently discharged into the septic system could migrate deeper into the vadose zone; however, the amounts of these contaminants are expected to be small, because these contaminants were not purposely discharged into the septic system, and no unplanned releases have been documented. Because surface contamination has been documented and characterized at UPR-200-W-19, it is believed that the representative site would bound the analogous sites in terms of risk; (6) *Potential for hydrologic and contaminant impacts to groundwater:* Because of the shallow nature of the site, and the limited contaminant inventory released to the sites in comparison to other 200-UW-1 Operable Unit waste sites designed to accept liquid effluent, the site is not believed to have impacted groundwater.

Table 2-7. Unplanned Release UPR-200-W-19 and Associated Analogous Waste Sites. (11 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Current Waste Site Cover/Vegetation	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)	Co-60 (Ci)	CCl_4 (kg)	Ferro-Cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
Solid Waste Group analogous sites to be evaluated using the UPR-200-W-19 model																			
200-W-56	The site is located approximately 137 m (150 yd) north of the 221-U Facility. The site consists of a pile of soil approximately 3.05 m (10 ft) in diameter containing wire, fencing material, metal scrap, cable, and grounding rods.	Rabbit brush, tumble weed, and cheat grass	The site is not marked or radiologically posted. There is no record of a release of radioactive or chemical contaminants at this site.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	This site is considered to be similar to and bounded by the representative site, based on the following criteria. (1) *Waste site configuration and construction:* Because the 200-W-56 Dump site consists of a pile of miscellaneous debris at the ground surface, it is similar to UPR-200-W-19, which was a surface spill. (2) *Volume of effluent received in relation to the available pore volume:* No effluent is known to have been discharged to the site. (3) *Contaminant inventory:* The contaminant inventory discharged to this site, if any, was not documented. However, because surface contamination has been documented at UPR-200-W-19, and the release occurred from a high-risk site, it is believed that the representative site would bound the analogous site in terms of risk. (4) *Depth of waste discharge:* The depth of release at UPR-200-W-19 is at the surface. Similarly, if any releases had occurred at the 200-W-56 Dump, they also would have been near the surface. (5) *Expected distribution of contaminants:* This criterion is not applicable to the 200-W-56 Dump, because no contamination is believed to exist at the site. (6) *Potential for hydrologic and contaminant impacts to groundwater:* This criterion is not applicable to the 200-W-56 Dump, because no contamination is believed to exist at the site.
200-W-57	The laydown area was located outside the fenced T-Hopper Storage Area, on the west side of the 2714-U Building. The site was an excess equipment area for storage for radiologically uncontaminated equipment.	Gravel	A RCRA general inspection in 1997 identified the material as an area needing to be addressed. The equipment was in the process of being salvaged and/or recycled by a junk dealer. The material has been removed and the area now consists of gravel and pavement. There is no record of a release of radioactive or chemical contaminants at this site.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	This site is considered to be similar to and bounded by the representative site based on the following criteria: (1) *Waste site configuration and construction:* Because the 200-W-57 Dump consisted of a laydown area for storage for radiologically uncontaminated equipment, which was subsequently removed, it does not have a structure associated with it, similar to UPR-200-W-19; (2) *Volume of effluent received in relation to the available pore volume:* No effluent is known to have been discharged to the site; (3) *Contaminant inventory:* The contaminant inventory discharged to this site, if any, was not documented. However, because surface contamination has been documented at UPR-200-W-19, and the release occurred from a high risk site, it is believed that the representative site would bound the analogous site in terms of risk; (4) *Depth of waste discharge:* This criterion is not applicable to the 200-W-57 Dump, because no contamination is believed to exist at the site. The depth of release at UPR-200-W-19 is at the surface. If any releases had occurred at the 200-W-57 Dump, they also would have been near the surface; (5) *Expected distribution of contaminants:* This criterion is not applicable to the 200-W-57 Dump, because no contamination is believed to exist at the site; (6) *Potential for hydrologic and contaminant impacts to groundwater:* This criterion is not applicable to the 200-W-57 Dump, because no contamination is believed to exist at the site.

Table 2-7. Unplanned Release UPR-200-W-19 and Associated Analogous Waste Sites. (11 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Current Waste Site Cover/Vegetation	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)	Co-60 (Ci)	CCl_4 (kg)	Ferro-Cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
200-W-71	An open trench is visible on a 1948 aerial photograph of the 200 West Area. The trench was located southeast of the 221-U Facility, south of 16th Street, and east of Beloit Avenue. The trench apparently has been backfilled and is not marked or posted. The 216-U-17 Crib is just west of the trench location.	Rabbit brush, tumble weed, and cheat grass	The 1948 aerial photograph shows an open trench and a spoil pile. Historical photos from 1950 and 1956 show smoke emitting from the trench. There are no designated burial grounds at this location. Later, the same area was used as a construction laydown area for the reconfiguration of U Plant for the uranium recovery process. A meeting held in 1987 with several knowledgeable long-time employees attributed the obvious surface debris to the U Plant construction activities. There was a general recollection among the older employees that natural uranium was once sent to a trench in this area. However, no radioactivity was ever detected during various core sampling in the area over the years. Based on the historical photographs and the general lack of information on this site and on UPR-200-W-8, this site may be the burn pit that is described in the UPR-200-W-8 waste site.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Significant uncertainties exist as to the nature of any releases at this 200-W-71 Pit site as well as the location of the site. Based on the historical photographs and the general lack of information on this site and on UPR-200-W-8, this site may be the burn pit that is described in the UPR-200-W-8 waste site. See the UPR-200-W-8 rationale below.
UPR-200-W-8 (Burial Ground/ Burning Ground or Burning Pit)	The site is located in the old burning ground, east of the 221-U Facility, adjacent to the corner of Beloit and 16th Street.	Soil, some rabbit brush, tumble weed, and cheat grass	Contamination was discovered in the spring of 1950 in the "Old Burning Ground," located east of the 221-U Facility. Approximately 13.9 m^2 (150 ft^2) were contaminated, with a maximum dose rate of 45 rad/h at 5 cm (2 in.). In 1950, approximately 150 ft^2 of ground were covered with 3 m (10 ft) of clean earth. In an interview conducted with 200 West Area personnel, they remembered the area being cleaned up around 1970 and the area released as a radiation zone. An unspecified amount of soil and debris were removed and transported to another burial ground for disposal. Based on the historical photographs and the general lack of information on this site, 200-W-71 may be the burn pit that is described as the UPR-200-W-8 waste site.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	This site is considered to be similar to and bounded by the representative site based on the following criteria: (1) *Waste site configuration and construction:* This criterion is not applicable, because the 200-W-8 Burial Ground site consisted of a trench that may have been used as a burning ground, compared to UPR-200-W-19, which was an unplanned release with no structure; (2) *Volume of effluent received in relation to the available pore volume:* No effluent is known to have been discharged to the site; (3) *Contaminant inventory:* The contaminant inventory discharged to this site was not documented, but the maximum dose rate of 45 rad/h at 5 cm (2 in.) is comparable to the 11.5 rad/h at a distance of 7.6 cm (3 in.) measured at UPR-200-W-19.. However, because surface contamination has been documented by soil sampling at UPR-200-W-19, and the release occurred from a high-risk site, it is believed that the representative site would bound the analogous site in terms of risk; (4) *Depth of waste discharge:* The 200-W-8 Burial Ground site consisted of a shallow trench that is believed to have been backfilled, and therefore the release depth of the contamination is similar to UPR-200-W-19; (5) *Expected distribution of contaminants:* The contaminant distribution at 200-W-8 Burial Ground is expected to be near the surface, because only solid waste was released at this site. Because contamination at the 200-W-8 Burial Ground is believed to have been cleaned up, UPR-200-W-19 would bound the 200-W-8 Burial Ground in terms of contaminant distribution; (6) *Potential for hydrologic and contaminant impacts to groundwater:* It is hypothesized that the potential for contaminant impacts on groundwater is low for the 200-W-8 Burial Ground because no liquid was discharged at this site.

Table 2-7. Unplanned Release UPR-200-W-19 and Associated Analogous Waste Sites. (11 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Current Waste Site Cover/Vegetation	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)	Co-60 (Ci)	CCl_4 (kg)	Ferro-Cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
Unplanned Release Group analogous sites to be evaluated using the UPR-200-W-19 model																			
UPR-200-W-118	UPR-200-W-118 was located on the railroad spur northwest of the 221-U Facility, adjacent to the 211-U Chemical Tank Farm. The release site consisted of the ground outside the concrete unloading station at the 211-U Tank Farm. The unplanned release site is no longer marked or posted. The contaminated railroad spur was given an unplanned release number in September 1980. A site visit by WIDS personnel indicates that in 1981 the area was posted as a Surface Contamination Area. When radiation surveys in 1982 did not find any significant contamination, the area was released from radiological controls. Although the railcar loading platform was no longer being used, residual contaminated acid in the pump pit and acid lines caused a spread of low-level contamination. The area was posted as a Contamination Area again in the early 1990s.	Gravel	This contaminated area was the result of drips and spills from the reclaimed nitric acid unloading station at the 211-U Chemical Tank Farm. Wind-borne particulate matter spread to the ground surface outside the concrete unloading station, contaminating approximately 0.4 hectare (1 acre) of ground. The Uranium Recovery Process at the 224-U Building received uranyl nitrate from the REDOX and PUREX Plants (S Plant and A Plant, respectively). After the uranium was removed, the reclaimed nitric acid was transferred from the 224-U Building to the 211-UA Building via overhead lines and was stored in the 211-UA tanks. In the 1960s and 1970s, the slightly radioactive nitric acid was recycled back to the REDOX and PUREX Plants. It was pumped out of the 211-UA tanks into railcars via underground lines and a pump pit and was returned to the separations facilities. Some leakage was associated with the pumping process and caused low-level radioactive contamination around the area. The area around the 211-U tanks and railroad spur has been stabilized with gravel and is posted as an Underground Radioactive Material Area.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	This site is considered to be similar to and bounded by the representative site based on the following criteria: (1) *Waste site configuration and construction:* The representative site and the analogous site in this grouping are unplanned releases expected to be limited to surface soils within 3 m (10 ft) of the ground surface based on the nature of the releases; (2) *Volume of effluent received in relation to the available pore volume:* This criterion is not applicable, because the volume of liquid discharged is not known; (3) *Contaminant inventory:* The contaminant inventory discharged to this site was not documented. However, because surface contamination has been documented at UPR-200-W-19, and the release occurred from a high risk site, it is believed that the representative site would bound the analogous site in terms of risk; (4) *Depth of waste discharge:* Both the representative site UPR-200-W-19 and the analogous site UPR-200-W-118 were releases to surface soil and therefore have similar release depths; (5) *Expected distribution of contaminants:* Because the release depths are similar, it is anticipated that contaminant distributions at the representative site and the analogous site would be similar. Because surface contamination has been documented and characterized at UPR-200-W-19, and the release occurred from a high-risk waste site, it is believed that the representative site would bound the analogous site in terms of risk; (6) *Potential for hydrologic and contaminant impacts to groundwater:* It is hypothesized that the potential for contaminant impacts on groundwater is low for these sites because of the shallow nature of the representative and analogous sites.

Table 2-7. Unplanned Release UPR-200-W-19 and Associated Analogous Waste Sites. (11 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Current Waste Site Cover/Vegetation	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)	Co-60 (Ci)	CCl_4 (kg)	Ferro-Cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
Shallow/Surface Waste Site Group analogous sites to be evaluated using the UPR-200-W-19 model																			
UPR-200-W-33	The site is located approximately 27 m (90 ft) east of the 224-U Building. The site is no longer marked or posted. In March 1955, a leaking flange of the C-5 Condensate Line from the 224-U Building caused a small area of the ground to become contaminated.	Gravel and/or asphalt	The release is associated with the Uranium Recovery Process at the 224-U Building. The original documentation stated that the ground contamination was "three feet square." This has been interpreted to mean 3 ft on each side. The radiation zone surrounding the contamination measured 10 by 15 ft. In 1955, the top 4 in. of contaminated soil was removed and new soil was used to fill the excavation. The site was removed from radiation zone status in 1970.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	This site is considered to be similar to and bounded by the representative site based on the following criteria: (1) *Waste site configuration and construction:* This site is an unplanned release of liquid waste to surface soil, similar to UPR-200-W-19, and therefore has no structure associated with it; (2) *Volume of effluent received in relation to the available pore volume:* This criterion is not applicable, because the volume of effluent discharged to UPR-200-W-33 is not known; (3) *Contaminant inventory:* The contaminant inventory at UPR-200-W-33 was not documented. However, because UPR-200-W-33 was a small release compared to UPR-200-W-19, it is believed that the representative site would bound the analogous sites in terms of risk; (4) *Depth of waste discharge:* UPR-200-W-33 was an unplanned release to surface soil and therefore similar to UPR-200-W-19 in terms of discharge depth; (5) *Expected distribution of contaminants:* Contaminant distribution from UPR-200-W-33 is believed to be limited to surface soils within 1 m (3 ft) of the ground surface, because the release was small and was cleaned up. Because the release depths are similar, and the effluent volume and contaminant inventory of UPR-200-W-19 is significantly higher, the representative site bounds this site; (6) *Potential for hydrologic and contaminant impacts to groundwater:* It is hypothesized that the potential for contaminant impacts on groundwater is low for these sites because of the shallow nature of the representative and analogous sites.
UPR-200-W-48	The site is located west of the 221-U Facility, at the west end of the 221-U Facility railroad cut at Bridgeport Avenue. The site is not posted or marked. On July 8, 1958, a survey of the railroad area revealed a spread of contamination in the vicinity of the road intersection with the railroad.	Gravel	On July 8, 1958, the unplanned release occurred when a jumper, wrapped in plastic, was transferred from a flat-bed truck to a railroad flat-car at the railroad crossing. The jumper was transferred to the truck and moved into the 221-U Railroad Tunnel. The contamination spread was caused by damage to the plastic wrapping during transfer. At the time of the release, dose rates of 9 rad/h were recorded over an area of about 93 m^2 (1,000 ft^2). A patch of gravel at the site may be part of the stabilization effort.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	This site is considered to be similar to and bounded by the representative site based on the following criteria: (1) *Waste site configuration and construction:* This site is an unplanned release of liquid waste to surface soil, similar to UPR-200-W-19, and therefore has no structure associated with it; (2) *Volume of effluent received in relation to the available pore volume:* This criterion is not applicable, because the UPR-200-W-48 effluent volume discharged is unknown; (3) *Contaminant inventory:* The contaminant inventory at UPR-200-W-48 was not documented, but the maximum dose rate of 9 rad/h is comparable to the 11.5 rad/h at a distance of 7.6 cm (3 in.) measured at UPR-200-W-19. However, because UPR-200-W-48 was a small release compared to UPR-200-W-19, it is believed that the representative site would bound the analogous sites in terms of contaminant inventory; (4) *Depth of waste discharge:* UPR-200-W-48 was an unplanned release to surface soil and therefore similar to UPR-200-W-19 in terms of discharge depth; (5) *Expected distribution of contaminants:* Contaminant distribution from UPR-200-W-48 is believed to be limited to surface soils within 1 m (3 ft) of the ground surface, because the release was small. Because the release depths are similar, and the effluent volume and contaminant inventory of UPR-200-W-19 is significantly higher, the representative site bounds this site; (6) *Potential for hydrologic and contaminant impacts to groundwater:* It is hypothesized that the potential for contaminant impacts on groundwater is low for these sites, because of the shallow nature of the representative and analogous sites.

Table 2-7. Unplanned Release UPR-200-W-19 and Associated Analogous Waste Sites. (11 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Current Waste Site Cover/Vegetation	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)	Co-60 (Ci)	CCl_4 (kg)	Ferro-Cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
UPR-200-W-55	The site is located adjacent to the 224-U Building loading ramp. The site is an unplanned release and is no longer marked or posted.	Unknown	In April 1960, 1.5 tons of uranium oxide powder spilled on the asphalt loading ramp when a loading hose broke. This resulted in contamination of the 224-U Building asphalt loading ramp and a nearby roadway. Following the incident, most of the powder was swept up and recovered, the remainder was washed off the asphalt, and it soaked into the adjacent ground surface.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	This site is considered to be similar to and bounded by the representative site based on the following criteria: (1) *Waste site configuration and construction:* This site is an unplanned release to the surface, similar to UPR-200-W-19, and therefore has no structure associated with it; (2) *Volume of effluent received in relation to the available pore volume:* This criterion is not applicable, because the volume of water used to wash off the asphalt is unknown; (3) *Contaminant inventory:* The contaminant inventory at UPR-200-W-55 was not documented. However, because most of the uranium oxide powder was swept up and recovered from UPR-200-W-55, and only a small release would remain, it is believed that UPR-200-W-19 would bound this site in terms of contaminant inventory; (4) *Depth of waste discharge:* UPR-200-W-55 was an unplanned release at the surface and therefore similar to UPR-200-W-19 in terms of discharge depth; (5) *Expected distribution of contaminants:* Contaminant distribution from UPR-200-W-55 is believed to be limited to surface soils within 1 m (3 ft) of the ground surface, because the release was small. Because the release depths are similar, and the effluent volume and contaminant inventory of UPR-200-W-19 are significantly higher, the representative site bounds this site; (6) *Potential for hydrologic and contaminant impacts to groundwater:* It is hypothesized that the potential for contaminant impacts on groundwater is low for these sites because of the shallow nature of the representative and analogous sites.
200-W-77	The site is located adjacent to the railroad track, west of the 216-U-16 Crib, and east of the stabilized 216-U-14 Ditch.	Gravel, some rabbit brush, tumble weed, and cheat grass	The site was submitted to WIDS in 1997 after the area was found to contain blown-in contaminated vegetation that had accumulated along the bank of the railroad track. The area is downwind of the 216-U-14 Ditch, which was being surface stabilized at the time. The 216-U-14 Ditch was a known source for contaminated vegetation at the time. The small contamination area originally was posted as a High Contamination Area. In 2000, soil and vegetation with contamination levels up to 10,000 counts per minute were removed from the area and the area was reposted as a Contamination Area. After the contaminated vegetation was removed, contamination up to 100 counts per second was reported. The site is currently a posted Contamination Area that measures 2 by 5 m (8 by 15 ft) and has been backfilled with gravel.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	This site is considered to be similar to and bounded by the representative site based on the following criteria: (1) *Waste site configuration and construction:* This site is an unplanned release to surface soil, similar to UPR-200-W-19, and therefore has no structure associated with it. (2) *Volume of effluent received in relation to the available pore volume:* This criterion is not applicable, because UPR-200-W-77 was believed to have been caused by windblown vegetation that was contaminated, and therefore had no liquid effluent. (3) *Contaminant inventory:* The contaminant inventory at UPR-200-W-77 was not documented. However, because UPR-200-W-77 was a small release, it is believed that the UPR-200-W-19 would bound this site in terms of contaminant inventory. (4) *Depth of waste discharge:* UPR-200-W-77 was an unplanned release at the surface, and therefore similar to UPR-200-W-19 in terms of discharge depth. (5) *Expected distribution of contaminants:* Contaminant distribution from UPR-200-W-77 is believed to be limited to surface soils within 1 m (3 ft) of the ground surface, because the release was small. Because the release depths are similar, and the effluent volume and contaminant inventory of UPR-200-W-19 is significantly higher, the representative site bounds this site. (6) *Potential for hydrologic and contaminant impacts to groundwater:* It is hypothesized that the potential for contaminant impacts on groundwater is low for these sites because of the shallow nature of the representative and analogous sites.

Table 2-7. Unplanned Release UPR-200-W-19 and Associated Analogous Waste Sites. (11 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Current Waste Site Cover/Vegetation	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)	Co-60 (Ci)	CCl_4 (kg)	Ferro-Cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
UPR-200-W-78	The site is located approximately 37 m (120 ft) south of the 224-U Building at the former Uranium Trioxide barrel storage area. The site is no longer marked or posted.	Gravel and asphalt	The contamination was first discovered in a radiation survey performed with a truck-mounted monitor in 1970. The equipment detected contamination levels up to 20,000 counts per minute in an area of approximately 3.7 m^2 (40 ft^2). The contamination is presumed to have occurred before 1969, when the last pallets were moved from the 224-U Building. Immediately after the contamination was discovered, an operator was dispatched with a shovel and bucket to pick up the contaminated dirt. No other contamination was found.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	This site is considered to be similar to and bounded by the representative site based on the following criteria: (1) *Waste site configuration and construction:* This site is an unplanned release to surface soil, similar to UPR-200-W-19, and therefore has no structure associated with it. (2) *Volume of effluent received in relation to the available pore volume:* This criterion is not applicable, because UPR-200-W-78 was believed to have been caused by a spill of uranium oxide powder, and therefore had no liquid effluent.; (3) *Contaminant inventory:* The contaminant inventory at UPR-200-W-78 was not documented. However, because contaminated soil was removed from UPR-200-W-78, it is believed that UPR-200-W-19 would bound this site in terms of contaminant inventory. (4) *Depth of waste discharge:* UPR-200-W-78 was an unplanned release to surface soil, and therefore similar to UPR-200-W-19 in terms of discharge depth. (5) *Expected distribution of contaminants:* Because contaminant distribution from UPR-200-W-78 is believed to be limited to surface soils within 1 m (3 ft) of the ground surface, and contaminated soil was removed from the site, the representative site bounds this site. (6) *Potential for hydrologic and contaminant impacts to groundwater:* It is hypothesized that the potential for contaminant impacts on groundwater is low for these sites because of the shallow nature of the representative and analogous sites.
200-W-85	The site is located 30 m (100 ft) east of the 2727-WA Sodium Storage Building equipment storage yard.	Gravel and soil	The 6 by 6 m (20 by 20 ft) site was originally posted as a Surface Contamination area. The posting surrounded some growing rabbit brush and grass. No soil discoloration or disturbance is apparent. No radiological survey could be found to determine when the area was posted or what the radiological conditions were inside the posted area. In 2001, the area was covered with clean backfill material and downposted to an Underground Radioactive Material Area. The area was covered with clean backfill to an unknown thickness.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	This site is considered to be similar to and bounded by the representative site based on the following criteria: (1) *Waste site configuration and construction:* This site is an unplanned release to surface soil, similar to UPR-200-W-19, and therefore has no structure associated with it. (2) *Volume of effluent received in relation to the available pore volume:* This criterion cannot be evaluated, because the exact source of UPR-200-W-85 is not known. (3) *Contaminant inventory:* The contaminant inventory at UPR-200-W-85 was not documented; however, because this site is a small release, it is believed that the UPR-200-W-19 would bound this site in terms of contaminant inventory. (4) *Depth of waste discharge:* UPR-200-W-85 was an unplanned release to surface soil, and therefore similar to UPR-200-W-19 in terms of discharge depth. (5) *Expected distribution of contaminants:* Contaminant distribution from UPR-200-W-85 is believed to be limited to surface soils within 1 m (3 ft) of the ground surface and, because the release is small, the representative site bounds this site. (6) *Potential for hydrologic and contaminant impacts to groundwater:* It is hypothesized that the potential for contaminant impacts on groundwater is low for these sites because of the shallow nature of the representative and analogous sites.

Table 2-7. Unplanned Release UPR-200-W-19 and Associated Analogous Waste Sites. (11 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Current Waste Site Cover/Vegetation	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)	Co-60 (Ci)	CCl_4 (kg)	Ferro-Cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
200-W-87	The site is located adjacent to the railroad track, 61 m (200 ft) northwest of the 2714-U Building and T-Hopper yard on the U Plant chemical spur railroad track west of the 216-U-16 Crib and east of the stabilized 216-U-14 Ditch.	Gravel and soil	The site was originally a posted Contamination Area on a portion of the railroad spur. The site was discovered and submitted to WIDS as a discovery site in 2000. At that time, no radiological survey could be located to explain why the area was posted or what the radiological conditions were inside the posted area. Research performed by WIDS indicates that originally the site may have been posted because of the presence of a potentially contaminated train on the siding from 1996 to 1998. Tests on the train indicated that it had no smearable contamination. In 1998, the train was removed and the Contamination Area posting may have remained in place. The area was covered with clean backfill and downposted to an Underground Radioactive Material Area in 2001. The site was covered with clean backfill to an unknown depth.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	This site is considered to be similar to and bounded by the representative site based on the following criteria: (1) *Waste site configuration and construction:* This site is a potential unplanned release to surface soil associated with a potentially contaminated train; similar to UPR-200-W-19 and, therefore, has no structure associated with it. (2) *Volume of effluent received in relation to the available pore volume:* This criterion cannot be evaluated, because it is unknown if any waste was released. (3) *Contaminant inventory:* This criterion cannot be evaluated, because it is unknown if any waste was released. (4) *Depth of waste discharge:* If any releases had occurred from UPR-200-W-87 they would have been to surface soil and therefore similar to UPR-200-W-19 in terms of discharge depth. (5) *Expected distribution of contaminants:* This criterion cannot be evaluated, because it is unknown if any waste was released. (6) *Potential for hydrologic and contaminant impacts to groundwater:* This criterion cannot be evaluated, because it is unknown if any waste was released.
200-W-89	The site is located near the intersection of Beloit Avenue and 16th Street in the 200 West Area, east of the 224-U Building. The site is a posted Underground Radioactive Material Area where the 252-U Electrical Substation had been located. A large electrical transformer, surrounded with radioactive material signs, is located near the center of the Underground Radioactive Material Area. All aboveground structures, with the exception of one transformer, were demolished and disposed of.	Gravel	The 252-U Electrical Substation was decommissioned and demolished in 1998. The large transformer was left in place because it was too costly to move. The area was stabilized with gravel in 1999 and posted as an Underground Radioactive Material Area. Before decommissioning, readings of 5,000 d/min beta/gamma and 3,500 d/min alpha were reported for equipment associated with the substation. After decommission, maximum readings of 700 counts per minute were reported for the remaining gear and the soil. It is believed that the site became contaminated over time from emissions from the 291-U Stack. No polychlorinated biphenyls were identified at the site. The area was stabilized with gravel to an unknown depth in 1999.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	This site is considered to be similar to and bounded by the representative site based on the following criteria: (1) *Waste site configuration and construction:* This site is an unplanned release to surface soil, similar to UPR-200-W-19. A concrete foundation is associated with this site. (2) *Volume of effluent received in relation to the available pore volume:* This criterion would not be applicable, because the release is associated with the release of contaminated particles. (3) *Contaminant inventory:* This criterion cannot be evaluated, because the exact source of UPR-200-W-89 is not known. (4) *Depth of waste discharge:* UPR-200-W-89 was an unplanned release at the surface and therefore similar to UPR-200-W-19 in terms of discharge depth. (5) *Expected distribution of contaminants:* Contaminant distribution from UPR-200-W-89 is believed to be limited to surface soils within 1 m (3 ft) of the ground surface, because the release was small and may have been caused by emissions from the 291-U-1 Stack. Because the release depths are similar, the representative site bounds this site. (6) *Potential for hydrologic and contaminant impacts to groundwater:* It is hypothesized that the potential for contaminant impacts on groundwater is low for these sites because of the shallow nature of the representative and analogous sites.

Table 2-7. Unplanned Release UPR-200-W-19 and Associated Analogous Waste Sites. (11 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Current Waste Site Cover/ Vegetation	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)	Co-60 (Ci)	CCl_4 (kg)	Ferro-Cyanide (kg)	Hexone (kg)	Nitrate (kg)	NPH (kg)	$Na_2Cr_2O_7$ (kg)	TBP (kg)			
UPR-200-W-117	The release site was the ground around the railroad cut northwest of the 221-U Facility.	Gravel	In 2000, a posted Surface Contamination area was located on the railroad spur leading to the 221-U railroad cut and tunnel. Most of the posted area is railroad track on a bed of gravel. There is an unusual patch of asphalt across a portion of the railroad track, inside the posted Surface Contamination area. The original unplanned release had been posted with Surface Contamination signs in 1980. This was released from posting in 1983. Later the area extending from the tunnel door to a point 55 m (180 ft) down the track was posted as a Contamination Area. The source of the contamination is believed to be liquid and particulate matter that dropped from railroad cars moving equipment in and out of the 221-U Facility over time. In 2001, the site was graded and covered with 0.3 m (1 ft) of clean gravel and downposted to an Underground Radioactive Material Area.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	This site is considered to be similar to and bounded by the representative site based on the following criteria: (1) *Waste site configuration and construction:* This site is an unplanned release of liquid and particulate waste to surface soil, similar to UPR-200-W-19, and therefore has no structure associated with it; (2) *Volume of effluent received in relation to the available pore volume:* This criterion is not applicable, because UPR-200-W-117 and the representative site UPR-200-W-19 had relatively low volumes of effluent discharged to them; (3) *Contaminant inventory:* This criterion cannot be compared directly, because the contaminant inventory at UPR-200-W-117 was not documented. However, because UPR-200-W-117 was a widely spread release compared to UPR-200-W-19, it is believed that the representative site would bound the analogous sites in terms of risk; (4) *Depth of waste discharge:* UPR-200-W-117 was an unplanned release to surface soil and therefore is similar to UPR-200-W-19 in terms of discharge depth; (5) *Expected distribution of contaminants:* Contaminant distribution from UPR-200-W-117 is believed to be limited to surface soils within 1 m (3 ft) of the ground surface, because the release was spread over a large area. Because the release depths are similar, and the effluent volume and contaminant inventory per unit area of UPR-200-W-19 is believed to be significantly higher, the representative site bounds this site. Both UPR-200-W-117 and UPR-200-W-19 are believed to have had contamination spread laterally through windblown vegetation and soil; (6) *Potential for hydrologic and contaminant impacts to groundwater:* It is hypothesized that the potential for contaminant impacts on groundwater is low for these sites because of the shallow nature of the representative and analogous sites.
UPR-200-W-60	Spotty contamination extended from the 221-U Tunnel door along the railroad tracks for a distance of 69 m (225 ft). This unplanned release is located in the UPR-200-W-117 unplanned release site.	Gravel	In 1966, contaminated water dripped from a hole in the bottom of a purex equipment transfer box as the box was being pulled from the 221-U Facility tunnel. Radioactivity along the tracks ranged from a few thousand counts per minute up to 1 rad/h. In 1966, the contamination was isolated and cleaned. This site is contiguous with a later unplanned release (UPR-200-W-117). The site was backfilled with gravel to a depth of 0.3 m (1 ft) as part of the remediation of UPR-200-W-117 in 2001.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	This site is associated with UPR-200-W-117; see description above.

- = not detected or not analyzed.
NPH = normal paraffin hydrocarbon.
PUREX = Plutonium-Uranium Extraction (Plant or process).
RCRA = *Resource Conservation and Recovery Act of 1976.*
REDOX = Reduction-Oxidation (Plant or process).
TBP = tributyl phosphate.
VCP = vitrified clay pipeline.
WAC = *Washington Administrative Code.*
WIDS = *Waste Information Data System.*
WAC 246-272-18501, "On-Site Sewage Systems," "Abandonment."
Waste Information Data System, Hanford Site database.

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

Risk Element	216-U-8 Crib	216-U-12 Crib	216-U-4 Reverse Well/ 216-U-4A French Drain	UPR-200-W-19	216-U-1 and 216-U-2 Cribs	200-W-42 VCP and UPR-200-W-163
Does the Site meet Human Health PRGs - Chemicals?						
Do the concentrations meet WAC 173-340-745(5) Method C	Yes	Yes	Yes	Yes	Yes	Yes
Does the Site meet Human Health PRGs - Radionuclides? Assumes that No Credit is Taken for the Protectiveness of the Existing Cover.						
Dose at 0 years (mrem/yr)	262	None	108	163	157	24800
Radionuclides that contribute dose, 0 years	Cs-137	None	Cs-137	Cs-137	Cs-137	Cs-137
Dose at 50 years (mrem/yr)	82.8	None	37.1	51.5	49.6	7820
Radionuclides that contribute dose, 50 years	Cs-137	None	Cs-137	Cs-137	Cs-137	Cs-137
Dose at 150 years (mrem/yr)	8.44	None	7.5	5.19	5.00	799
Radionuclides that contribute dose, 150 years	Cs-137	None	Cs-137	Cs-137	Cs-137	Cs-137
Years to reach 15 mrem	141	None	125	129	128	831
Does the Site meet Groundwater Protection PRGs[a] – Chemicals?						
Are groundwater protection standards met based on initial screening?	No	No	No	No	No	No
Contaminants modeled based on initial screen	Antimony Nitrate N as nitrate and nitrite Uranium	Arsenic N as nitrate and nitrite Uranium	Mercury Uranium	Antimony	Antimony Uranium	Arsenic N as nitrate and nitrite Uranium
Vadose zone modeling results	N as nitrate and nitrite peaks at > 1000 years Uranium peaks at > 1000 years Nitrate does not exceed the PRG. Antimony does not reach groundwater.	N as nitrate and nitrite peaks at year 2027 Uranium does not exceed PRG. Arsenic does not reach groundwater.	Uranium peaks at > 1000 years. Mercury does not reach groundwater	Antimony does not exceed the PRG based on 216-U-1 and 216-U-2 Crib results.	Uranium peaks at > 1000 years Antimony does not reach groundwater	N as nitrate and nitrite and Uranium do not exceed PRG. Arsenic does not reach groundwater.
Predicted to exceed standard (calendar years)	N as nitrate and nitrite during years 2920 - 3400 Uranium during years 2450 - >12002	N as nitrate and nitrite during years 2017 - > 3000	Uranium during years 7100 - 12002	No	Uranium during years 3400 - > 12002	No
Does the site meet groundwater protection PRGs[a]	No	No	Yes	Yes	Yes	Yes
What constituents exceed?	N as nitrate and nitrite Uranium	N as nitrate and nitrite	None	None	None	None

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

Risk Element	216-U-8 Crib	216-U-12 Crib	216-U-4 Reverse Well/ 216-U-4A French Drain	UPR-200-W-19	216-U-1 and 216-U-2 Cribs	200-W-42 VCP and UPR-200-W-163
Does the Site meet Groundwater Protection PRGs[a] – Radionuclides?						
Are groundwater protection standards met based on initial screening?	No	Yes	Yes	Yes	No	Yes
Contaminants modeled based on initial screen	Tc-99	None	None	None	Tc-99	None
Vadose zone modeling results	Tc-99 does not exceed the PRG.	None	None	None	Tc-99 peaks at year 3000	None
Predicted to exceed standard (calendar years)	No	No	No	No	Tc-99 during years 2670 – 3850	No
Does the site meet groundwater protection PRGs[a]	Yes	Yes	Yes	Yes	No	Yes
Which constituents exceed?	None	None	None	None	Tc-99	None
Does the Site meet Ecological PRGs – Chemicals?						
Do the concentrations meet ecological PRGs?	Yes	Yes	Yes	Yes	Yes	Yes
Does the Site meet Ecological PRGS - Radionuclides?						
Do the concentrations meet ecological PRGs?	Yes	Yes	Yes	Yes	Yes	No
Constituents that exceed PRGs	None	None	None	None	None	Cs-137

NOTE: This table presents a summary of the constituents identified as primary risk contributors in Appendix C and the constituents identified as a potential groundwater protection concern as discussed in Appendix D.

[a] groundwater protection is evaluated first by screening against the PRGs calculated based on WAC 173-340-747(4) followed by an evaluation of the listed constituents using an alternate fate and transport model in accordance with WAC 173-340-747(8). This process is documented in Appendix C and D.

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," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-340-747(8), "Deriving Soil Concentrations for Ground Water Protection," "Overview of Methods," "Alternative Fate and Transport Models," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

HI = hazard index.
HQ = hazard quotient.
PRG = preliminary remediation goal.
RAO = remedial action objective.

CHAPTER 3.0

DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIATION GOALS

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CONTENTS

3.0 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIATION GOALS 3-1
3.1 LAND USE 3-1
3.1.1 Current Land Use 3-1
3.1.2 Anticipated Future Land Use 3-2
3.1.3 Regional Land Use 3-5
3.1.4 Groundwater Use 3-5
3.2 CONTAMINANTS OF POTENTIAL CONCERN AND CONTAMINANTS OF CONCERN 3-6
3.3 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS 3-6
3.4 REMEDIAL ACTION OBJECTIVES 3-6
3.5 PRELIMINARY REMEDIATION GOALS 3-9
3.5.1 Direct Exposure Preliminary Remediation Goals for Nonradioactive Contaminants 3-10
3.5.2 Direct Exposure Remediation Goals for Radionuclides 3-11
3.5.3 Remediation Goals for the Protection of Groundwater 3-13
3.6 REFERENCES 3-15

TABLES

Table 3-1. Summary of Nonradionuclide Soil Preliminary Remediation Goals for All Pathways 3-19

Table 3-2. Summary of Radionuclide Preliminary Remediation Goals for All Pathways. 3-23

TERMS

ARAR	applicable or relevant and appropriate requirement
BCG	biota concentration guide
BDAC	Biota Dose Assessment Committee
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CLARC	cleanup levels and risk calculations, see Ecology 94-145
COC	contaminant of concern
COPC	contaminant of potential concern
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
FFS	focused feasibility study
GRA	general response action
HAB	Hanford Advisory Board
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
Implementation Plan	*200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program.*, DOE/RL-98-28
LFI	limited field investigation
MCL	maximum contaminant level
NA	not applicable
NCP	"National Oil and Hazardous Substances Pollution Contingency Plan" (40 CFR 300)
NEPA	*National Environmental Policy Act of 1969*
NBS	National Bureau of Standards
OU	operable unit
PRG	preliminary remediation goal
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
RDL	required detection limit
RESRAD	RESidual RADioactivity (code)
ROD	record of decision
STOMP	Subsurface Transport Over Multiple Phases (code)
TSD	treatment, storage, and disposal (unit)

3.0 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIATION GOALS

This chapter defines the land use within the 200-UW-1 Operable Unit (OU) and the region and defines the remedial action objectives (RAO) and preliminary remediation goals (PRG). DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (Implementation Plan) and DOE/RL-95-13, *Limited Field Investigation for the 200-UP-2 Operable Unit* (LFI report) provide initial information on these items for the 200 Areas waste sites. For this focused feasibility study (FFS), the Implementation Plan information was compared to the data collected during the LFI, and refinements were made as appropriate for the waste sites.

The RAOs are media-specific or OU-specific objectives for protecting human health and the environment. They are developed considering the land use, contaminants of potential concern (COPC), potential applicable or relevant and appropriate requirements (ARAR), and exposure pathways (site conceptual model). They also specify remediation goals so that an appropriate range of remedial options can be developed for evaluation. This chapter describes the elements used to develop the RAOs and presents the RAOs and remediation goals used to evaluate the alternatives.

The RAO process begins by identifying potential future land use and the COPCs for the facility. This information ensures that the remedial alternatives being considered can address adequately the types of contaminants present, and it facilitates the refinement of potential ARARs. The RAOs also provide the basis for developing the general response actions (GRA) that will satisfy the objectives of protecting human health and the environment. The RAOs are defined as specifically as possible without limiting the range of GRAs that can be applied.

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 the plutonium production reactors in the 100 Areas. Most of the facilities directly associated with fuel reprocessing are now inactive and awaiting final disposition. The Plutonium Finishing Plant continues to operate to process a residual backlog of plutonium. Several waste management facilities operate in the 200 Areas, including permanent waste disposal facilities such as the Environmental Restoration Disposal Facility (ERDF), low-level radioactive waste burial grounds, and a *Resource Conservation and Recovery Act of 1976* (RCRA)-permitted, mixed-waste trench. Construction of tank waste treatment facilities in the 200 Areas began in 2002, and the 200 East Area is the planned disposal location for the vitrified low-activity tank

wastes. Past-practice disposal sites in the 200 Areas are being evaluated for remediation, which may include institutional controls (e.g., deed restrictions, covenants) as part of the selected remedy. Other Federal agencies, such as the U.S. Department of the Navy, use the Hanford Site 200 East Area treatment, storage, and disposal (TSD) facilities. In addition, a commercial low-level radioactive waste disposal facility currently is operated by US Ecology, Inc., on a 100 acre tract of land at the southeast corner of the 200 East Area that is leased to the State of Washington.

The U.S. Department of Energy (DOE)-selected land use for the Central Plateau, is documented in the land-use record of decision (ROD) (64 FR 61615, "Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement (HCP EIS)"). Per the ROD, industrial (exclusive) land use is expected to continue for sites located within the exclusive-use boundary (core zone) for the next 50 years.

According to DOE/EIS-0222-F, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*, 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 Low-Level Radioactive Waste Compact could continue using the US Ecology site for commercial radioactive waste. Research supporting the dangerous waste, radioactive waste, and mixed-waste TSD 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 is continued industrial (exclusive) activities for the foreseeable future. The DOE worked for several years with cooperating agencies and stakeholders to define land-use goals for the Hanford Site and develop future land-use plans (Drummond 1992, *The Future for Hanford: Uses and Cleanup, The Final Report of the Hanford Future Site Uses Working Group)*. The cooperating agencies and stakeholders included the National Park Service, Tribal Nations, states of Washington and Oregon, local county and city governments, economic and business development interests, environmental groups, and agricultural interests. These efforts initially were reported by Drummond (1992) and culminated in DOE/EIS-0222-F and the associated ROD (64 FR 61615), which were issued in 1999.

The Future Site Uses Working Group was organized by Federal, Tribal, state, and local governments with jurisdictional interests in the Hanford Site. The Working Group was charged with three related tasks:

- Examine the Hanford Site and identify a range of potential future uses for the Site
- Select appropriate cleanup scenarios necessary to make these future uses possible in light of potential exposure to contamination, if any, after cleanup

- Look for convergences among the Working Group's cleanup scenarios for any priorities or criteria that could prove useful in focusing or conducting the cleanup of the Hanford Site.

DOE/EIS-0222-F was written to address the growing need for a comprehensive, long-term approach to planning and development on the Hanford Site because of the DOE's separate missions of environmental restoration, waste management, and science and technology. DOE/EIS-0222-F analyzes the potential environmental impacts of alternative land-use plans for the Hanford Site and considers the land-use implication of ongoing and proposed activities. In DOE/EIS-0222-F, the land-use designation for sites inside the core zone is industrial (exclusive): Areas suitable and desirable for the TSD of hazardous, dangerous, radioactive, and nonradioactive wastes and related activities.

Under the preferred land-use alternative selected in the ROD (64 FR 61615), the area inside the core zone of the Central Plateau was designated for industrial (exclusive) use. The current vision for all of the 200 Areas is that it will continue to be used for the TSD of hazardous, dangerous, radioactive, and nonradioactive wastes. DOE/EIS-0222-F and the 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 to support industrial land uses, lease facilities for waste disposal (e.g., US Ecology), and demolish facilities that have no further beneficial use.

Following the issue of this ROD, the Hanford Advisory Board (HAB) provided advice to the Tri-Parties regarding the land use and associated exposure scenarios associated with the Central Plateau (HAB 132, "Exposure Scenarios Task Force on the 200 Area"). http://www.hanford.gov/public/boards/hab/advice/habadv-132.pdf). The HAB acknowledged that some waste will remain in the core zone when cleanup of the Central Plateau is completed and advised that the core zone be as small as possible. The Tri-Parties responded to this advice (Klein et al. 2002, "Consensus Advice #132: Exposure Scenarios Task Force on the 200 Area," 02-HAB-0006, http://www.hanford.gov/public/boards/hab/advice/habresp-132.pdf), presenting the risk framework as an attachment for future planning. The risk framework includes the following seven items:

1. "The core zone (200 Areas including B Pond (main pond), and S Ponds) will have an Industrial Scenario for the foreseeable future.

2. "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 the wastes left in place for the 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.

3. "DOE will follow the required regulatory processes for groundwater remediation (including public participation) to establish the points of compliance and remedial

action objectives. 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 iodine-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 be restored to drinking water levels outside the core zone.

4. "No drilling for water use or otherwise will be allowed in the core zone. An intruder scenario will be calculated for in assessing the risk to human health and environment.

5. "Waste Sites outside the core zone but within the Central Plateau (200 N, 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.

6. "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.

7. "The framework does not deal with the tank retrieval decision."

Based on this documentation and current Central Plateau assumptions, the alternative evaluations considered the following anticipated land-use requirements.

- The core zone will have an industrial scenario for the foreseeable future. This evaluation considers the following uses:
  - Industrial-exclusive use for the next 50 yr (through 2050)
  - Industrial land use (non-DOE worker) for 100 yr after 2050 (through 2150)
  - Industrial land use post – 150 years.
- Groundwater contamination under the core zone will preclude beneficial use for the foreseeable future. This evaluation considers the following:
  - No consumptive use of groundwater for the next 150 yr, based on the expected period of waste management
  - Any selected remedy will provide for no further degradation of groundwater from the 200-UW-1 OU waste sites

- No drilling for water or other purposes will be allowed in the core zone, except as part of a U.S. Environmental Protection Agency (EPA)/Washington State Department of Ecology-approved monitoring or cleanup plan.

In addition, risks were calculated considering the possibility of intruders 150 yr from now (2150), based on the assumption that active institutional controls no longer would be in place.

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, as well as surrounding 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

DOE/EIS-0222-F indicates that contamination in the groundwater would restrict use. Groundwater in the Central Plateau currently is contaminated and is not withdrawn for beneficial uses. Water beneath the core zone is expected to be unsuitable for beneficial uses for the next 150 years as the core zone facilities are decommissioned and institutional controls are maintained. Additionally, it is assumed that the tritium and I-129 plumes beyond the core zone boundary will exceed the drinking water standards for the period from 150 to 300 years into the future. As a result, groundwater in the Central Plateau is not expected to be suitable for beneficial uses for the next 300 years.

This FFS evaluates potential future impacts to groundwater from current vadose zone contaminants at the representative sites, but does not evaluate groundwater remediation or risks. These issues will be addressed through the evaluation of the groundwater OUs (e.g., 200-UP-1 Groundwater OU) and through other sitewide assessments.

3.2 CONTAMINANTS OF POTENTIAL CONCERN AND CONTAMINANTS OF CONCERN

Contaminants that have the potential to contribute to site risk are referred to as COPCs. Identification of COPCs is an important process, because it determines the list of chemicals for which further risk evaluations will be developed. Development of COPCs in the data evaluation and risk assessment process is based on EPA/540/1-89/002, *Risk Assessment Guidance for Superfund (RAGS), Volume I -- Human Health Evaluation Manual, (Part A) Interim Final,* OSWER 9285.7-01A. The list of constituents considered as COPCs is determined by comparing contaminant concentrations with screening factors (e.g., background), thereby developing a set of data for use in risk assessment. The evaluation of COPCs is presented in Appendix C, specifically Section C3.2, with a summary provided in Table C-23. This list of COPCs is carried forward and presented in the risk assessment results. This process compares the observed constituent concentrations to the following:

- Radiological dose exposure limits
- WAC 173-340, "Model Toxics Control Act -- Cleanup," cleanup levels.

Only those constituents that exceed one or more of these criteria are retained as contaminants of concern (COC).

3.3 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The potential ARARs for the 200-UW-1 OU are identified in Appendix B.

3.4 REMEDIAL ACTION OBJECTIVES

The RAOs are general descriptions of 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, 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 provide a basis for evaluating the capability of a specific remedial alternative to achieve compliance with potential ARARs and/or an intended level of risk protection for human health or the environment. The preliminary RAOs for the cleanup of the 200 Areas for soil

waste sites were developed in the Implementation Plan (DOE/RL-98-28) and include the following.

- Prevent or mitigate risk to human and ecological receptors associated with ingestion of, dermal contact with, inhalation of, and external exposure to contaminants at levels that exceed ARARs or a risk range of 10^{-4} to 10^{-6}.
- Prevent or mitigate the migration of contaminants to groundwater such that no further degradation occurs and ensure protection of the Columbia River.
- Prevent or mitigate the migration of contaminants to groundwater so that contaminants do not reach levels in groundwater that exceed ARARs or a risk of 10^{-4} to 10^{-6}.
- Prevent plant and animals from creating a migration pathway for the contaminants.
- Prevent or mitigate risk to workers performing remedial action.
- Provide conditions suitable for proposed future land use.
- Prevent destruction of significant cultural resources and sensitive wildlife habitat. Minimize the disruption of cultural resources and wildlife habitat in general, and prevent adverse impacts to cultural resources and threatened or endangered species.

Based on these preliminary RAOs, the following RAOs were developed specific to the 200-UW-1 OU:

- 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).
- RAO 2 – Provide conditions suitable for future industrial land use and protect ecological receptors, respectively, by
  - Preventing exposure to radiological constituents at concentrations that will cause a dose rate limit of 15 mrem/yr above background for industrial workers (OSWER Directive 9200.4-31P, EPA/540/R-99/006, *Radiation Risk Assessment At CERCLA Sites: Q & A*,). A dose rate limit of 15 mrem/yr above background generally achieves the U.S. Environmental Protection Agency (EPA) excess lifetime cancer risk threshold, which ranges from $1x10^{-6}$ to $1x10^{-4}$
  - Protecting 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 TBC criteria), respectively.

- RAO 3[1] – 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," groundwater protection criteria so that no further degradation of the groundwater results from contaminant leaching from the 200-UW-1 OU waste sites.

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

The first RAO addresses protection from nonradionuclide contaminants. The RAO will be satisfied if the following conditions are met:

- Total human health carcinogenic risks calculated using industrial exposure assumptions, in accordance with the equations presented in WAC 173-340-745(5), do not exceed $1x10^{-5}$

- Human health noncarcinogenic hazard indexes, calculated using industrial exposure assumptions and the equations in WAC 173-340-745(5), do not exceed 1

- Soil concentrations of COCs do not exceed applicable thresholds for protection of ecological receptors.

The second RAO addresses protection from radionuclide contaminants. The RAO will be satisfied if the following conditions are met:

- Industrial worker dose rates, caused by exposure to waste or contaminated soil, do not exceed 15 mrem/yr above background

- Terrestrial animal exposure rates do not exceed 0.1 rad/day

- Waste is 15 ft or more below the ground surface.

The third RAO addresses protection of groundwater resources. The RAO will be satisfied if the following conditions are met:

- Soil concentrations are below WAC 173-340-747 groundwater protection methods, or

- The flux of contaminants into groundwater does not cause groundwater concentrations to exceed maximum contaminant levels (MCL) at the point of compliance, or

- The flux of contaminants into groundwater is reduced or eliminated, based on a decreasing trend in the difference between the concentration of contaminants in up-gradient and down-gradient wells.

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[1] Note: Protection of the Columbia River from contaminants in this OU is achieved through RAO 3; there is no surface water in the immediate vicinity of the waste sites that requires a separate RAO.

The fourth RAO addresses protection of cultural resources, wildlife habitat, and threatened or endangered species. The RAO will be satisfied if the following conditions are met:

- RAOs 1, 2, and 3 are met.
- Cultural and ecological reviews are performed to evaluate the construction area for potential impacts (e.g., bird nesting grounds), and appropriate mitigative measures are implemented.

3.5 PRELIMINARY REMEDIATION GOALS

The PRGs are a numerical expression of the RAOs, based on attainment of acceptable levels of human health and ecological risk. For the 200-UW-1 OU, the PRGs are identified for individual hazardous substances identified as COCs as well as for the COPCs. 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 will be evaluated based on site-specific information and the potential for contaminant interaction.

These numeric soil PRGs were developed independently for the protection of human health, the protection of ecological receptors, and the protection of groundwater. 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[2] (RDL). If the lowest of the PRGs is lower than background concentrations or the RDL, then background concentrations or the RDL, whichever is higher, becomes the PRG per 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 COPCs evaluated and the COCs retained.

Meeting these PRGs and the potential ARARs and, by extension, achieving RAOs, can be accomplished by reducing concentrations (or activities) of contaminants to remediation goal levels or by eliminating potential exposure pathways/routes. Contaminant-specific and numeric soil and particulate PRGs for direct exposure and protection of groundwater typically are presented as concentrations (milligrams per kilogram or milligrams per cubic meter) or activities (picocuries per gram), respectively. Final remedial action goals developed from the PRGs will be specified in a ROD that identifies the selected remedial alternative for the 200-UW-1 OU waste sites.

Residual risks following completion of remediation of the waste sites must meet the RAOs. Documentation of actual soil contaminant concentrations achieving cleanup objectives would be presented in a cleanup verification package for the 200-UW-1 OU. The cleanup verification package would describe the remediation activities completed, identify any significant

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[2] The RDL is based on current approved laboratory contractor RDLs. The RDL is consistent with practical quantitation limits defined in WAC 173-340-200, "Definitions." The RDL is used because it is the contractual defined criterion.

contamination remaining, summarize the sampling and data analysis approach, and demonstrate attainment of cleanup levels.

3.5.1 Direct Exposure Preliminary Remediation Goals for Nonradioactive Contaminants

Numeric PRGs, expressed in terms of concentration (e.g., milligram per kilogram), were developed for each of the 200-UW-1 OU nonradionuclide constituents using the latest version (February 12, 2001) of WAC 173-340, based on an industrial land-use scenario. The PRGs for direct exposure and protection of terrestrial wildlife were developed independently and subsequently compared to each other to determine which offered the most restrictive value that would be protective of all pathways. Development of the PRGs for the individual pathways is summarized in the following subsections.

3.5.1.1 Protection of Human Health

For human receptors, preliminary remediation goals 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 the upper boundary of the estimated excess lifetime cancer risk of one in one hundred thousand (i.e., 1×10^{-5}). Risk-based standards for individual noncarcinogenic substances are set at concentrations that would result in no acute or chronic toxic effects on human health and the environment; this corresponds to a hazard index of less than 1. Consistent with this approach, the methodology described for industrial properties under WAC 173-340-745(5), "Soil Cleanup Standards for Industrial Properties," "Method C Industrial Soil Cleanup Levels," is used to calculate the risk-based standards; the most restrictive values from Ecology 94-145, *Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation; CLARC, Version 3.1*, are used. However, these tables do not include values for lead. Consequently, the PRG cited for lead is the Method A value for industrial sites obtained from WAC 173-340-900, "Tables," Table 745-1. Table 3-1 lists the nonradiological PRGs for direct human exposure for those COCs.

3.5.1.2 Protection of Ecological Receptors

Each of the 200-UW-1 OU waste sites is within the industrial area identified in DOE/EIS-0222-F and within the area designated by the ROD as industrial (exclusive) (64 FR 61615). 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), *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA), and RCRA commitments and, among other things, will allow for the development of new waste management facilities. Sites within the core 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 habitation by biota. However, cleanup to industrial land-use standards may not continue to be protective of ecological receptors after loss of institutional controls. A screening-level ecological risk assessment has been used to develop soil PRGs for the protection of terrestrial wildlife.

Because the waste sites in the FFS are all within the core zone, only terrestrial wildlife risks will be 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 need only 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 on the waste sites. Surveys before field activities begin will confirm the presence or absence of protected species. For sites with institutional controls to prevent excavation of deeper soil, a conditional point of compliance may be set at the biologically active soil zone, which is assumed to extend to a depth of 2.7 m (9 ft) (DOE/RL-2001-06, *Accelerating Cleanup and Shrinking the Site*, Table 2-2). Priority contaminants 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 and COPCs that are protective of ecological receptors, as indicated in Table 3-1.

3.5.2 Direct Exposure Remediation Goals for Radionuclides

The PRGs for direct exposure to radioactive contamination for both human and ecological receptors are described in the following subsections.

3.5.2.1 Human Exposure

For the locations within the core zone, DOE dose limits of 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 to be restricted for an additional 100 years by enforcement of effective institutional controls. After that time, although institutional controls still would exist, an intruder presumably could obtain access to the area and establish a residence. The presence of effective barriers during this period would prevent access to contaminated materials.

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. 40 CFR 300, "National Oil and Hazardous Substances Pollution and Contingency Plan" (NCP) establishes that CERCLA cleanup actions generally should achieve a level of risk within the 1×10^{-4} to 1×10^{-6} carcinogenic risk range 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 1×10^{-4} and that a specific risk estimate around 1×10^{-4} may be considered acceptable, if justified based on site-specific conditions (EPA/540/R-99/006 [OSWER Directive No. 9200.4-31P]). The goal of remediation is to achieve the 1×10^{-4} to 1×10^{-6} risk range, using a dose of 15 mrem/yr above background as an operational guideline to achieve this goal. Demonstration that the 1×10^{-4} to 1×10^{-6} residual risk-range goal has been achieved will be accomplished through final verification sampling during closeout of a site.

Numerical values of radionuclide PRGs corresponding to the 15 mrem/yr guidance limit depends on the specific exposure scenario selected for remedial design and site-specific parameters

(e.g., the areal extent of the waste site). Radionuclide PRGs corresponding to the 15 mrem/yr guidance limit for direct exposure to contaminated soil have been calculated for the industrial (exclusive) scenario as described in Appendix C. The individual PRGs for the identified COCs and COPCs are calculated using the RESidual RADioactivity (RESRAD) dose assessment model (ANL/EAD-4, *User's Manual for RESRAD, Version 6* and ANL, 2002, *RESRAD for Windows, Version 6.2.1*) and are provided in Table 3-2.

The soluble salts of uranium present noncarcinogenic toxic effects that are evaluated by a hazard quotient, in addition to the incremental cancer risks presented by the radioactive isotopes of uranium. If the hazard quotient exceeds 1, the possibility exists for systemic toxic effects. However, the dose from total uranium will exceed the 15 mrem/yr guidance limit at an activity or concentration less than that corresponding to a hazard quotient of 1. Therefore, it would be expected that cleanup to meet the radioactivity hazard also would be adequate to address the hazard associated with chemical toxicity.

3.5.2.2 Ecological Exposure

The international community has been involved for more than 20 years in evaluating the effects of ionizing radiation on plants and animals. The International Atomic Energy Agency (IAEA) issued a study in 1992, IAEA 332, *Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards*, endorsing the 1977 and 1990 International Commission on Radiological Protection (ICRP) reports, *Recommendations of the International Commission on Radiological Protection* (ICRP Publication 26 and ICRP Publication 60) and stating that chronic radiation exposure rates below 0.1 rad/d will not harm plant and animal populations and that radiation standards for human protection also will protect populations of nonhuman biota. The report implies that exposure limits of 0.1 rad/d for animals and 1 rad/d for plants will protect populations, but additional evaluation of effects may be needed if sensitive species are present.

ORNL/TM-13141, *Effects of Ionizing Radiation on Terrestrial Plants and Animals: A Workshop Report*, presents information from a DOE-sponsored workshop held in 1995. The workshop was attended by 12 experts in radioecology and ecological risk assessment. The goal of the workshop was to evaluate the adequacy of current approaches to radiological protection, as exemplified by the IAEA report. The attendees reviewed DOE's perspective and responsibilities, rationales underlying the IAEA conclusions, and a summary of ecological data from the former Soviet Union. The consensus of the workshop participants was that the 0.1 rad/d limit for animals and the 1 rad/d limit for plants recommended by the IAEA are adequately supported by the available scientific information. However, they concluded that guidance is needed on implementing the limits and that the existing data support the application of the recommended limits for populations of terrestrial and aquatic organisms to representative rather than maximally exposed individuals.

In response to the workshop findings, DOE produced DOE/STD-1153-2002, which provides a graded approach to ecological risk assessment for radionuclides and screening level biota concentration guides (BCG). For radiological constituents, no promulgated screening or cleanup levels are available. The potential effects of surface residual contamination on terrestrial receptors are evaluated using the terrestrial radionuclide screening levels presented in

DOE-STD-1153-2002, developed by the biota dose assessment committee (BDAC). The BDAC has been assisting DOE in developing this technical standard, which provides a graded approach for evaluating radiation doses to biota. The technical standard provides a cost-effective, easy-to-implement methodology that can be used to demonstrate compliance with DOE dose limits and with findings of the IAEA and the National Council on Radiation Protection and Measurements regarding doses below which deleterious effects on populations of aquatic and terrestrial organisms have not been observed. The technical standard also can be used to assess ecological effects of radiological exposure when conducting ecological risk assessments.

The DOE's graded 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 it is consistent with the eight-step EPA approach for conducting ecological risk assessments. The DOE recommends a three-step process that 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. Additionally, DOE and the BDAC have created a RESRAD-BIOTA model that provides a tool that allows screening based on site-specific ecological receptors and/or screening with less conservative (i.e., more realistic) exposure and effect assumptions. The final version of RESRAD-BIOTA is not released; however, draft versions (latest is Version 1.0 Beta 3) are available. Although the RESRAD-BIOTA model is in draft form and currently is not validated, the inputs and equations are based on the guidance provided in DOE-STD-1153-2002.

The BCGs contained in the technical standard guidance include conservative screening concentrations that are judged to be protective of the most sensitive terrestrial organisms, assuming an exposure rate of 0.1 rad/day.[3] Each radionuclide-specific BCG represents the limiting radionuclide concentration in environmental media (i.e., soil, sediment, or water) that would not exceed DOE's established or recommended dose standards for biota protection. Therefore, soil concentrations that are less than the BCGs are not considered to pose a threat to terrestrial receptors.

3.5.3 Remediation Goals for the Protection of Groundwater

Remediation goals for the protection of groundwater must address both contamination reaching the groundwater and contamination remaining in the ground after remediation (i.e., residual contamination). The remediation goals must consider risk-based standards where contamination

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

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 concentrations 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 of 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 potential ARARs (e.g., WAC 173-340-747) and published risk-based standards, whichever is most stringent. Consistent with this approach, soil concentrations protective of groundwater are established by evaluating 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"). The actual evaluations for these waste sites are conducted in Appendices C and D. Calculated values of soil concentrations protective of groundwater were calculated using formulas from WAC 173-340-747 and inputs from Ecology 94-145. Table 3-1 provides the preliminary remediation goals for nonradionuclides identified as COCs or COPCs.

3.5.3.2 Radionuclide Preliminary Remediation Goals for the Protection of Groundwater

Title 40 CFR 141, "National Primary Drinking Water Regulations," Title 40, *Code of Federal Regulations*, specifies MCLs for radionuclide contaminants in drinking water. Remediation goals for radionuclide contaminants in water, protective of both groundwater and surface water, are based on achieving these MCLs. Remediation goals for radionuclides in water, considered protective of human health, also are considered protective of potential ecological receptors at the groundwater/river interface.

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, "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 on the basis of a 2 L/d drinking water intake using the 168-h 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 Table D.2 of EPA/540/R-00/007, *Soil Screening Guidance for Radionuclides: User's Guide*, OSWER Directive 9355.4-16A. If two or more radionuclides are present, the sum of their annual dose rate 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*).

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.

3.6 REFERENCES

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Table 3-1. Summary of Nonradionuclide Soil Preliminary Remediation Goals for All Pathways. (4 Pages)

Constituent	Hanford Site Background [a] (mg/kg)	Required Detection Limit [b] (mg/kg)	Direct Contact [c] (mg/kg)	Groundwater Protection [d] (mg/kg)	Terrestrial Wildlife Protection [e] (mg/kg)	Overall PRG [f] (mg/kg)	Rationale [g]
Contaminants of Concern							
Nitrogen in nitrite and nitrate [h]	11.7	0.75	350,000	40	--	40	Groundwater Protection
Uranium	3.21 [a]	1	10,500	1.31	--	3.21	Background
Contaminants of Potential Concern Screened Out Through Risk Assessment [i]							
Chloride	100	2	--	1,000	--	1,000	Groundwater Protection
Fluoride	2.81	5	--	5.78	--	5.78	Groundwater Protection
Nitrate (as nitrogen)	11.7	0.75	unlimited	40	--	40	Groundwater Protection
Nitrite	--	0.75	350,000	4	--	4	Groundwater Protection
Sulfate	237	5	--	1,000	--	1,000	Groundwater Protection
Antimony	--	0.6	1,400	5.4	--	5.4	Groundwater Protection
Arsenic	6.47	1	87.5	0.034	7	6.47	Background
Barium	132	2	245,000	923	102	132	Background
Cadmium	0.81 [a]	0.5	3,500	0.69	14	0.81	Background
Chromium	18.5	1	5,250,000	2,000	67	67	Terrestrial Wildlife
Cobalt	15.7	2	70,000	290	--	290	Groundwater Protection
Copper	22	1	130,000	263	217	217	Terrestrial Wildlife
Lead	10.2	5	1,000	270	118	118	Terrestrial Wildlife
Manganese	512	5	490,000	65.3	1,500	512	Background
Mercury	0.33	0.2	1,050	2.09	5.5	2.09	Groundwater Protection
Nickel	19.1	4	70,000	130	980	130	Groundwater Protection
Selenium	--	1	17,500	5.2	0.3	1	RDL
Silver	0.73	0.2	17,500	13.6	--	13.6	Groundwater Protection
Strontium	--	1	2,100,000	2,920	--	2,920	Groundwater Protection
Thallium	--	0.5	245	1.59	--	1.59	Groundwater Protection

Table 3-1. Summary of Nonradionuclide Soil Preliminary Remediation Goals for All Pathways. (4 Pages)

Constituent	Hanford Site Background [a] (mg/kg)	Required Detection Limit [b] (mg/kg)	Direct Contact [c] (mg/kg)	Groundwater Protection [d] (mg/kg)	Terrestrial Wildlife Protection [e] (mg/kg)	Overall PRG [f] (mg/kg)	Rationale [g]
Titanium	2,570	1	unlimited	unlimited	--	unlimited	unlimited
Vanadium	85.1	2.5	24,500	2,240	--	2,240	Groundwater Protection
Zinc	67.8	1	1,050,000	5,970	360	360	Terrestrial Wildlife
Acenaphthene	--	0.33	210,000	121	--	121	Groundwater Protection
Acetone	--	0.02	3,150,000	28.9	--	28.9	Groundwater Protection
Benzoic acid	--	16.5	14,000,000	257	--	257	Groundwater Protection
Bis(2-ethylhexyl) phthalate	--	0.33	9,380	13.9	--	13.9	Groundwater Protection
2-Butanone	--	0.01	2,100,000	19.6	--	19.6	Groundwater Protection
Bromomethane	--	0.01	4,900	0.00518	--	0.01	RDL
Carbon disulfide	--	0.005	350,000	5.65	--	5.65	Groundwater Protection
Chloromethane	--	0.01	10,100	0.0165	--	0.0165	Groundwater Protection
2-Chlorophenol	--	0.165	17,500	0.943	--	0.943	Groundwater Protection
Di-n-butylphthalate	--	0.33	350,000	56.5	--	56.5	Groundwater Protection
1,4-Dichlorobenzene	--	0.005	5,470	0.03	--	0.03	Groundwater Protection
Hexane	--	1	210,000	96.2	--	96.2	Groundwater Protection
Kerosene	--	5	2,000	2,000	5,000	2,000	Groundwater Protection
Methylene Chloride	--	0.005	17,500	0.0218	--	0.0218	Groundwater Protection
Pentachlorophenol	--	0.33	1,090	0.0115	4.5	0.33	RDL
Pyrene	--	0.33	105,000	655	--	655	Groundwater Protection
Tetrachloroethene	--	0.005	2,570	0.0091	--	0.0091	Groundwater Protection
Toluene	--	0.005	700,000	7.27	--	7.27	Groundwater Protection
Tributyl phosphate	--	0.33	185	6.18	--	6.18	Groundwater Protection

Table 3-1. Summary of Nonradionuclide Soil Preliminary Remediation Goals for All Pathways. (4 Pages)

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

Notes:

[a] Background values based on DOE/RL-92-24, Summary Table 2, Lognormal Distribution 90%; uranium background is based on the combined background for the specific isotopes found in DOE/RL-96-12, Table 5-1, lognormal distribution 90%. Cadmium is based on Ecology 94-115, Table 8.

[b] The required detection limit is based on current approved laboratory contractor RDLs. The RDL is consistent with the practical quantitation limits defined in WAC 173-340-200. The RDL is used because it is the contractual defined criteria.

[c] Direct contact values represent concentrations that are protective of human health. 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). Where WAC 173-340 does not have specific values to perform the calculations, provisional values are used from the EPA Region 3 Risk Based Concentration Tables, April 2005 Update (EPA 2005).

[d] Values represent vadose zone soil concentrations that will be protective of groundwater. Values are calculated using the WAC 173-340-747(4) fixed parameter three-phase partitioning model (Equation 747-1). Where input parameter values for Equation 747-1 are not provided in WAC 173-340-747(4) or in the CLARC Version 3.1 tables, values are obtained from the Oak Ridge National Laboratory *Risk Assessment Information Risk Tools Toxicity Values Nonradionuclides* database (ORNL, 2005) available on the Internet at http://risk.lsd.ornl.gov/tox/tox_values.shtml . Values represented are for screening purposes. Site specific evaluation and modeling will be performed to determine that remedial actions are protective of groundwater.

[e] Industrial soil levels protective of terrestrial wildlife are obtained from WAC 173-340-900, Table 749-3.

[f] Listed values represent the most restrictive soil preliminary remediation goal. This process takes the most conservative value derived from evaluation of direct contact, groundwater, and terrestrial wildlife protection and evaluates this value to ensure that it is not less than natural background and analytical considerations, as indicated in WAC 173-340-700(6)(d). Values represented are for screening purposes. Site-specific evaluation and modeling will be performed to determine if remedial actions are protective of human health and the environment.

[g] Provides the basis (or rationale) for selected preliminary remediation goals values. This is based on discussions provided in note "f".

[h] The anion form of nitrogen typically is found in the Hanford Site soils as nitrate; as such, the N value is based on nitrate references. However, where nitrate values are not available, the value for nitrite is used.

[i] Contaminants of potential concern are provided for informational purposes only.

Table 3-1. Summary of Nonradionuclide Soil Preliminary Remediation Goals for All Pathways. (4 Pages)

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

DOE/RL-92-24, *Hanford Site Soil Background: Part 1, Soil Background for Nonradioactive Analytes.*
DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides.*
Ecology 94-115, *Natural Background Soil Metals Concentrations in Washington State.*
Ecology 94-145, *Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation; CLARC, Version 3.1.*
EPA, 2005, *EPA Region 3 Risk Based Concentration (RBC) Tables*, April 2005 Update, available on the Internet at www.epa.gov/reg3hwmd/risk/human/index.htm .
ORNL, 2005, *Risk Assessment Information Risk Tools Toxicity Values Nonradionuclides* database, available on the Internet at http://risk.lsd.ornl.gov/tox/tox_values.shtml.
WAC 173-340, "Model Toxics Control Act – Cleanup."
WAC 173-340-200, "Definitions."
WAC 173-340-700(6)(d), "Overview of Cleanup Standards," "Requirements for Setting Cleanup Levels," "Natural Background and Analytical Considerations."
WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties."
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," "Overview of Methods," "Fixed Parameter Three-Phase Partitioning Model."
WAC 173-340-900, "Tables."

CLARC = cleanup levels and risk calculations.
EPA = U.S. Environmental Protection Agency.
PRG = preliminary remediation goal.
RDL = required detection limit.
Unlimited = Pure material (1,000,000 mg/kg)
-- = no value established

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

Constituent	Hanford Site Background [a]	Required Detection Limit [b]	Direct Exposure[c] (pCi/g) (15 mrem/yr Dose)	Terrestrial Wildlife BCG[d] (pCi/g)	Groundwater Protection[e] (pCi/g)	Overall PRG[f] (pCi/g)	Rationale[g]
Contaminants of Concern							
Cesium-137	1.05	0.1	23.4	115[b]	NA[e]	23.4	Direct Contact
Technetium-99	--	1	412,000	4,490	0.506	1	RDL
Contaminants of Potential Concern Screened Out Through Risk Assessment [h]							
Americium-241	--	1	335	3,890	NA[e]	335	Direct Contact
Cesium-134	--	0.1	8.43	11.3	NA[e]	8.43	Direct Contact
Cobalt-60	0.00842	0.05	4.90	692	NA[e]	4.90	Direct Contact
Curium-244	--	1	744	--	NA[e]	744	Direct Contact
Europium-152	--	0.1	11.4	1,520	NA[e]	11.4	Direct Contact
Europium-154	0.0334	0.1	10.3	1,290	NA[e]	10.3	Direct Contact
Europium-155	0.0539	0.1	426	15,800	NA[e]	426	Direct Contact
Neptunium-237	--	1	59.2	--	NA[e]	59.2	Direct Contact
Plutonium-238	0.00378	1	470	--	NA[e]	470	Direct Contact
Plutonium-239/240	0.0248	1	425	6,110	NA[e]	425	Direct Contact
Potassium-40	16.6	0.5	76.4	--	NA[e]	76.4	Direct Contact
Radium-226	0.815	0.1	7.03	50.6	NA[e]	7.03	Direct Contact
Radium-228	--	0.2	8.15	43.9	NA[e]	8.15	Direct Contact
Selenium-79	--	10	NA[c]	--	NA[e]	NA	No Limit Established
Sodium-22	--	0.1	5.83	--	NA[e]	5.83	Direct Contact
Strontium-90	0.178	1	2,530	22.5	NA[e]	22.5	Terrestrial Wildlife
Thorium-228	--	1	7.73	--	NA[e]	7.73	Direct Contact
Thorium-232	1.32	1	4.80	1,510	NA[e]	4.8	Direct Contact
Uranium-233/234	1.1	1	2,665	4,830	NA[e]	2,665	Direct Contact
Uranium-234	1.1	1	2,665	5,130	NA[e]	2,665	Direct Contact
Uranium-235	0.109	1	101	2,770	NA[e]	101	Direct Contact
Uranium-238	1.06	1	504	1,580	NA[e]	504	Direct Contact

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

Constituent	Hanford Site Background[a]	Required Detection Limit[b]	Direct Exposure[c] (pCi/g) (15 mrem/yr Dose)	Terrestrial Wildlife BCG[d] (pCi/g)	Groundwater Protection[e] (pCi/g)	Overall PRG[f] (pCi/g)	Rationale[g]

NOTE:

[a] Background values based on DOE/RL-96-12, Table 5-1, lognormal distribution 90%. U-233/U-234 is based on the U-234 value.

[b] The required detection limit is based on current approved laboratory contractor RDL. The RDL is consistent with the practical quantitation limits defined in WAC 173-340-200. The RDL is used because it is the contractual defined criteria.

[c] Direct exposure values represent activities for individual radionuclides corresponding to a 15 mrem/yr dose rate in an industrial scenario. Values will be lower for multiple radionuclides to achieve the same dose rate. Listed values are used to evaluate the top 4.6 m (15 ft) of the soil column. Additionally, Se-79 does not have a regulatory limit.

[d] Biota Concentration Guide, DOE-STD-1153-2002, Table 6.4 of Module 1 and the associated calculator. The Cs-137 value is based on RESRAD-BIOTA Level 3, Beta Version 3.

[e] Values calculated based on EPA/540/R-00/007 (OSWER 9355.4-16A), Table D.2 in picocuries per liter and modeled using RESRAD to a soil based concentration. For those constituents where a value is not listed, the RESRAD (ANL/EAD-4) and/or STOMP (PNNL-12034) models predict that the constituent at concentrations present in the representative sites will not reach groundwater within 1,000 years at levels of concern. Additionally, Se-79 does not have a groundwater protection regulatory limit. Values represented are for screening purposes. Site-specific evaluation and modeling will be performed to determine if remedial actions are protective of human health and the environment.

[f] Listed values represent the most restrictive soil PRG. This process takes the most conservative value derived from evaluation of direct contact, groundwater, and terrestrial wildlife protection and evaluates this value to ensure that it is not less than natural background and analytical considerations, as indicated in WAC 173-340-700(6)(d).

[g] Provides the basis (or rationale) for selected PRG values. This is based on discussions provided in note "f".

[h] The contaminants of potential concern are provided for informational purposes only.

ANL/EAD-4, *User's Manual for RESRAD*, Version 6.2.1.

DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides.*

DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota.*

EPA/540/R-00/007, *Soil Screening Guidance for Radionuclides: User's Guide*, OSWER 9355.4-16A.

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

WAC 173-340-200, "Definitions."

WAC 173-340-700(6)(d), "Overview of Cleanup Standards," "Requirements for Setting Cleanup Levels," "Natural Background and Analytical Considerations."

-- = no value established.
BCG = biota concentration guide.
NA = not applicable.
PRG = preliminary remediation goal.
RDL = required detection limit.
RESRAD = RESidual RADioactivity (dose model).
STOMP = Subsurface Transport Over Multiple Phases.

CHAPTER 4.0

REMEDIAL ACTION ALTERNATIVES

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CONTENTS

4.0 REMEDIAL ACTION ALTERNATIVES 4-1
4.1 DEVELOPMENT OF ALTERNATIVES 4-1
4.1.1 Screening and Identification of Technologies 4-1
4.1.2 Summary of Remedial Technologies and Process Options Retained for 200-UW-1 Operable Unit Alternative Development 4-9
4.2 DESCRIPTION OF ALTERNATIVES 4-9
4.2.1 Alternative 1 – No Action 4-9
4.2.2 Alternative 2 – Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation 4-10
4.2.3 Alternative 3 – Removal, Treatment, and Disposal 4-11
4.2.4 Alternative 4 – Engineered Barrier 4-12
4.3 INDEPENDENT WORK ACTIVITIES 4-17
4.3.1 241-U-361 Settling Tank Sludge Removal 4-17
4.3.2 Monitoring 4-18
4.4 POSTREMEDIATION INTRUDER RISK EVALUATIONS 4-18
4.5 REFERENCES 4-19

FIGURES

Figure 4-1. Generalized Removal, Treatment, and Disposal Alternative. 4-21

Figure 4-2. Illustration of Conceptual Monolithic and Capillary Barrier Designs. 4-22

Figure 4-3. Modified RCRA Subtitle C Barrier Design (modified from DOE/RL-93-33). 4-23

TABLES

Table 4-1. Summary of Alternatives and Associated Components. 4-24

Table 4-2. Technology Types and Process Options for Soil and Sludge 4-25

TERMS

ALCD	Alternative Landfill Cover Demonstration
bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ET	evapotranspiration
FFS	focused feasibility study
GRA	general response action
HEPA	high-efficiency particulate air (filter)
HIC	high-integrity container
Implementation Plan	*200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*, DOE/RL-98-28
OU	operable unit
PRG	preliminary remediation goal
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
RESRAD	RESidual RADioactivity (code)
TRU	waste materials contaminated with more than 100 nCi/g of transuranic materials having half-lives longer than 20 years
WAC	*Washington Administrative Code*

4.0 REMEDIAL ACTION ALTERNATIVES

The remedial action alternatives (RAO) are developed and described in this chapter. Applicability of these alternatives to the waste sites also is considered. Additional activities that are independent of the remedial alternatives are evaluated. Postremediation risks are evaluated based on the representative sites and proposed remedial alternatives.

4.1 DEVELOPMENT OF ALTERNATIVES

Significant efforts and evaluations have contributed to defining applicable technologies and process options that address Central Plateau waste sites. DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (Implementation Plan), Appendix D, provides initial information on identification and screening of remedial technologies for these waste sites. The Implementation Plan represents a Phase I feasibility study and, as a result, formed the basis for the development of remedial alternatives. This activity and evaluation provide the basis for the following steps in developing remedial alternatives:

- Identify general response actions (GRA) to satisfy RAOs
- Identify potential technologies and process options associated with each GRA
- Screen process options to select a representative process for each type of technology, based on their effectiveness, implementability, and cost.

This focused feasibility study (FFS), using the Implementation Plan as the basis, further refines the alternatives based on site-specific conditions to develop an appropriate set of remedial action alternatives for the 200-UW-1 Operable Unit (OU) waste sites. The proposed remedial action alternatives that are applicable to the 200-UW-1 OU waste sites are summarized in Table 4-1. The following sections provide additional summary information on technology screening from the Implementation Plan.

4.1.1 Screening and Identification of Technologies

This section serves as the final screening to identify potentially viable technologies for the 200-UW-1 OU. The initial identification and screening of remedial technologies conducted in the Implementation Plan, Appendix D, are modified for this FFS based on information specific to the sites in the 200-UW-1 OU. The following subsections summarize the technology screening conducted (i.e., rescreening of the Implementation Plan remedial technologies that are retained for the 200-UW-1 OU). The technologies are discussed by GRA group. Table 4-2 represents a roadmap for technology selection between the Implementation Plan and this FFS.

Potentially applicable technology types and process options were identified and screened in the Implementation Plan in accordance with *Comprehensive Environmental Response, Compensation and Liability Act of 1980* (CERCLA) guidance, using effectiveness,

implementability, and relative cost as criteria to eliminate those options that are least feasible and retaining those options that are considered most viable (see Table D-2 in Appendix D of the Implementation Plan).

Because the initial screening in the Implementation Plan was preliminary, and because additional site-specific risk assessment and characterization information is available, the remedial technologies presented in the Implementation Plan were rescreened for application to the 200-UW-1 OU. Following is a brief screening-level discussion of the technologies and the results of the refinements.

4.1.1.1 No Action

The "National Oil and Hazardous Substances Pollution 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 (DOE/RL-98-28) for the 200-UW-1 OU and is carried forward in this FFS.

4.1.1.2 Institutional Controls

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

The depth of the contamination at some waste sites limits the number of technologies applicable to removing contaminants at the site. Therefore, institutional controls, especially monitoring of the groundwater near those sites, will be an important component of the remediation alternatives.

No changes have been made to this technology from what appeared in the Implementation Plan, based on site-specific information. The institutional controls technologies will be incorporated into remedial alternatives.

4.1.1.3 Containment

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

4.1.1.3.1 Surface Barriers (Engineered Barrier)

The surface-barrier or engineered-barrier technologies are applicable for groundwater, human health, and ecological protection. Several different types of surface barriers have been evaluated for use at the Hanford Site in separate documents.

Generally, engineered barriers consist of surface barriers constructed over contaminated waste sites to control the amount of water that infiltrates into contaminated media, to reduce or eliminate leaching of contamination to groundwater. In addition to their hydrological performance, barriers also may function as physical barriers to prevent intrusion by human and ecological receptors, limit wind and water erosion, and attenuate radiation. The surface barriers proposed in this FFS rely predominantly 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 it is retained in the soil by absorption and adsorption until evapotranspiration (ET) processes move the water back to the atmosphere. Such designs are particularly suitable for semiarid and arid climates that have 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. Key design criteria require that the soil layer be of sufficient thickness and quality in terms of water-holding capacity and the ability to support native vegetation to accommodate design precipitation events or conditions. Water balance studies at the Hanford Site have shown that 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 have been and continue to be evaluated within the U.S. Department of Energy (DOE) complex (Sandia National Laboratory, Los Alamos National Laboratory, Idaho National Engineering and Environmental Laboratory, Nevada Test Site, Hanford Site), and by the U.S. Environmental Protection Agency (EPA). The Alternative Cover Assessment Program, under the sponsorship of 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"). Other examples of barrier study include the application of a monolayered vegetative cover at the DOE Nevada Test Site and the DOE Alternative Landfill Cover Demonstration project in New Mexico, managed by the Sandia National Laboratory (Dwyer 2001, "Finding a Better Cover"). The goal of most of these efforts is to provide reliable data on design, cost, construction, and performance for alternative barriers. The intent of this FFS is not to select and design the most applicable ET barrier but to evaluate barrier performance in general using the CERCLA process. Based on the available data cited above, ET barriers are carried forward for remedial alternative development and evaluation.

Information gained from these studies and programs, including the Hanford Barrier program at the 216-B-57 Crib, will be used to support the remedial design if ET barriers are selected as the preferred remedy. Site-specific conditions establish the level of hydraulic or physical barrier performance required.

A four-year (fiscal years 1995 through 1998) treatability test was successfully completed 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. The results of the treatability test are reported in DOE/RL-99-11, *200-BP-1 Prototype Barrier Treatability Test Report*.

The principal surface barrier performance parameters evaluated during the treatability test included water balance within the barrier under ambient and extreme precipitation conditions; surface wind and water erosion; stability of the barrier foundation, surface, and riprap side slope; surface vegetation dynamics; and animal intrusion. Using irrigation techniques, extreme precipitation conditions were simulated by applying water up to three times normal precipitation amounts, including 1,000-year storms. Treatability test objectives were achieved or exceeded by the four years of testing. Results demonstrate that the barrier is easily constructed with standard construction equipment, performance criteria have been 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*. Water balance, barrier stability, vegetation, and animal intrusion monitoring continue at the barrier. Results have shown essentially no drainage through upper barrier silt layers and no measurable amounts of drainage through the asphalt layer/functional barrier system. Drainage does occur at the side slopes. Barrier side slopes and surface have remained stable. The barrier maintains a healthy coverage of native plants. The vegetation has been shown to effectively remove water. The barrier showed minimal small-mammal burrowing activity with no impact on barrier performance during the monitoring period.

The ET barriers can be divided into two categories: capillary barriers and monolithic barriers. The barriers retained in the 200 Areas Implementation Plan (DOE/RL-98-28) (i.e., the Hanford Barrier, the Modified *Resource Conservation and Recovery Act of 1976* (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 distinct textural interface in capillary ET barriers between the fine and coarse soil layers creates a capillary break, which functionally increases the water-holding capacity of the fine-grained soil over that associated with unimpeded vertical drainage. Water will not flow into the coarse layer until the water content approaches saturation in the fine-grain soil layer. If the textural interface is sloped, water will move laterally in the fine-soil layer above the interface, which provides an additional mechanism for water removal.

The advantage of the monolithic barrier is its simplicity. A single soil layer simplifies construction and maintenance and is better able to accommodate differential settlements or subsidence relative to a capillary barrier. 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 that are 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.

Advantages of capillary barriers are reduced soil thickness, greater design control for retaining water within the effective root zone, and the ability to move water laterally out of the barrier. If lateral drainage along the textural interface is desired, special design considerations must be addressed, such as the ability of the soil to conduct water laterally (unsaturated flow) over the length of the sloped interface, and the final routing and disposition of the drainage. Furthermore, capillary barriers produce relatively low moisture conditions in the lower coarse layer, which may serve to limit biointrusion and maximize root retention in the ET zone. If the capillary break is compromised, the performance of the barrier diminishes.

The three capillary cap designs retained in the 200 Areas 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., transuranic, low –level, hazardous, sanitary). 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. At several points, the regulations indicate that alternate regulatory requirements may be used to supplant the prescriptive regulations. The Modified RCRA Subtitle 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, *Focused Feasibility Study of Engineered Barriers for Waste Management Units in the 200 Areas*). The Modified RCRA Subtitle C Barrier also was developed because the conventional RCRA Subtitle C cap design is aimed at areas with much higher precipitation and is not effective for arid climates. In arid climates, the prescriptive clay barrier's performance is degraded because of the lack of moisture. 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 transuranic constituents. This barrier remains functional for a performance period of 1,000 years. Also, it provides the maximum available degree of containment and hydrologic protection for the evaluated designs. The design is composed of nine layers of durable material with a combined thickness of 4.5 m (14.7 ft). The barrier layers maximize moisture retention and ET capabilities and minimize moisture infiltration and biointrusion, considering long-term variations in Hanford Site climate.

Considering the level of supporting documentation, and Hanford Site-specific field data that 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 ET-type

barriers are considered to be an appropriate process option for the waste sites in the 200-UW-1 OU. The standard RCRA, asphalt, concrete, and cement-type barriers were rejected in the Implementation Plan (DOE/RL-98-28) because of their limited effectiveness and duration in an arid climate; they are similarly rejected in this FFS.

The performance and design parameters would be determined during remedial design. Both the monolithic and the capillary barriers have been shown to be equivalent to or to exceed the performance of the standard RCRA Subtitle C Barrier design, and both have been approved or planned for use in several western states (DOE/RL-93-33).

If an engineered barrier is identified as the preferred alternative, finalization of site-specific designs will occur as part of the remedial design process and will consider the RAOs and requirements to be 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 will have varying barrier performance requirements, and more than one barrier design (e.g., monolithic and capillary barrier) may be deployed to address waste site engineered barrier needs.

4.1.1.3.2 Slurry Walls and Grout Walls

Slurry walls and grout walls were retained in the Implementation Plan. Slurry walls and grout walls often are used to contain contaminated groundwater but have application in the vadose zone to limit (1) the horizontal movement of moisture into contaminated materials or (2) the vertical migration of contaminants. Vertical barriers are a supplemental element in the design of surface caps to effectively improve containment performance in deeper zones; both slurry walls and grout walls are suitable technologies for this application. However, the need for horizontal control of contaminant migration has not been identified, based on available site characterization data, and therefore they are rejected in this FFS.

4.1.1.4 Removal 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 materials generally is accomplished using standard earthmoving equipment, such as backhoes and front-end loaders. This technology is retained for use at sites as a standalone remedial alternative. Most of the sites in the 200-UW-1 OU contain the majority of their contamination in the depth range of 0 to 15 m (0 to 50 ft). Excavation to 15 m (50 ft), while possible, 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.

The levels of contamination in many of the waste sites in the 200-UW-1 OU pose a dose threat to workers. The levels of Cs-137 and potentially other radionuclides, as well as the duration

required for excavation of some of the deep contamination waste sites, increase the threat to workers (evaluated further in Appendix G); safety controls will be required to address the contaminant concentrations and durations for these activities. Shielded excavation equipment for these wastes will be required to reduce worker dose.

4.1.1.5 Ex Situ Treatment

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, and solidification/stabilization. However, all of these technologies except thermal desorption and vitrification are rejected for this FFS because of limited effectiveness and applicability to contaminant types and distribution in the 200-UW-1 OU. 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 available characterization data (see Chapter 2.0 for nature and extent discussion) and the results of the risk assessment, the waste sites primarily are contaminated with radionuclides, nitrate, and metals; remediation for hydrocarbons or organics is not necessary. These technologies are ineffective for radionuclides and inorganic compounds and, therefore, were rejected for this FFS.

The primary separation technique for solid media using mechanical separation is sieving to segregate material according to size, but other physical properties also may be used as a basis for segregation (e.g., local discoloration of soil). This technology is not deemed necessary to dispose of waste at the sites in this FFS. The main disadvantage of this technology is that increased waste handling carries the potential of increased worker risk and the production of fugitive dust. This process has been used as a component of removal and disposal actions on the Hanford Site. Experience in the 300 Area burial grounds has shown that certain problems with sieving solid debris may be encountered, specifically clogging of the sieving device.

Soil washing has limited effectiveness on many radionuclides, with the risk of higher exposures to workers and potentially high costs associated with the soil washing, especially if chemicals are needed to remove contaminants. Based on process knowledge and site characterization data (see Chapter 2.0) treatment is not required to meet Environmental Restoration Disposal Facility (ERDF) waste acceptance criteria.

Ex situ vitrification is costly and is deemed unnecessary to dispose of waste at the ERDF.

Solidification/stabilization technologies generally are used to immobilize soil contaminants; this is assumed to be unnecessary for disposal to the ERDF, but may be necessary for tank sludge disposal at an onsite or offsite facility.

4.1.1.6 In Situ Treatment – (Vitrification, Vapor Extraction, Grout Injection, Soil Mixing, Dynamic Compaction, and Natural Attenuation)

These technologies were retained in the Implementation Plan to mitigate contaminant mobility or to treat organics in situ.

Vitrification is rejected, because the depth of the majority of the contamination is at or below the 6.1 m (20 ft) process depth limit and because of the physical size of the waste sites and the implementation problems associated with this technology. In situ vitrification also is not retained for use at the tanks because of the high cost and implementation problems.

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 them 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 has been implemented at several small-scale sites, although in situ grouting has not been applied to large-scale sites that have many radiological and chemical hazards, such as the 200-UW-1 OU sites. Grout injection as a stand-alone action is rejected because of the size and depth of the waste sites and its unproven effectiveness on large-scale sites that have radiological and chemical hazards. The technology is applicable to remedial alternatives to fill voids in pipelines (e.g., 200-W-42 Vitrified Clay Pipeline/UPR-200-W-163), to fill voids in cribs, and to fill voids in tanks that will remain in place after contamination is removed.

Dynamic compaction is used to increase the soil density, compact the 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) deep. Dynamic compaction is rejected in this FFS as a standalone action, because the chemicals and radionuclides at these sites are deep, and compaction would not be effective. Dynamic compaction is retained in the FFS as an element of engineered barriers; this technology frequently is used to prepare a waste site for cap construction.

Deep soil mixing uses large augers (mixers) and injector head systems to inject and mix solidifying agents (cement or pozzolanic based) into contaminated soil in place. The process reduces the mobility of contaminants by entraining them 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 FFS because of the size and depth of the waste sites to be treated and the associated costs.

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

4.1.2 Summary of Remedial Technologies and Process Options Retained for 200-UW-1 Operable Unit Alternative Development

Based on the screening presented in Section 4.1.1, the remedial technologies and process options that were retained for development of the 200-UW-1 OU-specific remedial alternatives are summarized in Table 4-2. The following section provides a summary of the remedial action alternatives developed for evaluation in this FFS based on the technologies carried forward in this table.

4.2 DESCRIPTION OF ALTERNATIVES

This section provides a description of the alternatives considered for evaluation in this FFS, including the following:

- No Action (Alternative 1)
- Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation (Alternative 2)
- Removal, Treatment, and Disposal (Alternative 3)
- Engineered Barrier (Alternative 4).

The alternatives described in this section are presented as standalone alternatives; however, the impacts from remediation activities at adjacent sites will need to be considered during implementation of these alternatives. These impacts include considerations such as construction of the Canyon Disposition Initiative barrier. See Table 4-1 for a summary of alternatives and components.

4.2.1 Alternative 1 – No Action

40 CFR 300 requires that a no-action alternative be evaluated as a baseline for comparison with other remedial alternatives. 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 would be instituted or continued. Selecting the no-action alternative would require that a waste site pose no unacceptable threat to human health or the environment.

Based on the 200-UW-1 OU evaluations and the results of the risk assessment, none of the representative sites meet the industrial land-use RAOs using the no-action alternative. The no-action alternative is carried forward in this FFS for comparison purposes and to address analogous waste sites that are expected to meet the RAOs and preliminary remediation goals (PRG) without any action.

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

Under this alternative, existing soil covers would be maintained and/or augmented as needed to provide protection from intrusion by biological receptors, along with legal barriers (such as deed restrictions and excavation permits) and physical barriers (such as fencing) that would mitigate contaminant exposure. Radioactive contaminants remaining beneath the clean soil cover would be allowed to decay in place (i.e., attenuate naturally) thereby reducing risk until remediation goals are met.

A clean soil cover could be represented either as clean backfill over subsurface structures (e.g., cribs) or as a surface stabilization layer of clean soil, or both in combination, as is the case with several sites in the 200-UW-1 OU. This alternative may be preferable in the following circumstances:

- When contaminant concentrations are very close to remedial goals within the acceptable timeframe
- For contaminants that naturally attenuate and are not mobile in the environment
- When the cost to remediate does not gain a comparable amount of risk reduction, and/or
- When the cost for active remediation (e.g., removal, treatment, disposal, engineered barrier) is prohibitive.

Based on literature searches regarding the root and burrowing depths of vegetation and animals present on the Hanford Site, a soil thickness sufficient to prevent biological intrusion generally would be 2.4 to 3.0 m (8 to 10 ft). Further evaluations on the Hanford Site (DOE/RL-2001-06, *Accelerating Cleanup and Shrinking the Site*, Table 2-2) have indicated that a conditional point of compliance may be set, for sites implementing institutional controls, at the biologically active soil zone, which is assumed to extend to a depth of 2.7 m (9 ft). This means that contaminants below 2.7 m (9 ft) do not require remediation or institutional controls to be protective of ecological receptors. WAC 173-340, "Model Toxics Control Act -- Cleanup," specifies a conditional point of compliance for ecological receptors of 1.8 m (6 ft) below ground surface (bgs) with institutional controls. Many of the waste sites have a soil cover (i.e., surface stabilization, backfill) over the contaminated zone of 1.8 m (6 ft) or more. The maximum surface stabilization layer thickness at any of the representative sites is 0.5 m (1.75 ft), and several of the waste sites addressed in this FFS have an existing surface stabilization layer of about 0.5 m (between 1.5 and 2 ft). The clean backfill over the contaminated zone also provides additional soil thickness.

For sites having a clean soil cover <4.6 m (15 ft), more stringent institutional controls (e.g., physical and legal barriers, biological monitoring, removal of deeply rooted plants, control of deep burrowing animals) would need to be implemented. Water- and land-use restrictions also would be used to prevent exposure. However, none of the representative sites have sufficient soil cover over the contaminated zone to prevent biological intrusion to 4.6 m (15 ft).

Natural attenuation relies on natural processes to lower contaminant concentrations until cleanup levels are met. Monitored natural attenuation would include sampling and/or environmental monitoring, consistent with EPA guidance (EPA/540/R-99/006, *Radiation Risk Assessment At CERCLA Sites: Q & A*, OSWER Directive No. 9200.4-31P), to verify that contaminants are attenuating as expected and to ensure that contaminants remain isolated (e.g., will not lead to degradation of groundwater or be released to air or biota). 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.

Additional monitoring of groundwater may be required near sites with mobile contaminants left in place, to verify that groundwater is not being impacted. The existing network of groundwater monitoring wells in the Central Plateau should be adequate for monitoring most sites, in coordination with the 200-UP-1 Groundwater OU. If remediation or other activities result in wells being decommissioned, additional wells may be needed.

4.2.3 Alternative 3 – Removal, Treatment, and Disposal

Structures and soil with contaminant concentrations above the PRGs would be removed using conventional techniques and would be disposed to an approved disposal facility, most probably the ERDF. Special precautions would be used to minimize the generation of onsite fugitive dust. Depending on the configuration of the area to be excavated, shoring 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 depends on which categories of PRGs are exceeded. For example, if human health direct-contact or ecological PRGs are exceeded, removals would be conducted to a maximum of 4.6 m (15 ft). Conversely, if groundwater protection is required, soils, to the extent practicable, would be removed to meet groundwater protection PRGs. For the 216-U-1 and 216-U-2 Cribs, the 216-U-8 Crib, and 216-U-12 Crib, deeper excavation would be required to meet groundwater protection criteria for this alternative. For these waste sites, contamination is at significant depth and requires the creation of benches (similar to mining operations) to slope back the excavation to achieve greater depths. These benches are planned at 7.6 m (25-ft) intervals to ensure safe operations and excavation access.

Below-grade structures that extend below 4.6 m (15 ft) likely would be removed completely, if practicable. Figure 4-1 illustrates how excavation generally would proceed under this alternative.

The remediation of sites under this removal, treatment, and disposal alternative would be guided by the observational approach. The observational approach is a method of planning, designing, and implementing a remedial action that relies on information (e.g., samples) collected during remediation to guide the direction and scope of the effort. Data collected are used 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 is localized in only a portion of a waste site.

Requirements for safety, monitoring, and sampling generally are well understood, especially at the Hanford Site, where numerous removal, treatment, and disposal actions have been

implemented in radiological and hazardous environments. Radioactive waste requires special-handling protocols, but remote-controlled equipment is not necessary, based on process knowledge and observed concentrations of radionuclides from characterization activities. Removal technologies do not require that the precise extent of contamination be known before excavation. Rather, the extent of contamination is assessed as the excavation proceeds, and the extent of remediation is adjusted accordingly. In this alternative, soils will be removed until the PRGs are achieved (Figure 4-1), or to a maximum depth of 4.6 m (15 ft), or to below the engineered structure, or as required to meet groundwater protection criteria. If previously unknown contamination above the PRGs is discovered, the extent of remediation may be increased following consultation with the DOE, EPA, and the Washington State Department of Ecology (Ecology). A decision to excavate to a greater depth to protect groundwater would depend on factors such as the cost of further remediation, amount of risk reduction achieved, volume of soil generated, availability of disposal facility capacity, impacts on cultural and ecological resources, logistics and interference with other onsite activities/structures, worker safety issues, and implementability of the excavation for the deeper contamination. Based on existing information, soil and/or debris removed from the waste sites are not anticipated to require ex situ treatment to meet disposal requirements at the ERDF or to reduce waste volumes. Contaminated soil will be containerized on site (e.g., containers, "burrito wraps," bulk shipment) and transported to the ERDF, located near the U Plant Area in the 200 West Area. Low-level radioactive waste and/or hazardous waste are acceptable for disposal at the ERDF, in accordance with the waste acceptance criteria (BHI-00139, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*).

After the clean cover and contaminated soil are removed and the RAOs are met, uncontaminated soil would be used to backfill the excavation. The backfill material could be found at a variety of sources, including local borrow pits and the excavated material that is 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.

4.2.4 Alternative 4 – Engineered Barrier

4.2.4.1 General Engineered Barrier Technology Description

Engineered barriers consist of surface barriers constructed over contaminated waste sites to control the amount of water that infiltrates into contaminated media, to reduce or eliminate leaching of contamination to groundwater. In addition to their hydrological performance, barriers also may function as physical barriers to prevent intrusion by human and ecological receptors, limit wind and water erosion, and shield radiation. Institutional controls would be required to prevent intrusion to the capped area and to prevent activities that might alter the effectiveness of the barrier. Institutional controls (including legal, administrative, or physical controls such as deed restrictions, excavation permits, fencing) are required to minimize the potential for exposure to contamination. Monitoring associated with this alternative includes performance monitoring to ensure that the barrier is performing as designed as well as monitoring groundwater to ensure that RAO #3 is met.

4.2.4.2 Alternative Barriers

The Implementation Plan (DOE/RL-98-28) identified surface barriers that are engineered for arid climates (i.e., alternative barriers) as a viable remediation alternative for containment of waste, as opposed to conventional surface barriers (e.g., standard RCRA Subtitle C Barrier design). Conventional barriers are multilayered systems that rely on geomembranes, clay layers, or a combination of both to form a hydraulic barrier to prevent the vertical movement of water. More recently, alternative barriers have been gaining acceptance, particularly for use in semiarid and arid climates such as the Hanford Site. Alternative barriers that predominantly rely on ET processes to control the movement of water are referred to as ET barriers in this FFS.

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. Precipitation is allowed to infiltrate at the surface, where it is retained in the soil by absorption and adsorption until ET processes remove the water back to the atmosphere. Such designs are particularly 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 removed. Key design criteria require that the soil layer be of a sufficient thickness and quality in terms of water-holding capacity and ability to support native vegetation to accommodate maximum precipitation events or conditions. A range of soil types can be used. Generally, as soil texture becomes more coarse, water holding capacity decreases, and layer thickness requirements increase. Other engineering factors that influence soil suitability include susceptibility to frost heave and soil piping, and shrink-swell properties. Water balance studies at the Hanford Site have shown that 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).

Two common types of ET barriers include monolithic barriers, which rely on a relatively thick single layer of soil, and capillary barriers, which consist of a fine-grained soil layer overlying a relatively coarse-grained soil layer. The distinct textural interface between the fine-grained and coarse-grained soil layers creates a capillary break, which functionally increases the water-holding capacity of the fine-grained soil over that associated with unimpeded vertical drainage. Water will not flow into the coarse layer until the water content in the upper fine-grained layer approaches saturation. If the textural interface is sloped, water will move laterally down slope in the fine-soil layer above the interface, which provides an additional mechanism for water removal. However, laterally draining water would need to be routed away from the waste site. An illustration of a conceptual monolithic and capillary barrier design is provided in Figure 4-2.

The advantage of the monolithic barrier is its simplicity, its demonstrated performance in arid and semiarid areas, its cost and, unlike a multilayer system, its ability to structurally self-heal after subsidence or a seismic event. A single soil layer simplifies construction and maintenance and is better able to accommodate differential settlements or subsidence relative to a capillary barrier. 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 that are susceptible to subsidence. If the capillary break is compromised, the performance of the barrier diminishes. Differential settlements can disrupt the

continuity of layers (i.e., offset layers) which can create large macropores. A broad range of options is available (e.g., dynamic compaction, compaction grouting) to mitigate subsidence potential before barrier construction. For example, the 216-U-1 and 216-U -2 Cribs were constructed with subsurface void space (i.e., constructed with two unfilled timbered boxes), which can be filled with grout to eliminate the void. 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.

Advantages of capillary barriers are reduced soil thickness, greater design control for retaining water within the effective root zone, and the ability to move water laterally out of the barrier. If lateral drainage along the textural interface is desired, special design considerations must be addressed such as the ability of the soil to conduct water laterally (unsaturated flow) over the length of the sloped interface, and the final routing and disposition of the drainage. Furthermore, capillary barriers produce relatively low moisture conditions in the lower coarse layer, which may serve to limit biointrusion and maximize root retention in the ET zone.

The ET barriers have been and continued 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, under the sponsorship of 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). Other examples of barrier study include the application of a monolayered vegetative cover at the DOE Nevada Test Site and the DOE Alternative Landfill Cover Demonstration (ALCD) Project in New Mexico, managed by the Sandia National Laboratory (Dwyer 2001). The goal of most of these efforts is to provide reliable data on design, cost, construction, and performance for alternative barriers.

As part of the ALCD Project (DOE/EM-0558, *Alternate Landfill Cover*, available on the Internet at http://apps.em.doe.gov/ost/pubs/itsrs/itsr10.pdf) the DOE evaluated several barrier designs using field-scale (13 x 100 m) demonstration plots. Construction costs for these demonstration plots varied from \$73.89/m^2 to \$92.64/m^2 for ET-type barriers, compared to \$157.54/m^2 for the conventional RCRA Subtitle C Barrier design. Barriers that are designed to site-specific conditions (i.e., local borrow soils) with simple layering, cost less than barriers with multiple layers requiring imported materials (e.g., clays, geomembranes), as is the case for the conventional RCRA Subtitle C Barrier design. Furthermore, the ALCD Project evaluated the cost of deploying full-scale barriers at a mixed-waste landfill and concluded that capital costs for a conventional RCRA Subtitle C Barrier were more than twice the costs of an ET barrier and that operating and maintenance costs over 30 years were almost six times greater than for an ET barrier.

These alternative barriers can be contrasted with conventional RCRA barriers. These alternative barriers have been evaluated in DOE/RL-93-33. Under this evaluation, a graded set of conceptual surface barrier designs was developed that provide variable levels of environmental protection and optimized performance under Hanford Site-specific environmental conditions

(e.g., arid climate, borrow sources). Three alternative barrier designs were proposed (Hanford Barrier, a Modified RCRA Subtitle C Barrier, and a Modified RCRA Subtitle D Barrier) to address various categories of waste (e.g., transuranic, low-level, hazardous, sanitary). Fundamentally, 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 the design is expected to be equivalent to, or to exceed the performance of, the conventional design. The Modified RCRA Subtitle C Barrier design (Figure 4-3) 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 design includes the components of a capillary barrier (50 cm [20-in.] silt loam with pea gravel, 50 cm [20-in.] silt loam, and 15 cm [6 in.] sand filter layers) overlying a secondary barrier system using a low-permeability layer (15 cm [6-in.] gravel filter, 15 cm [6 in.] drainage, 15 cm [6 in.] low-permeability asphalt, and 10 cm [4 in.] base course layers). 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 bottom layer (layer 8 shown in Figure 4-3) is grading fill.

DOE/RL-93-33 identified the Modified RCRA Subtitle C Barrier (i.e., capillary barrier) as the baseline design for sites containing dangerous waste, low-level waste, or mixed waste. Hanford Site-specific field data demonstrate that capillary barriers perform well (DOE/RL-99-11, PNNL-13033, DOE/RL-93-33). The Hanford Barrier overlying the 216-B-57 Crib, which is similar to the Modified RCRA Subtitle C Barrier (i.e., both are capillary barriers), has provided the most site-specific barrier performance data to date and has performed well during the 8 years of monitoring (CP-14873).

4.2.4.3 Preferred Engineered Barrier Technology

The preferred engineered barrier technology for waste sites addressed in this FFS is an ET barrier as opposed to a conventional surface barrier. ET barriers have been shown to be equivalent to, or to exceed the performance of, the standard RCRA Subtitle C Barrier design. They also are more cost effective in arid climates and have a longer design life than the standard RCRA Subtitle C Barrier. ET barriers have been approved or planned for use in several western states (EPA, *Alternative Landfill Cover Project Profiles*, EPA Technology Innovation Program, http://www.clu-in.org/products/altcovers/usersearch/lf_search.cfm; DOE/RL-93-33). At the Nevada Test Site, DOE has a regulator-approved monofill ET cover for a mixed-waste disposal facility.

If an engineered barrier is identified as the preferred alternative, finalization of site-specific designs will occur as part of the remedial design process and will consider the RAOs and requirements defined in the record of decision, as well as design, 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 will have varying barrier performance requirements, and more than one barrier design (e.g., monolithic and capillary barrier) may be deployed to address 200-UW-1 OU waste site engineered barrier needs. Installing and monitoring more than one barrier type would have the broader benefit of being able to collect comparative field performance data to support future remedial decision-making at other waste sites in the Central Plateau.

An engineered barrier is applicable for groundwater, human health, and ecological protection, especially for contaminants that will remain in place.

Cap design will need to take into account both limiting percolation, thereby protecting groundwater, and limiting intrusion as performance requirements. The time period for limiting intrusion will depend on the type of contaminants present, as well as the period of institutional control. For example, if the contaminants were cesium and technetium, the barrier design would have to limit percolation to support the RAO of no further groundwater degradation and concurrently would have to limit intrusion via a series of various actions (e.g., eliminate pathways, maintain institutional controls). The engineered barrier alternative includes provisions for groundwater monitoring for those waste sites that have deep vadose zone contamination.

Use of an engineered barrier alternative would require an assessment of the lateral extent of contamination during the confirmatory and/or remedial design sampling phases to properly size the cap 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 of the barrier beyond the footprint of the waste zone (referred to as overlap) is expected and is dependent on the barrier design used and the depth of contamination. For the purpose of the FFS, an overlap of 6.1 m (20 ft) is assumed. The type and availability of barrier construction materials is also a design consideration. The results of the most recent investigation (BHI-01551, *Alternative Fine-Grained Soil Borrow Source Study Final Report*) would need to be considered during remedial design for selection of the barrier construction materials. A more detailed geotechnical evaluation of borrow sites likely may be required to support the design process.

Site preparation activities require completion before barrier construction begins and may include site stabilization activities and the removal of obstructions. The FFS assumes that some site stabilization will be required at all waste sites and uses dynamic compaction as the baseline technology. Structures and pipelines that obstruct at the surface location of barrier placement would be removed or stabilized before construction begins. These structures, if they do not contain contaminated material, may be abandoned in place. Contaminated structures that exceed the PRGs would need to be removed.

Caps require surveillance and maintenance throughout their life to ensure continued protection. In addition, some level of performance monitoring also would be expected, to ensure that the barrier is performing as designed. This FFS assumes fairly robust performance monitoring during the first 5 years after construction, followed by more streamlined program in subsequent years. For the majority of the sites in this FFS, a design life of 500 years is considered to be sufficient, because the contaminants decay to protective levels at the surface within 500 years, with the exception of one site. For barriers that use naturally stable geologic materials, the key factor establishing life expectancy is projected wind-erosion rates, which can be minimized by maintaining the vegetation cover, adding gravel to the upper portion of the surface layer, or other armoring methods.

Postremediation requirements for the surveillance, inspection, maintenance, and monitoring of this engineered barrier alternative will be established using the data quality objectives process

and will be defined in an operations and maintenance plan. The operations and maintenance plan will, as needed, detail barrier performance; vadose zone or groundwater monitoring needs; RCRA treatment, storage, and disposal unit postclosure monitoring requirements; monitoring methods; analytes and intervals; maintenance activities and frequencies; and associated procedures.

4.3 INDEPENDENT WORK ACTIVITIES

This section provides discussion of additional work activities that are independent of the remedial alternatives.

4.3.1 241-U-361 Settling Tank Sludge Removal

The 241-U-361 Settling Tank served as a settling tank for liquid waste enroute to the 216-U-1 and 216-U-2 Cribs from 1951 through 1967. This tank received cell drainage from Tank 5-6 in the 221-U Building, waste from the 224-U Building, and 276-U Solvent Handling Building solvent scrubbing waste. It is estimated that 106,000 L (28,000 gal) of sludge and 378 L (100 gal) of supernatant remain in the tank (BHI-01018, *Environmental Restoration Contractor Management Plan for Inactive Miscellaneous Underground Storage Tanks*). Because of the amount and nature of material in the tank, it is assumed that the sludge and liquid will require removal regardless of the final remedial alternative.

HNF-6354, *Tank 241-Z-361 Sludge Retrieval and Treatment Alternatives*, was reviewed to assess applicable sludge removal options with respect to the 241-U-361 Settling Tank. Based on the review, all the options studied in HNF-6354 apply to the 241-U-361 Settling Tank. However, because the 241-Z-361 Tank is anticipated to contain transuranic (TRU)[1] waste, the removal, stabilization/treatment option did not consider disposal of sludge to the ERDF. Sludge sample data collected from the 241-U-361 Settling Tank in the mid-1970s (BHI-01018) indicate that the sludge would not meet the definition of TRU waste. As a result, the option of using the ERDF for disposal may be applicable and preferred.

This option can be implemented by excavating to the top of the tank to access the 1.2 m (4-ft) diameter manhole cover. The sludge then can be pumped from the manhole into an applicable container (e.g., high-integrity container (HIC) with dewatering capabilities). This HIC easily can be shielded if needed, using a concrete culvert. If necessary, shielding also can be placed over the tank and manhole to reduce personnel exposure during sludge removal operations.

Water removed during dewatering of the sludge in the HICs can be returned to the tank to assist in sluicing sludge from the tank. The water removed during dewatering can be contained and transported for treatment and disposal at the 200 Areas Effluent Treatment Facility providing the waste acceptance criteria are met. During sludge removal operations, high-efficiency particulate

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

air (HEPA) -filtered exhausters can be attached to a riser to control airflow through the manhole, into the tank, and out the riser, reducing potential airborne contamination at the work area.

4.3.2 Monitoring

Monitoring within the 200-UW-1 OU will be integrated and defined in a U Plant Area operations and maintenance plan. This plan will encompass the U Plant Area and will integrate the monitoring needs associated with the various projects (such as 200-UP-1 Groundwater OU groundwater monitoring, 221-U Facility, ancillary facilities) and selected remedy needs (such as barrier performance monitoring, monitored natural attenuation monitoring). Additional integration will be accomplished for the 200-UW-1 OU specific to the institutional controls required with the preferred remedies as well as needs associated with these various other projects.

4.4 POSTREMEDIATION INTRUDER RISK EVALUATIONS

Appendix E presents the risk assessment for a postremediation inadvertent intruder scenario. Three intruder scenarios were evaluated in this FFS (i.e., construction trench worker, well driller, and rural resident). Of these three scenarios, the construction trench worker scenario is most consistent with the Central Plateau land-use assumptions and shows that the waste sites are below regulatory guidelines in 150 years, when the intruder scenario is assumed to begin.

Four representative waste sites were included in this analysis: the 216-U-4 Reverse Well/ 216-U-4A French Drain, the 216-U-8 Crib, the 216-U-12 Crib, and UPR-200-W-19. The conceptual models (Appendix E, Figures E-1 through E-3) used in this analysis assume that after 150 years (50 years of operation plus 100 years of active institutional controls) at the 200-UW-1 OU soil waste sites, an inadvertent intruder will construct a utility trench through the engineered surface barrier of a waste site. The contaminated materials are brought to the surface and stockpiled along the sides of the trench.

Human health risk resulting from radionuclide contaminants of potential concern at the 200-UW-1 OU was evaluated using the RESidual RADioactivity (RESRAD) (code) model (ANL 2002, *RESRAD for Windows*, Version 6.21). The site-specific and default input parameters used in this evaluation are consistent with those used in preparation of the baseline risk assessment presented in Appendix C of this FFS report.

The radionuclides evaluated for each of the representative sites by scenario are included in Appendix E, Table E-1. Table E-2 summarizes the site dimensions and volumes for each of the representative sites. Table E-3 provides a summary of the input parameters used to perform RESRAD modeling. Table E-4 summarizes the all-radionuclides, all-pathways dose and risk estimates, respectively, for each representative waste site, by intruder scenario. Dose and risk also are presented graphically for each waste site (Appendix E, Figures E-4 through E-23).

The results of the analysis for each intruder scenario are summarized as follows.

- The construction trench worker scenario shows both dose and risk values for each waste site to be below regulatory guidelines (15 mrem/yr above background dose and 10^{-4} to 10^{-6} risk) in 150 years, when the intruder scenario is assumed to begin (i.e., year 0).

- The well driller scenario shows dose and risk values for the 216-U-4 Reverse Well/ 216-U-4A French Drain and 216-U-12 Crib to be below regulatory guidelines (15 mrem/yr above background dose and 10^{-4} to 10^{-6} risk) in 150 years. However, dose and risk for the 216-U-8 and 216-U-1/216-U-2 Crib sites do not fall below regulatory guidelines until 235 and 310 years from the date of this FFS, respectively.

- The rural residential scenario shows dose and risk values for the 216-U-12 Crib to be below regulatory guidelines (15 mrem/yr above background dose and 10^{-4} to 10^{-6} risk) in 150 years. However, dose and risk for the 216-U-4 Reverse Well/216-U-4A French Drain, 216-U-8 Crib, and 216-U-1/216-U-2 Crib sites do not fall below regulatory guidelines until 160, 400, and 410 years from date of this FFS, respectively.

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Figure 4-1. Generalized Removal, Treatment, and Disposal Alternative.

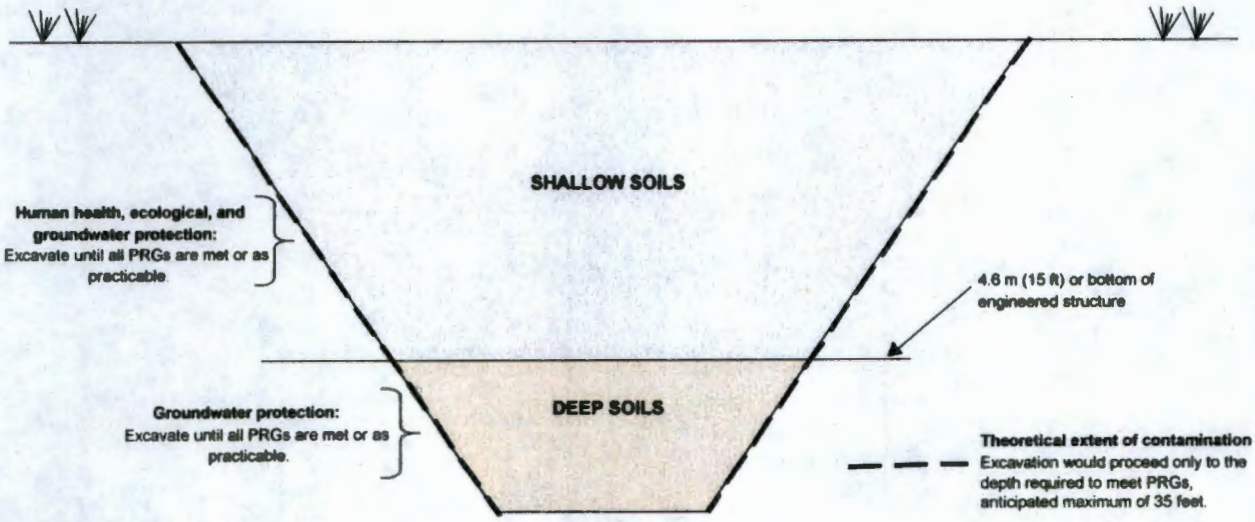

Figure 4-2. Illustration of Conceptual Monolithic and Capillary Barrier Designs.

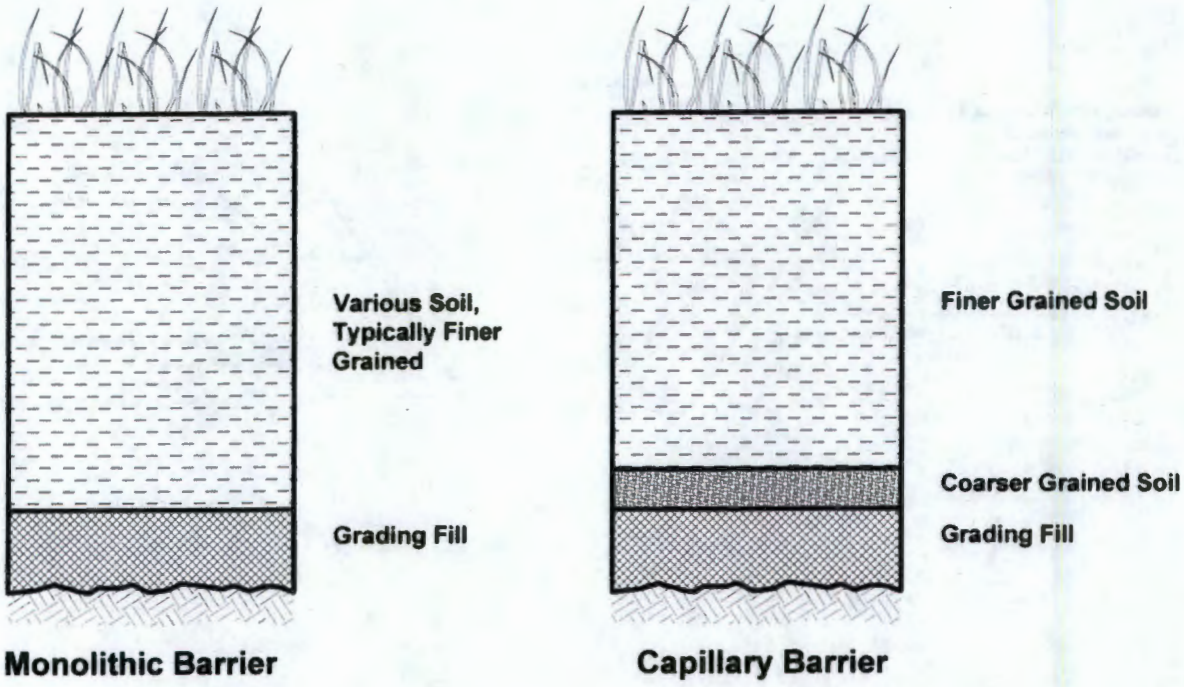

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Figure 4-3. Modified RCRA Subtitle C Barrier Design (modified from DOE/RL-93-33).

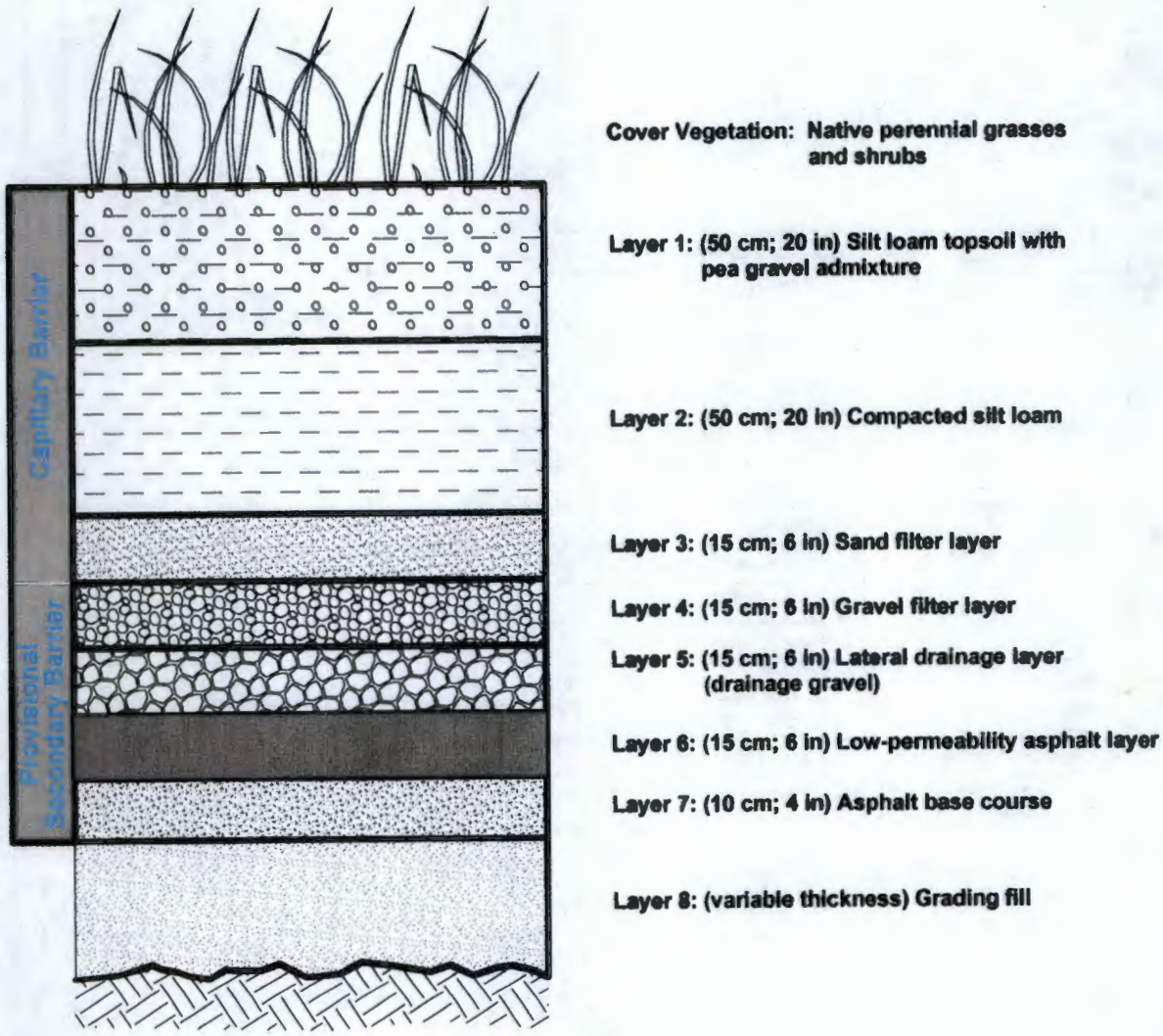

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Table 4-1. Summary of Alternatives and Associated Components.

Technology Type	Process Option	Alternative 1 - No Action	Alternative 2 – Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation	Alternative 3 – Removal, Treatment, and Disposal	Alternative 4 – Engineered Barrier
No Action	Not Applicable	X			
Land-Use Restrictions	Deed Restrictions		X		X
Access Controls	Signs/Fences		X		X
	Entry Control		X		X
Monitoring	Groundwater		X		X
	Air		X		X
Surface Barriers	Existing Soil Cover		X		
	Evapotranspiration Barrier				X
Excavation	Conventional			X	
Landfill Disposal	Onsite Landfill			X	
	Offsite Landfill/Repository				
Chemical/Physical Treatment	Grout Injection (pipelines and tanks)				
	Dynamic Compaction				X
Biological Treatment	Natural Attenuation	X	X		X

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

General Response Action	Technology Type	Process Option	Retained in Implementation Plan[1]	Retained in this Document
No Action	No Action	Not Applicable	Yes	Yes
Institutional Controls	Land Use Restrictions	Deed Restrictions	Yes	Yes
	Access Controls	Signs/Fences	Yes	Yes
		Entry Control	Yes	Yes
	Monitoring	Ground Water	Yes	Yes
		Air	Yes	Yes
	Surface Barriers	Existing Soil Cover	No	Yes
Containment, Including Evapotranspiration Barriers	Surface Barriers	Evapotranspiration Barriers[2]	Yes	Yes
		Asphalt, Concrete, Cement-Type Cap	No	No
		Standard RCRA Caps	No	No
	Vertical Barriers	Slurry Walls	Yes	No
		Grout Curtains	Yes	No
		Cryogenic Walls	No	No
	Soil Stabilization	Membranes/Sealants/Wind Breaks/Wetting Agents	No	No
Removal	Excavation	Conventional	Yes	Yes
Disposal	Landfill Disposal	Onsite Landfill	Yes	Yes
		Offsite Landfill/Repository	Yes	Yes
Ex Situ Treatment	Thermal Treatment	Calcination	No	No
		Thermal Desorption	Yes	No
		Incineration	No	No
		Pyrolysis	No	No
		Steam Reforming	No	No
		Vitrification	Yes	No
	Physical/Chemical Treatment	Chemical Leaching	No	No
		Dehalonization	No	No
		Vapor Extraction	Yes	No
		Soil Washing	Yes	No
		Mechanical Separation	Yes	No
		Solvent Extraction	No	No
		Chemical Reduction/Oxidation	No	No
		Solidification/ Stabilization	Yes	No
	Biological Treatment	Composting	No	No
		Biological Treatment	No	No
		Landfarming	No	No
		Slurry Phase Biotreatment	No	No

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

General Response Action	Technology Type	Process Option	Retained in Implementation Plan[1]	Retained in this Document
In Situ Treatment	Thermal Treatment	Vitrification	Yes	No
		Thermally Enhanced Vapor Extraction	No	No
	Chemical/Physical Treatment	Soil Flushing	No	No
		Vapor Extraction	Yes	No
		Grout Injection (pipelines and tanks)	Yes	Yes
		(Deep) Soil Mixing	Yes	No
		Dynamic Compaction (component of engineered barrier)	Yes	Yes
	Biological Treatment	Biodegradation	No	No
		Bioventing	No	No
		Natural Attenuation	Yes	Yes

[1] Table based on Table D-1 from Appendix D of DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*; updated based on 200-UW-1 Operable Unit information.

[2] ET barriers include Modified RCRA Subtitle C Barrier, Hanford Barrier, and other evapotranspiration barriers.

RCRA = *Resource Conservation and Recovery Act of 1976*..

CHAPTER 5.0

DETAILED ANALYSIS OF ALTERNATIVES

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CONTENTS

5.0 DETAILED ANALYSIS OF ALTERNATIVES 5-1
5.1 DESCRIPTION OF EVALUATION CRITERIA 5-1
5.1.1 Overall Protection of Human Health and the Environment 5-2
5.1.2 Compliance with Applicable or Relevant and Appropriate Requirements 5-2
5.1.3 Long-Term Effectiveness and Permanence 5-3
5.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment 5-3
5.1.5 Short-Term Effectiveness 5-4
5.1.6 Implementability 5-4
5.1.7 Cost 5-5
5.1.8 State Acceptance 5-5
5.1.9 Community Acceptance 5-5
5.2 RCRA PERFORMANCE STANDARDS 5-6
5.2.1 Minimize Need for Further Maintenance 5-7
5.2.2 Protection of Human Health and the Environment 5-8
5.2.3 Site Reclamation 5-8
5.2.4 Landfill Requirements 5-8
5.2.5 Postclosure Requirements 5-9
5.3 DETAILED ANALYSIS OF ALTERNATIVES 5-9
5.3.1 Detailed Analysis of Alternative 1: No Action 5-10
5.3.2 Detailed Analysis of Alternative 2: Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation 5-12
5.3.3 Detailed Analysis of Alternative 3: Removal, Treatment, and Disposal 5-15
5.3.4 Detailed Analysis of Alternative 4: Engineered Barrier 5-24
5.4 NATIONAL ENVIRONMENTAL POLICY ACT OF 1969 VALUES EVALUATION 5-29
5.4.1 Description of National Environmental Policy Act of 1969 Values 5-30
5.4.2 Detailed Evaluation of the National Environmental Policy Act of 1969 5-31
5.5 REFERENCES 5-34

TABLES

Table 5-1. Crosswalk Between RCRA Treatment, Storage, and Disposal Postclosure Plan Requirements and Supporting Documentation. 5-37

Table 5-2. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation. 5-38

Table 5-3. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. 5-42

Table 5-4. Detailed Analysis Summary for Alternative 4 – Engineered Barrier. 5-47

Table 5-5. Net Present Worth Cost Estimates (in $1,000) 5-51

TERMS

ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
CERCLA	*Comprehensive Environmental Response, Compensation and Liability Act of 1980*
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
FFS	focused feasibility study
MCL	maximum contaminant level
NEPA	*National Environmental Policy Act of 1969*
OU	operable unit
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
Tri-Parties	Ecology, EPA, and DOE
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TSD	treatment, storage, and disposal (unit)
VCP	vitrified clay pipeline

5.0 DETAILED ANALYSIS OF ALTERNATIVES

This chapter presents the detailed analysis of the remedial alternatives described in Chapter 4.0 for the 200-UW-1 Operable Unit (OU) waste sites included in this focused feasibility study (FFS). The waste sites evaluated in this FFS have characteristics (e.g., size, waste type, heterogeneity, extent of contamination, location) that influence the analysis of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) evaluation criteria. This analysis discusses the impact of these characteristics on each criterion within an alternative.

5.1 DESCRIPTION OF EVALUATION CRITERIA

The U.S. Environmental Protection Agency (EPA) has developed 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, to address the statutory requirements and the technical and policy considerations that are 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 applicable or relevant and appropriate requirements (ARAR)
- 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 that do not comply with ARARs (or justify a waiver) do not meet statutory requirements and are eliminated from further consideration in this FFS. 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 feasibility studies 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 the proposed plan (DOE/RL-2003-24, *Proposed Plan for the 200-UW-1 Operable Unit*), a document prepared by the Washington State Department of Ecology (Ecology), EPA, and U.S. Department of Energy (DOE) (Tri-Parties). The proposed

plan will identify the preferred remedy 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, *National Environmental Policy Act of 1969* (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 both the DOE *Secretarial Policy on National Environmental Policy Act* (DOE 1994) and DOE O 451.1B, *National Environmental Policy Act Compliance Program*. Potential effects on NEPA values also are discussed in this chapter.

5.1.1 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). To conclude the overall performance of the remedial alternative, the alternative will be evaluated as a summary of the effect of an alternative on potential exposure pathways rather than as a reiteration of components of other criteria.

5.1.2 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, *Technical 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 200-UW-1 OU are presented in Appendix B, and each alternative is assessed for compliance against these ARARs. When an ARAR is not met, the basis for justifying a waiver must be presented.

5.1.3 Long-Term Effectiveness and Permanence

This criterion addresses the results of a remedial action in terms of risks that remain at the Site after remedial action objectives (RAO) 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, potential routes of exposure, 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.

5.1.4 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.

5.1.5 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, radiation exposure, or air quality impacts from off-gas 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 exposures as low as reasonably achievable (ALARA).

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.

5.1.6 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.

5.1.7 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.

Cost estimates for this FFS are +50 percent, -30 percent, in accordance with EPA/540/G-89/004. The cost estimates for the purposes of this study are presented in either 2003 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.

5.1.8 State Acceptance

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

5.1.9 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.

5.2 RCRA PERFORMANCE STANDARDS

This chapter proposes how the closure performance standards will be met. The proposed alternatives have been evaluated for compliance with the *Resource Conservation and Recovery Act of 1976* (RCRA) closure performance standards identified in WAC 173-303-610(2), "Dangerous Waste Regulations," "Closure and Post-Closure," "Closure Performance Standards," and in WAC 173-303-665(6), "Dangerous Waste Regulations," "Landfills," "Closure and Post-Closure Care." The preferred alternative must comply with the established closure requirements. These standards require the closure of treatment, storage, and disposal (TSD) units in a manner that achieves the following:

- Minimizes the need for further maintenance
- Controls, minimizes, or eliminates, to the extent necessary to protect human health and the environment, postclosure escape of dangerous waste, dangerous waste constituents, leachate, contaminated runoff, or dangerous waste decomposition products to the ground, surface water, groundwater, or atmosphere
- Returns the land to the appearance and use of surrounding land areas to the degree possible, given the nature of the previous dangerous waste activity.

The standards for final closure of a landfill (WAC 173-303-665(6)(a) require that the final cover be designed and constructed to perform as follows:

- Provide long-term minimization of migration of liquids through the closed landfill
- Function with minimum maintenance
- Promote drainage and minimize erosion or abrasion of the cover
- Accommodate settling and subsidence so that the cover's integrity is maintained
- Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.

The RCRA closure performance standards, as identified in WAC 173-303-610(2), for the 216-U-12 Crib RCRA TSD unit will be evaluated in concert with the CERCLA criteria. The first two closure standards are effectively addressed as part of the nine-criteria evaluation required by CERCLA. The first standard is evaluated as part of the CERCLA criterion for long-term effectiveness and permanence. The second closure standard is included in the CERCLA criterion for overall protectiveness; compliance with ARARs; reduction in toxicity, mobility, or volume; implementability; and long-term effectiveness. The requirement to return the land to the appearance and use of surrounding land areas is not specifically addressed by the CERCLA process but is an element of the NEPA values.

In addition, RCRA corrective action performance standards found in WAC 173-303-646(2), "Dangerous Waste Regulations," "Closure and Post-Closure," "Corrective Action," "Requirements," state that corrective action:

- Protects human health and the environment for all releases of dangerous waste and dangerous constituents, including releases from all solid waste management units at the facility
- Is required regardless of the time at which waste was managed at the facility or placed in such units and regardless of whether such facilities or units were intended for the management of solid or dangerous waste
- Must be implemented by the owner/operator beyond the facility boundary, where necessary, to protect human health and the environment.

The RCRA corrective action performance standards are consistent with the CERCLA criteria. The CERCLA criteria include an evaluation of overall protectiveness that fulfills the RCRA corrective action performance standard for protecting human health and the environment. Other CERCLA criteria, such as compliance with ARARs; reduction of toxicity, mobility, and volume; and long-term and short-term implementability, also support this evaluation.

Corrective action information on design, implementation, and monitoring of the selected remedy for the TSD unit will be included in the CERLCA postdecision documentation. Compliance schedules for corrective action will be integrated with the remedial action schedules required by the CERCLA postdecision documentation. The CERCLA remedial action process fulfills the state remedial investigation and feasibility study requirements in WAC 173-340, "Model Toxics Control Act -- Cleanup,". The CERCLA criteria include an evaluation of overall protectiveness that fulfills the RCRA corrective action performance standard for protecting human health and the environment. Other CERCLA criteria, such as compliance with ARARs; reduction of toxicity, mobility, and volume; and long-term and short-term implementability, also support this evaluation.

5.2.1 Minimize Need for Further Maintenance

This section describes how the 216-U-12 Crib will be closed to meet the performance standard of WAC 173-303-610(2)(a)(i), requiring the owner or operator of a TSD facility to close the facility in a manner that minimizes the need for further maintenance. This standard also is consistent with the landfill closure requirements of WAC 173-303-665(6)(a).

The proposed strategy is to close the 216-U-12 Crib as a landfill and to construct a final cover as discussed in Sections 4.2.5 and 5.3.4. The proposed final cover is an engineered barrier. The engineered barrier will be designed in compliance with WAC 173-303-665(6)(a) to control the amount of water infiltrating contaminated media, thereby reducing or eliminating the amount of leachate going into the groundwater, while preventing the intrusion of humans and ecological receptors into contaminated soils. The engineered barrier also will be designed to limit erosion. Additionally, this FFS proposes the use of institutional controls as part of the alternative to

provide additional protection against human intrusion and would provide for groundwater monitoring as a means of identifying impacts to groundwater. Section 4.2.4 provides additional discussion of the engineered barrier alternative and associated components.

5.2.2 Protection of Human Health and the Environment

This section describes how the 216-U-12 Crib will be closed to meet the performance standard of WAC 173-303-610(2)(a), requiring the owner or operator of a TSD facility to close the facility in a manner that controls, minimizes, or eliminates, to the extent necessary to protect human health and the environment, postclosure escape of dangerous waste, dangerous constituents, leachate, contaminated runoff, or dangerous waste decomposition products to the ground, surface water, groundwater, or the atmosphere. This standard is consistent with the landfill closure requirements of WAC 173-303-665(6)(a).

The proposed strategy is to construct a engineered barrier for final cover. The proposed final cover system over the 216-U-12 Crib would minimize the postclosure escape of dangerous waste via direct exposure, leachate, or runoff. No surface water bodies are present in the surrounding area of the 216-U-12 Crib that would be impacted by the landfill. The proposed engineered barrier and the proposed use of institutional controls address source control and reduction in contaminant migration; therefore, they support further nondegradation of groundwater. The proposed engineered barrier also prevents direct exposure to dangerous wastes by breaking the receptor pathway.

5.2.3 Site Reclamation

The performance standard of WAC 173-303-610(2)(a)(iii) states that the owner or operator of a TSD facility is required to close the facility in a manner that returns the land to the appearance and use of the surrounding land areas to the degree possible, given the nature of the previous dangerous waste activity. The land surrounding the 216-U-12 Crib is native shrub-steppe, interspersed with large areas of disturbed ground dominated by annual grasses. This area is highly disturbed. Once the proposed final cover is installed, the engineered barrier and the surrounding disturbed area would be revegetated to further enhance evapotranspiration, limit erosion, and blend the site area into the surrounding landscape.

5.2.4 Landfill Requirements

WAC 173-303-665(6)(a) requires that the owner or operator cover the landfill or cell with a final cover designed and constructed to perform the following:

- Provide long-term minimization of migration of liquids through the closed landfill
- Function with minimum maintenance
- Promote drainage and minimize erosion or abrasion of the cover

- Accommodate settling and subsidence so that the integrity of the cover is maintained
- Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.

The landfill closure requirements of WAC 173-303-665(6)(a) are consistent with the closure performance standard of WAC 173-303-610(2)(a) and are addressed in Sections 5.2.2, 5.2.3, and 5.2.4. The proposed final cover will be designed to control the amount of water infiltrating contaminated media, thereby reducing or eliminating the amount of leachate going into the groundwater. The engineered barrier also would prevent the intrusion of humans and ecological receptors into contaminated soils.

The barrier materials used for the final cover will be selected during the remedial design process and will consider waste-specific hydrologic and physical performance requirements, local material resources, and current surface-barrier technology in defining cost-effective engineered barrier design. The engineered barrier design will increase performance as well as minimize maintenance requirements throughout the postclosure care period in accordance with WAC 173-303-665(6)(a)(ii). The design will consider the drainage and erosion control identified in WAC 173-303-665(6)(a)(iii). The permeability requirements of WAC 173-303-665(6)(a)(v) also will be addressed during the remedial design process. Subsidence is not considered to be a major factor in maintenance activities at the 216-U-12 Crib. These requirements are consistent with the closure performance standards of WAC 173-303-610(2)(a) and are addressed in Sections 5.2.2 and 5.2.3.

5.2.5 Postclosure Requirements

The postclosure requirements of WAC 173-303-665(6)(b) for landfill closure and postclosure care require the owner/operator to comply with the requirements contained in WAC 173-303-610(7), "Dangerous Waste Regulations," "Closure and Post-Closure," "Post-Closure Care and Use of Property"; (8), "Post-Closure Plan; Amendment of Plan"; (9), "Notice to Local Land Authority"; and (10), "Notice in Deed to Property." These requirements will be incorporated through the U Plant Area operations and maintenance plan as necessary. A cross-walk of these requirements is provided in Table 5-1.

5.3 DETAILED ANALYSIS OF ALTERNATIVES

This section presents the detailed analysis of the alternatives under an industrial (exclusive) land-use scenario. This section also incorporates elements of the NEPA evaluation. The remaining elements are presented in Section 5.4.

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 site plus any analogous sites.

5.3.1 Detailed Analysis of Alternative 1: No Action

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

5.3.1.1 Overall Protection of Human Health and the Environment

For the 200-UW-1 OU waste sites, the no-action alternative would fail to provide overall protection of human health and the environment (as shown in Appendices C and D, and summarized in Sections 2.7 and 2.8) where contaminants concentrations would remain onsite that do not meet the RAOs. Because of these circumstances, this alternative fails to meet this criterion under CERCLA. However, there are four waste sites where, upon confirmatory sampling, the no-action alternative may be considered appropriate. Upon completion of the sampling, risk evaluations may be conducted to confirm that the no-action alternative is appropriate for these four waste sites. These sites include the following:

- 200-W-56 and 200-W-57 Dumps, because both waste sites were equipment laydown or staging areas and are understood not to have contained hazardous or radioactive contaminants. Both of these sites are similar to the 200-W-CSLA[1], another U Plant Area waste site that is a rejected site under the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989)

- UPR-200-W-8 Pit and UPR-200-W-8 Burning Ground, because this waste site may have been cleaned up in the 1970s

- 2607-W7 Septic Tank, because this waste site was abandoned in 1999 in accordance with the requirements of WAC 246-272-18501, "Department of Health," "On-Site Sewage Systems," "Abandonment." Additionally, this waste site will be located beneath the 221-U Facility proposed barrier.

The DOE is performing other activities to reduce the driver for potential transport of contaminants to groundwater from natural and artificial recharge. These activities are being performed at DOE's own initiative, independent of the cleanup remedies:

- Decommissioning of old wells that pose a potential pathway for contaminant transport to groundwater

- Elimination of artificial recharge from septic systems and leaking water lines that may present a driving force for contaminant transport

- Continuation of environmental monitoring.

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[1] CSLA = Construction Surface Laydown Area.

5.3.1.2 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 potential ARARs for the waste sites where contaminants above the RAOs would remain on site. For the four sites listed above, this alternative would meet the potential ARARs.

5.3.1.3 Long-Term Effectiveness and Permanence

This alternative would not be effective in the long term, because contaminants would remain in the majority of the waste sites without controls to maintain the existing soil cover. This assumes that the existing soil covers would fail before the RAOs were met at the waste sites. For the four sites listed above, this alternative would be affective.

5.3.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Reduction of toxicity, mobility, or volume would occur in the form of natural attenuation. Natural attenuation is a process that results in a reduction of toxicity, mobility, or volume through natural processes such as radioactive decay. Most of the contaminants identified during characterization would be influenced by the radioactive decay process. Radioactive decay is a well-understood natural attenuation process based on a first-order rate reaction. Radioactive decay is calculated easily using the half-lives of the individual radionuclides present. EPA/540/R-99/009, 1999, *Use of Monitored Natural Attenuation at Superfund RCRA Corrective Action and Underground Storage Tank Sites November 1997*, OSWER 9200.4-17P, 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 option. The no-action alternative does not use any control or monitoring.

5.3.1.5 Short-Term Effectiveness

No short-term risks 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 over most of the waste sites and appropriate safety measures for work activities.

5.3.1.6 Implementability

The no-action alternative could be implemented immediately and would not present any technical problems. All of the 200-UW-1 OU waste sites currently are undergoing in situ natural attenuation.

5.3.1.7 Cost

The no-action alternative would involve no cost.

5.3.2 Detailed Analysis of Alternative 2: Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation

In this alternative, existing soil covers are maintained as needed to provide continuous protection from intrusion by biological receptors. In addition, institutional controls (such as deed restrictions, land-use zoning, and excavation permits) are put in place to prevent human access to the site. Monitoring would be conducted to demonstrate that natural attenuation was occurring and that contamination was being contained as concentrations decreased. A summary of the results of the alternative evaluation process is presented in Table 5-2; these results are discussed in more detail below.

5.3.2.1 Overall Protection of Human Health and the Environment

Alternative 2, maintain existing soil cover, institutional controls, and monitored natural attenuation, would provide overall protection of human health and the environment (as shown in Appendices C and D, and summarized in Sections 2.7 and 2.8) for sites that show protection of groundwater and achieve human health and environmental protection within 150 years. All of the representative waste sites in the 200-UW-1 OU exceed the human-health protection criteria when evaluated without considering the existing soil cover. With the exception of the 200-W-42 Vitrified Clay Pipe (VCP)/UPR-200-W-163 site, each of these waste sites reaches the protection criteria within a 150-year period. All waste sites exceed the groundwater protection criteria with the exception of the 216-U-4 Reverse Well / 216-U-4A French Drain and the UPR-200-W-19 unplanned release waste sites.

However, several of the analogous waste sites have a limited contaminant inventory, primarily located within the shallow zone. These analogous sites are assumed, based on the representative sites, to be protection of human health and environment through maintenance of the existing soil cover. Confirmatory sampling would be used to validate the groundwater protection criterion and to determine the appropriate timeframe for decay of the constituents to acceptable levels.

In addition, the 221-U Facility is undergoing a concurrent CERCLA process (DOE/RL-2001-11, *Final Feasibility Study for the Canyon Disposition Initiative (221-U Facility)*, Rev. 1), with the anticipated remedy including the placement of an engineered barrier. The boundary of the barrier covers several sites addressed in this FFS. Implementation of the barrier at the 221-U Facility would allow these sites to undergo institutional controls and, in concert with the 221-U Facility barrier, the sites would be protected. These sites are as follows:

- 216-U-4 Reverse Well and 216-U-4A French Drain
- UPR-200-W-118 unplanned release
- UPR-200-W-78 unplanned release
- 2607-W7 Septic Tank and Tile Field.

The remaining representative waste sites (216-U-1 Crib, 216-U-2 Crib, 216-U-8 Crib, and 216-U-12 Crib) exceed the groundwater protection RAO. Groundwater beneath these sites is being addressed in the 200-UP-1 Groundwater OU. Furthermore, the DOE is performing other activities to reduce the driver for potential transport of contaminants to groundwater from natural and artificial recharge, including decommissioning of old wells that pose a potential pathway for

contaminant transport to groundwater, eliminating artificial recharge from septic systems and leaking water lines that may present a driving force for contaminant transport, and the continuation of environmental monitoring. Completion of these three activities will need to be documented in the final remedy selection for the U Plant Area.

Generally, the waste sites in this FFS, with the exception of the structures, have been covered with clean surface or stabilization soil. In addition, access to the waste sites is controlled through Hanford Site access control, with chain-link fencing and/or signage. The Hanford Site has a thorough and comprehensive radiation area access-control program, operated by the Hanford Site contractors. Currently, the waste sites are in a surveillance and maintenance program. The program generally involves an annual surface radiation survey for sites that have been stabilized or a perimeter survey for sites that have not been stabilized. If the survey identifies areas of surface contamination, additional controls are applied to the affected area, or the area is stabilized or augmented with clean soil. Waste sites are kept clear of deep-rooted plant species, using herbicide and manual plant removal.

Monitoring within the 200-UW-1 OU will be integrated and defined in a U Plant Area operations and maintenance plan. This plan will encompass the U Plant Area and will integrate the monitoring needs associated with the various projects and the selected remedy needs. Additional integration will be accomplished for the U Plant Area that is specific to the institutional controls. This planning effort will include contingency plans associated with the anticipated maintenance of the existing soil cover, institutional controls, and monitored natural attenuation.

The 241-U-361 Settling Tank, the analogous site to the 216-U-1 and 216-U-2 Cribs, poses an additional remedial challenge. It is estimated that 106,000 L (28,000 gal) of sludge and 378 L (100 gal) of liquid remain in the tank. Given the volume and nature of this material, removal of the sludge from the tank is included as an element of each remedial action alternative. The tank contents will be removed, treated as appropriate, and disposed. Based on existing information, the stabilized waste can be disposed at the Environmental Restoration Disposal Facility (ERDF). Under this alternative the tank void will be filled, with the void material selected as part of the remedial design.

5.3.2.2 Compliance with Applicable or Relevant and Appropriate Requirements

Applying this alternative at the representative waste sites 216-U-1 and 216-U-2 Cribs, 216-U-8 Crib, 216-U-12 Crib, and 200-W-42 VCP/UPR-200-W-163 would not comply with the potential ARARs, because it is not protective of human health and the environment as shown in Appendices C and D, and summarized in Sections 2.7 and 2.8.

However, this alternative would comply with all potential ARARs for the remaining representative waste sites 216-U-4 Reverse Well, 216-U-4A French Drain, and the UPR-200-W-19 unplanned release and those other sites that are in the barrier boundary of the 221-U Facility assumed engineered barrier (the UPR-200-W-118 unplanned release, UPR-200-W-78 unplanned release, and the 2607-W7 Septic Tank and Tile Field). The combination of Alternative 2, coupled with the proposed 221-U Facility engineered barrier, would accelerate achieving the ARARs, because the pathway for exposure would be removed.

The ARARs also would be met for the 241-U-361 Settling Tank, given the institutional control period of 150 years and the anticipation that any residual contaminants remaining after removal will reach acceptable levels within this timeframe.

5.3.2.3 Long-Term Effectiveness and Permanence

Under Alternative 2, contaminants would remain in the waste sites, with controls to prevent inadvertent human and biological intrusion into the waste until contaminant concentrations beneath the existing barrier reached acceptable levels. This alternative would rely on natural attenuation (e.g., radioactive decay) to decrease radionuclide contaminants until concentrations reached levels that would be protective of human health and the environment.

This alternative would be an effective and permanent remedial action for the waste sites that will achieve the ROAs through natural attenuation within about 150 years. Section 2.7 provides a summary of the human health and ecological risk assessment conducted in Appendix C. The 216-U-4 Reverse Well, the 216-U-4A French Drain, and the unplanned release UPR-200-W-19 achieve the RAOs within the 150-year timeframe. The remaining representative waste sites show exceedance of the RAOs, specifically groundwater protection. All waste sites with the exception of 200-W-42 VCP/UPR-200-W-163 achieve ecological protection.

For those waste sites that may be combined with the 221-U Facility engineered barrier (216-U-4 Reverse Well, 216-U-4A French Drain, UPR-200-W-118, UPR-200-W-78, 2607-W7 Septic Tank and Tile Field), Alternative 2 would be used until the proposed barrier over the 221-U Facility is in place. This proposed barrier would provide additional effectiveness and permanence, as noted in the Alternative 4 discussion.

5.3.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Under this alternative, reduction of toxicity, mobility, and volume of the contaminants would occur only through natural attenuation processes (e.g., radioactive decay). The progress and effectiveness of natural attenuation may be monitored, as appropriate.

5.3.2.5 Short-Term Effectiveness

For Alternative 2, only minimal short-term risks are expected, and these are associated with monitoring and maintenance activities. These activities would be conducted by experienced workers using appropriate safety precautions. Risks would decrease over time as the radionuclides decay.

If institutional controls were to fail, risks to intruders and/or ecological receptors could be at unacceptable levels, depending on when failure occurred. Again, risks decrease over time as the radionuclides decay.

Only two of the representative sites, 216-U-4 Reverse Well/216-U-4A French Drain and UPR-200-W-19, would reach RAOs within 150 years. The remaining representative sites would reach RAOs after 150 years, primarily because of groundwater protection issues.

5.3.2.6 Implementability

Alternative 2 could be implemented easily and would not present significant 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 and is being coordinated with RCRA and CERCLA monitoring programs. The area is either posted with signs and/or restricted by fencing. Additional monitoring wells or boreholes are easy to implement, although presently there is some coverage from the sitewide monitoring network.

Removal of the sludge within the 241-U-361 Settling Tank is implementable using proven techniques.

5.3.2.7 Cost

Estimates for the alternative 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. The input parameters used in these estimates are the best available at this time, but in many cases, the data on contaminants of concern, site locations, and site dimensions are limited. Despite these uncertainties, the cost estimates are of sufficient quality to fulfill the primary objective, which is to aid in selecting preferred remedial alternatives.

Table 5-5 at the end of this chapter shows the cost estimates of the alternative for each applicable waste site. This alternative would involve costs for activities similar to current activities that involve periodic surveillance of the waste sites for evidence of contamination and biologic intrusion, herbicide application or other activities to control deep-rooted plants, maintenance of signs and/or fencing, maintenance of the existing soil cover (including an assumed periodic addition of soil), and administrative controls. These costs are based on an individual waste site and do not reflect economies of scale that might be obtained by implementing a common alternative or aggregated remedies across multiple waste sites. An additional cost is provided for the waste sites to be coordinated with the 221-U Facility barrier. These costs are based on an assumption that the proposed barrier would be in place within the next 20 years. The present-worth costs assume a 3.2 percent discount rate (based on current Office of Management and Budget information) and the estimated number of years for natural attenuation to meet the RAOs for monitoring and maintenance.

5.3.3 Detailed Analysis of Alternative 3: Removal, Treatment, and Disposal

In this alternative, structures and soil with constituent concentrations exceeding the RAOs are excavated, using the observational approach and conventional excavation techniques. For some waste sites, contamination exists at significant depths (approximately 60 m [200 ft] bgs) and requires an engineered excavation such as benching. At the remaining waste sites, the excavation will use standard approaches similar to those of other excavations occurring on the Hanford Site. Excavation continues until all contaminated material exceeding the RAOs is removed and the site is backfilled with clean material. Excavated material is disposed of as

appropriate, presumably at the ERDF. A summary of the results of the alternative evaluation process is presented in Table 5-3; these results are discussed in more detail below.

5.3.3.1 Overall Protection of Human Health and the Environment

This alternative would provide a high degree of protection to future humans and the environment (as shown in Appendices C and D and summarized in Sections 2.7 and 2.8), because the contaminants are removed from the waste site. The groundwater would be protected. Aboveground structures (e.g., a portion of the 216-U-4 Reverse Well) would be removed, as necessary. Furthermore, the 241-U-361 Settling Tank and associated liquids and sludge would be removed and disposed of. The rest of the belowground structures (e.g., cribs, tanks, pipelines) would be removed or abandoned in accordance with current regulations. Structures would be abandoned if RAOs were met. Because contaminants not meeting the RAOs would be removed from a waste site and placed in an approved disposal facility (the ERDF), failure of this alternative is not likely. Residual risks would be at acceptable levels for human health, environment, and groundwater protection. Verification sampling would be conducted to determine that RAOs 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. Removal of the contaminants provides for the most flexibility for future land use.

However, under this alternative, workers are exposed to highly contaminated soils with substantial dose rates, as estimated in Appendix G. The representative sites 216-U-1 and 216-U-2 Cribs, 216-U-8 Crib, and 216-U-12 Crib have contamination to depths near the water table. Excavation to these depths and in these levels of contamination is difficult and requires workers to be exposed to high contaminant concentrations as well as risks associated with deep excavations. This type of excavation is expensive and creates considerable waste that requires disposal. In addition, it requires the removal of more clean than contaminated soils in some cases. For example, it is estimated that approximately 98 percent of the soil volume excavated from the 216-U-1 and 216-U-2 Cribs is not contaminated. This is 211 million ft^3 of clean soil and 4.1 million ft^3 of contaminated soil. This includes a 15 percent increase in soil volume, once the material is excavated. The amount of risk reduction achieved by implementing this alternative at these three representative sites is considered low, because these waste sites exceed the groundwater protection criteria. However, many of the analogous sites are small, with anticipated shallow contaminants. The risk reduction achieved at the analogous sites is considered moderate, based on the assumption that the majority of the contamination is near the surface.

5.3.3.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 3 would comply with all potential ARARs by removing all soil in accordance with the RAOs, removing or abandoning any structures, and disposing of materials at the ERDF.

5.3.3.3 Long-Term Effectiveness and Permanence

For the excavated sites, this alternative would be effective over the long term and would be a permanent solution, because source term with concentrations above acceptable levels would be

removed from the waste sites. Both EPA and Ecology cleanup authorities prescribe that remedies use permanent solutions to the maximum extent practicable and where cost effective.

Excavation and transportation of waste and structures would disturb areas beyond the waste site boundaries during the implementation period. At some sites where large excavations are expected, these disturbed areas would increase significantly. These areas would need to be revegetated after disturbance but would not be adversely affected in the long term or permanently.

The removal of buried materials from the Central Plateau for redisposal on the Hanford Site at the ERDF transfers the long-term impact of buried waste from individual waste sites to one consolidated disposal facility. The ERDF is designed for long-term management of buried waste. Removal of soils from the waste sites would require expansion of the ERDF, because the volume of soil estimated to be removed from the 216-U-8 Crib alone (8.2 million yd^3) exceeds the current remaining capacity of ERDF (7.65 million yd^3) (as of February 2004). Many other operable units and waste sites at the Hanford Site may use ERDF as well.

216-U-1 and 216-U-2 Cribs and Their Analogous Site: This alternative provides long-term effectiveness and permanence for the cribs, because contaminants are removed and disposed of at the ERDF. Based on the evaluations conducted in Appendix C, Cs-137 concentrations exceeded the human health RAO within the near surface and are anticipated to decay to acceptable levels within 128 years. The evaluations conducted in Appendix D indicate that Tc-99 contaminant is present at elevated levels to approximately 51 m (168 ft) bgs and currently is found in groundwater (located at approximately 78 m [255 ft] bgs). Based on evaluations conducted in Appendix C, ecological protection values are met at this site.

This alternative meets RAOs 1, 2, and 3. However, because of the extent of excavation, impacted surface area, and need for additional backfill material, it is anticipated that a significant area will be disrupted (approximately 285 by 263 m [934 by 862 ft] at the surface of the open pit) and, consequently, meeting RAO 4 would prove difficult. Alternative 3 is the most reliable and permanent solution for the 241-U-361 Settling Tank, based on the conceptual site model, because contaminants will be removed in accordance with the RAOs.

216-U-8 Crib: Based on the evaluations conducted in Appendix C, Cs-137 concentrations exceeded the human health RAOs within the near surface and are anticipated to decay to acceptable levels within 141 years. The evaluations conducted in Appendix D indicate that uranium and nitrogen (as nitrates and nitrite) exceed the groundwater protection RAO immediately below the waste site. Both constituents are located throughout the soil column, with the maximum concentrations between 57.6 and 60.4 m (189 and 198 ft). Based on evaluations conducted in Appendix C, ecological protection values are met at this site.

This alternative meets RAOs 1, 2, and 3. However, because of the extent of excavation, impacted surface area, and need for additional backfill material, it is anticipated that a significant area will be disturbed (approximately 299 by 266 m [982 by 872 ft] at the surface of the open pit) and, consequently, meeting RAO 4 would prove difficult. Alternative 3 is most reliable and permanent for the 200-W-42 VCP/UPR-200-W-163, because contaminants will be removed in accordance with the RAOs.

216-U-12 Crib and Its Analogous Sites: Based on the site conceptual model, this alternative is reliable and permanent for the 216-U-5, 216-U-6, and 216-U-15 Trenches as well as the 216-U-16 and 216-U-17 Cribs, because contaminants will be removed in accordance with the RAOs. The nitrogen as nitrate and nitrite at the 216-U-12 Crib is present at elevated levels to approximately 61 m (200 ft) bgs and currently is found in groundwater (located at approximately 78 m [255 ft]). Based on evaluations conducted in Appendix C, ecological protection values are met at this site.

This alternative meets RAOs 1, 2, and 3. However, because of the extent of excavation, impacted surface area, and need for additional backfill material, it is anticipated that a significant area will be disrupted and, consequently, meeting RAO 4 would prove difficult.

216-U-4 Reverse Well / 216-U-4A French Drain and Their Analogous Site: Based on the evaluations conducted in Appendix C, Cs-137 concentrations are anticipated to exceed the human health RAO within the near surface and are anticipated to decay to acceptable levels within 125 years. The evaluations conducted in Appendices C and D indicate that groundwater and ecological protection values are met at this site. Alternative 3 is the most reliable and permanent alternative for these waste sites. Based on the conceptual site model, the contaminants will be removed in accordance with the RAOs using standard construction techniques.

UPR-200-W-19 and Its Analogous Sites: Based on the evaluations conducted in Appendix C, Cs-137 concentrations are anticipated to exceed the human health RAO within the near surface and are anticipated to decay to acceptable levels within 129 years. The evaluations conducted in Appendices C and D indicate that groundwater and ecological protection values are met at this site. Based on the conceptual site model, the contaminants will be removed in accordance with the RAOs using standard construction techniques.

200-W-42 VCP and UPR-200-W-163: Based on the evaluations conducted in Appendix C, Cs-137 concentrations are anticipated to exceed the human health RAO within the near surface and are anticipated to decay to acceptable levels within 831 years. The evaluations conducted in Appendices C and D indicate that groundwater and ecological protection values are met at this site. Based on the conceptual site model, the contaminants will be removed in accordance with the RAOs using standard construction techniques. An anticipated 21,489 m^3 (758,885 ft^3) of clean material would be removed to access the 19,200 m^3 (678,040 ft^3) of contaminated soils to a depth of 3 m (13 ft). Approximately 53 percent of the excavated material will be noncontaminated. As such, the amount of risk reduction (and thus control and permanence) gained from this alternative by excavating these waste sites is moderate.

5.3.3.4 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. With the availability of the ERDF, treatment is not anticipated. However, if all of the 200-UP-1 OU sites were excavated (or even just the 216-U-8 Crib), the ERDF would reach capacity, and waste would have to be either shipped offsite or disposed of onsite in, for example, another future ERDF. However, there is currently (as of February 2004) enough capacity at the ERDF to dispose of the soil from the smaller sites. Based on the

information contained in the remedial investigation reports, waste at all sites meets the ERDF waste acceptance criteria (BHI-00139, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*, Rev. 3). If any material does exceeds the disposal facility waste acceptance criteria, it would be stored on Site (consistent with storage requirements) until the material was treated to meet the ERDF's waste acceptance criteria or a treatability variance is approved. Movement of the waste to the ERDF will result in reduction of mobility.

Reduction of toxicity, mobility, or volume would occur 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. Most of the contaminants identified during characterization would be influenced by the radioactive decay process; however, concentrations are high enough to require long time periods for radionuclides to decay to acceptable levels (hundreds and, in a few cases, thousands of years).

In EPA/540/R-99/009, 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 process, the EPA considers source control and performance monitoring to be fundamental components of the alternative.

The ERDF could provide some additional protection against remobilization of contaminants over their current location by providing containment and capture, but this would be applicable only for extremely wet years or significant spills.

5.3.3.5 Short-Term Effectiveness

Alternative 3 would be effective immediately and would not require surface controls or monitoring activities following remediation. As noted, several of the representative sites have deeper contamination that would require additional measures beyond the removal, treatment, and disposal alternative. However, many of the analogous sites are small, with anticipated shallow contaminants.

Alternative 3 does require a significantly large excavation and exposes workers to contaminants during the action; additional worker safety associated with industrial hazards (e.g., heavy equipment, heat stroke) will need to be addressed. Short-term effects of this alternative would be associated primarily with worker safety during waste excavation, transportation, and disposal to the ERDF. These workers include the following personnel:

- Excavator operator located within the pit removing contaminated soils
- Haul truck drivers transporting contaminated materials
- Laborer providing dust suppression in the pit during excavation operations
- Haul truck drivers transporting contaminated materials
- Laborers tack welding and installing transportation dust covers on the shuttle trucks

- Radiation control technicians performing radiological surveys in the pit, during conveyance, and while the bulldozer operator spreads the excavated material in the ERDF

- Bulldozer operator spreading excavated materials within the confines of the ERDF.

The contaminants associated with nearly all of the waste sites result in significant dose to workers:

- 216-U-1/216-U-2 Cribs – excavator operator 116 person-rem; shuttle driver 39 person-rem; laborer 793 person-rem

- 216-U-8 Crib - excavator operator 2 person-rem; shuttle driver 0.7 person-rem; laborer 100 person-rem

- 216-U-12 Crib - excavator operator 0.0006 person-rem; shuttle driver 0.0002 person-rem; laborer 0.005 person-rem.

Table G-7 in Appendix G summarizes the dose to workers associated with the excavation and disposal process.

Physical disruption of the waste sites during excavation, increased human activity and noise, and generation of fugitive dust could affect local biological resources.

216-U-1 and 216-U-2 Cribs and Their Analogous Site: Alternative 3 does require a significantly large excavation at the cribs (approximately 285 by 263 m [934 by 862 ft] at the surface of the open pit). For the 216-U-1 and 216-U-2 Cribs, an anticipated 5,966,779 m^3 (210,714,769 ft^3) of clean material would be removed to access the 115,591 m^3 (4,082,040 ft^3) of contaminated soils to a depth of 60.4 m (168 ft). Approximately 98 percent of the excavated material will be noncontaminated.

216-U-8 Crib: Alternative 3 does require a significantly large excavation for the cribs (approximately 299 by 266 m [982 by 872 ft] at the surface of the open pit). For the 216-U-8 Crib, an anticipated 6,082,238 m^3 (214,792,186 ft^3) of clean material would be removed to access the 161,936 m^3 (5,718,720 ft^3) of contaminated soils to a depth of 60.4 m (198 ft). Approximately 97 percent of the excavated material will be noncontaminated.

216-U-12 Crib and Its Analogous Sites: Alternative 3 does require a significantly large excavation at the crib (approximately 277 by 250 m [910 by 820 ft] at the surface of the open pit). For the 216-U-12 Crib, an anticipated 5,813,531 m^3 (205,302,891 ft^3) of clean material would be removed to access the 63,894 m^3 (256,404 ft^3) of contaminated soils to a depth of 61 m (200 ft). Approximately 99 percent of the excavated material will be noncontaminated.

216-U-4 Reverse Well / 216-U-4A French Drain and Their Analogous Site: For the 216-U-4 Reverse Well and 216-U-4A French Drain, a anticipated 550 m^3 (19,406 ft^3) of clean material would be removed to access the 49 m^3 (1,725 ft^3) of contaminated soils to a depth of 4.6 m (15 ft). Approximately 92 percent of the excavated material will be noncontaminated.

UPR-200-W-19 and Its Analogous Sites: An anticipated 3,129 m^3 (110,504 ft^3) of clean material would be removed to access the 27,265 m^3 (962,838 ft^3) of contaminated soils to a depth of 3 m (10 ft). In this case, only 10 percent of the soil excavated is estimated to be noncontaminated.

200-W-42 VCP and UPR-200-W-163: An anticipated 21,489 m^3 (758,885 ft^3) of clean material would be removed to access the 19,200 m^3 (678,040 ft^3) of contaminated soils to a depth of 3 m (13 ft). Approximately 53 percent of the excavated material will be noncontaminated.

Because of the deep excavations that would occur, this alternative would result in a greater impact to habitat in those areas excavated to provide backfill materials. The 200-UW-1 OU waste sites are located within historically disturbed industrial areas. Short-term impacts to vegetation and animals at these sites would be low, because these sites currently are poor wildlife habitats and have little or no vegetation growing on them. Excavation of the waste sites could require expansion of the ERDF daily production capacity. Local environmental disruption (increased human activity, noise, dust) would occur in the Central Plateau because of ERDF construction activities. Worker safety issues common to construction activities would be associated with ERDF expansion. It is assumed that soil covers removed to access the cribs and trench bottoms likely would be used as backfill. If this assumption is not valid, the soil would be disposed of at the ERDF, and this would have a profound impact on the size of the ERDF expansion.

Transportation activities in the Central Plateau would increase as a result of bringing construction equipment to the site, transporting contaminated soils to the ERDF, and bringing clean fill to the excavated sites. Transportation impacts outside the Hanford Site would be low. Construction and waste excavation activities would be expected to require several months to several years. Several million cubic yards of fill soil would be transported from borrow areas located on or near the Hanford Site. Air monitoring around the waste sites would be used to monitor potential air releases (e.g., radiation, waste, fill material particulates) that could affect the public and the environment.

For removal and abandonment of structures, the short-term effects would be associated primarily with worker safety during aboveground structure demolition and removal, transportation, and disposal at the ERDF. Physical disruption of the study sites during structure demolition and removal, increased human activity and noise, and generation of fugitive dust could affect local biological resources. Short-term impacts to vegetation and animals at these sites would be low because these sites currently are poor wildlife habitats.

This alternative significantly impacts the time to achieve RAOs in soil. The RAOs would be achieved as soon as the excavation of the sites was completed. Including design and execution, the alternative could take from several months for small sites to up to a year for the largest sites.

5.3.3.6 Implementability

The excavation of contaminated soils would be expected to be technically implementable and feasible, although more complicated. Because of the deep excavations required, more sophisticated excavation equipment and techniques would be required. Removal of all

contaminated materials in accordance with the RAOs would allow for greater flexibility in future land use. The aboveground structures (e.g., vent pipes) would be removed along with the waste site soil covers and contaminated crib and trench soils. Ancillary pipelines associated with the waste sites will be addressed through a separate evaluation and decision-making process and are not addressed here. Every 0.3 m (1 ft) of excavation would required 0.5 m (1.5 ft) of side slope for a 1:1.5 ratio. This safety measure significantly increases the amount of material being excavated (sometimes by 99 percent), but is considered implementable when benching is used.

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.

Other waste sites and operations in the vicinity of the waste sites could influence the implementability of this alternative at a particular site. Some of the 200-UW-1 OU waste sites (e.g., 216-U-4B French Drain) are located near existing facilities (e.g., 222-U Laboratory). Implementing remedial actions at these sites would require coordination with operations personnel and could preclude or postpone certain remedial alternatives.

This alternative would not be either easily implemented or cost effective for those sites with contaminants at significant depth because of the following:

- Potential impacts to existing facilities and the infrastructure (such as roads and utilities)
- The needed ERDF capacity for disposal, laydown areas, and backfill material needs
- Increased worker risks, given that the contaminants impacting groundwater are at an estimated depth of around 61 m (200 ft) bgs
- Diminishing return of risk reduction versus cost expended.

Special excavation techniques, such as limited excavation lifts, downblending for health and safety, and protection systems (e.g., equipment modifications, decontamination areas) likely would be necessary to support this alternative, which would increase costs and disposal capacity significantly (these are discussed in greater detail in the following subsections).

216-U-1 and 216-U-2 Cribs and Their Analogous Site: To remove soils in accordance with the RAOs, the excavation would be advanced to a depth of 60.4 m (168 ft) bgs. Every 0.3 m (1 ft) of excavation would require 0.46 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. To remove the contaminants of concern for this group, 6 million m^3 (214 million ft^3) of soil would have to be removed.

Because of the proximity of the 216-U-1 and 216-U 2 Cribs to the 241-U-361 Settling Tank, excavation activities would be more complicated, because the excavation itself likely would encroach on the cribs.

216-U-8 Crib and Its Analogous Site: To remove soils in accordance with the RAOs, the excavation would be advanced to a depth of 60.4 m (198 ft) bgs. Every 0.3 m (1 ft) of excavation would require 0.46 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. To remove the contaminants of concern for this group, 6 million m^3 (221 million ft^3) of soil would have to be removed.

216-U-12 Crib and Its Analogous Sites: To remove soils in accordance with the RAOs at the 216-U-12 Crib, the excavation would be advanced to a depth of 61 m (200 ft) bgs. Every 0.3 m (1 ft) of excavation would require 0.46 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. To remove the contaminants of concern for this group, 5.8 million m^3 (207 million yd^3) of soil would have to be removed. The contaminated soil would be disposed of at the ERDF.

Alternative 3 is more easily implemented for the remaining cribs and trenches because of their limited contaminant depth.

216-U-4 Reverse Well and 216-U-4A French Drain and Their Analogous Sites: To remove soils in accordance with the RAOs, the excavation would be advanced to a depth of approximately 4.2 m (14 ft) bgs. Every 0.3 m (1 ft) of excavation would require 0.46 m (1.5 ft) of side slope for a 1:1.5 vertical to horizontal ratio. This safety measure increases the amount of material excavated.

UPR-200-W-19 and Its Analogous Sites: To remove soils in accordance with the RAOs, the excavation would be advanced to a depth of 4 m (13 ft) bgs. Every 0.3 m (1 ft) of excavation would require 0.46 m (1.5 ft) of side slope for a 1:1.5 vertical to horizontal ratio. This safety measure increases the amount of material excavated.

200-W-42 VCP and UPR-200-W-163: To remove soils in accordance with the RAOs, the excavation would be advanced to a depth of 4 m (13 ft) bgs. Every 0.3 m (1 ft) of excavation would require 0.46 m (1.5 ft) of side slope for a 1:1.5 vertical to horizontal ratio. This safety measure increases the amount of material excavated.

5.3.3.7 Cost

Table 5-5 shows the estimated costs of Alternative 3 for each applicable waste site; additional detail regarding the cost basis can be found in Appendix F. Included in the costs are mobilizing personnel and equipment; monitoring, sampling, and analysis; and excavating, transporting the waste to the ERDF, disposing of the waste at the ERDF, backfilling with onsite resources, additionally backfilling from a local stockpile, revegetating, and performing contractor oversight. Site-specific monitoring and maintenance costs are included for the institutional control sites. The costs associated with additional institutional controls are included for those sites that are anticipated to require additional monitoring because they contain contaminants at depth.

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 will do the work, with oversight performed by contractor personnel. The cost estimate assumes

that the subcontractor personnel are wearing Level C personnel protective equipment (i.e., coveralls and air filter respirators).

5.3.4 Detailed Analysis of Alternative 4: Engineered Barrier

An engineered barrier is built over the contaminated waste site, thus "capping" the site to prevent or limit water from infiltrating into the waste and to prevent intrusion by human or ecological receptors. The barrier would be monitored to evaluate its performance. Institutional controls (such as deed restrictions, land-use zoning, and excavation permits) would be required to minimize the potential for exposure to contamination or for compromising the barrier's effectiveness. A summary of the results of the CERCLA evaluation process is presented in Table 5-4; these results are discussed in more detail below.

5.3.4.1 Overall Protection of Human Health and the Environment

This alternative would break potential exposure pathways to receptors through placement of a surface barrier and institutional controls. Institution controls would be maintained at capped 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 cap 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) at depth. These sites include the 216-U-8 Crib, 216-U-12 Crib, and the 216-U-1 and 216-U-2 Cribs.

Alternative 4 also is protective for the 200-W-42 VCP/UPR-200-W-163 site, because the exposure pathway is removed, and institutional controls provide use limitations around the barrier.

At the 216-U-4 Reverse Well and 216-U-4A French Drain, institutional controls will need to be in place for 125 years, the time required for the constituents to naturally decay. At UPR-200-W-19, institutional controls will need to be in place for 129 years.

Furthermore, the DOE is performing other activities to reduce the driver for potential transport of contaminants to groundwater from natural and artificial recharge, including decommissioning of old wells that pose a potential pathway for contaminant transport to groundwater, eliminating artificial recharge from septic systems and leaking water lines that may present a driving force for contaminants transport, and continuing environmental monitoring.

Monitoring within the 200-UW-1 OU will be integrated and defined in a U Plant Area operations and maintenance plan. This plan will encompass the U Plant Area and will integrate the monitoring needs associated with the various projects and the selected remedy needs. Additional integration will be accomplished for the U Plant Area that is specific to the institutional controls. This planning effort will include contingency plans associated with the anticipated barrier performance, groundwater monitoring, institutional controls, and monitored natural attenuation.

5.3.4.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 4 would comply with all potential ARARs by eliminating or minimizing to the extent practicable the exposure pathway for those waste sites that do not have deep contamination concerns (i.e., protection of groundwater). Where contaminants that exceed the groundwater protection criterion remain at depth, groundwater monitoring may be required to show that no further degradation is achieved.

216-U-1 and 216-U-2 Cribs and Their Analogous Site 241-U-361 Settling Tank: The Tc-99 contaminant at the 216-U-1 and 216-U-2 Cribs is present at elevated levels to approximately 61 m (200 ft) bgs and currently is present in the groundwater (located at approximately 76 m [250 ft] bgs). Preliminary fate and transport modeling was conducted to simulate the reduced infiltration associated with the placement of an engineered barrier. This modeling indicates that the engineered barrier reduces the flux of contaminants into groundwater to an amount that, in the absence of other existing contaminant sources in groundwater, results in groundwater concentrations below the maximum contaminant level (MCL). For a detailed discussion of this modeling, the reader is directed to Appendix D.

216-U-8 Crib and Its Analogous Sites: This alternative meets the ARARs through the use of an engineered barrier. The uranium and nitrogen as nitrate and nitrite contaminants at the 216-U-8 Crib are present at elevated levels to approximately 61 m (200 ft) bgs and currently are present in groundwater (located at approximately 76 m [250 ft] bgs). The fate and transport modeling indicates that the engineered barrier reduces the flux of contaminants into groundwater to an amount that, in the absence of other existing contaminant sources in the groundwater, results in groundwater concentrations below the MCL. Implementation of this alternative at the analogous sites 200-W-42 VCP/UPR-200-W-163 complies, because it is anticipated that contaminants will reach acceptable levels within 150 years.

216-U-12 Crib and Its Analogous Sites: This alternative meets the ARARs through the use of an engineered barrier. The nitrogen as nitrate and nitrite contaminant at the 216-U-12 Crib is present at elevated levels to approximately 61 m (200 ft) bgs and currently is present in groundwater (located at approximately 76 m [250 ft] bgs). The fate and transport modeling indicates that the engineered barrier reduces the flux of contaminants into groundwater to an amount that, in the absence of other existing contaminant sources in the groundwater, results in groundwater concentrations below the MCL.

216-U-4 Reverse Well and 216-U-4A French Drain and Their Analogous Sites: Implementation of this alternative complies with ARARs, because it is anticipated that contaminants will reach acceptable levels within 150 years.

UPR-200-W-19 and Its Analogous Sites: Implementation of this alternative meets the ARARs for all the waste sites with the use of an engineered barrier designed to be protective for the necessary duration.

5.3.4.3 Long-Term Effectiveness and Permanence

The engineered barrier alternative would be protective of human health and the environment by breaking exposure pathways and ensuring that the cover material is maintained to continue that protection. Ultimately, the long-term effectiveness depends on maintaining the evapotranspiration barrier and associated institutional controls throughout the natural attenuation time frame to prevent exposure to potential receptors. The barrier reduces the potential for future groundwater concentrations to cause MCL exceedances in the future. Recent evaluation of the proposed barriers's ability to protect groundwater (see Appendix D) estimated that the placement of an engineered barrier over a waste site (in this case the 216-U-1 and 216-U-2 Cribs) results in lower peak groundwater concentrations and at a more distant time in the future, reducing contaminant (i.e., Tc-99) concentrations below potential contaminant of concern thresholds. In other words, the proposed barrier was shown to result in the reduction of future groundwater concentrations (peak concentration with the barrier is lower than without the barrier) and the peak was observed further into the future.

Maintenance activities would include erosion repairs and possible vegetation maintenance. Subsidence is not considered to be a major factor in maintenance activities for these waste sites. The assumption used is that institutional controls would not necessarily be maintained and could fail. Once remediated, the barrier and surrounding disturbed area would be revegetated to further enhance evapotranspiration, limit erosion, and blend the site area into the surrounding landscape.

Based on the results of the characterization and risk assessment (as shown in Appendices C and D and summarized in Sections 2.7 and 2.8), a barrier at the 216-U-1 and 216-U-2 Cribs, 216-U-8 Crib, 216-U-12 Crib, 216-U-4 Reverse Well / 216-U-4A French Drain, and UPR-200-W-19 representative sites would need to be maintained for between 125 and 141 years for natural attenuation to effectively remediate the site to meet the human health and ecological RAOs. In addition, DOE is expected to retain control of the Central Plateau for the foreseeable future because of the ERDF and the planned vitrified-waste disposal/storage facility. Therefore, routine maintenance of the barriers and associated institutional controls can be assumed during most of the necessary natural attenuation periods (Table 4-2). The engineered barrier alternative typically has a design life of 500 years; therefore, the engineered barrier would not require replacement for the representative waste sites because RAOs are reached well before the end of the 500-year design life. For the purposes of this FFS, it is assumed that maintenance will require additional material every 20 years. Engineered barriers can fail over time, especially if not properly maintained. However, failure of the engineered barriers is unlikely if maintenance and institutional control activities continue. Because a significant amount of risk attenuates for the sites within the institutional controls period, failure of the engineered barriers in later years would be associated with lower risks, specifically groundwater protection, than at present. Also, 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. The 5-year review also would focus on groundwater protection monitoring and effectiveness of the engineered barrier in addressing the mobile contaminants at depth (e.g., Tc-99, nitrates).

Representative Sites 216-U-1 and 216-U-2 Cribs, 216-U-8 Crib, 216-U-12 Crib, and All of Their Analogous Waste Sites: This alternative is reliable for these waste sites. It meets RAOs because it reduces the exposure to contaminants by limiting both human and ecological intrusion and reducing infiltration through the contaminated zone. Additional modeling was conducted to simulate the reduced infiltration associated with the placement of an engineered barrier. This modeling indicates that the engineered barrier reduces the flux of contaminants into groundwater to an amount that, in the absence of other groundwater contaminant sources already present from up-gradient sources, results in groundwater concentrations below the MCL. The proposed engineered barrier is designed to provide long-term isolation of contaminants contained within these sites. This is supported through the natural soil analogs present on the Hanford Site that provide an indication of the long-term stability and effectiveness of ET barriers that would exploit such locally available soil.

The residual risks to groundwater significantly decrease because of the reduced infiltration rate, coupled with natural radioactive decay. It is anticipated that groundwater monitoring will be required to corroborate the model results with the actual flux and resulting groundwater concentration of Tc-99, thereby supporting RAO 3 (no further degradation of the aquifer). For the 241-U-361 Settling Tank, Alternative 4 provides reliability by reducing exposure through the use of an engineered barrier. It is expected that during the design life of the barrier, the residual risk of contaminants will decrease to acceptable levels from natural radioactive decay.

Representative Sites 216-U-4 Reverse Well/ 216-U-4A French Drain and UPR-200-W-19, and All of Their Analogous Sites: Alternative 4 provides reliability by reducing exposure through the use of an engineered barrier. It is expected that during the design life of the barrier, the residual risk of contaminants will decrease to acceptable levels because of natural radioactive decay.

5.3.4.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Natural attenuation is an important treatment component of the engineered barrier alternative. The EPA has stated in its guidance on monitored natural attenuation (EPA/540/R-99/009) that natural attenuation processes "act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater." Thus, the guidance acknowledges that natural attenuation can be a viable treatment action where its use will be protective of human health and the environment. The engineered barrier alternative would rely on natural attenuation processes (most importantly radioactive decay in place with little or no contaminant transport) to reduce radioactivity to levels that would not present a risk to human health or the environment. The engineered barrier would significantly reduce the infiltration of water, thereby reducing the mobility of contaminants.

5.3.4.5 Short-Term Effectiveness

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. Barrier construction is expected to be complete in less than 1 year. Because the sites currently have a soil cover over them, radiation exposure from soil contaminants is not an issue. However, if structures were removed, workers could be

exposed to potentially contaminated debris and radioactive material. Worker risk would be controlled through adherence to health and safety procedures and Occupational Safety and Health Administration regulations. Air monitoring would address potential air releases (e.g., barrier-material particulates) that could affect the public during construction of the surface barriers.

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. This alternative would not result in direct exposure to or release of contaminants, so the alternative would not increase the potential for receptor exposure to contaminants. Potential impacts from fugitive dust would be minimized through appropriate contamination control measures during barrier construction. No risks to the community exist, given the isolated location of the waste sites.

Borrow source material used for the selected barrier would be transported from borrow areas located on or near the Hanford Site. Anticipated volumes of these materials are identified in Appendix F. Silt borrow locations have not yet been determined. Borrow materials most likely would come from near the waste sites or from Pit 30, which is located between the 200 East and 200 West Areas, and Quarry 2 Area C, which is located on the Fitzner-Eberhardt Arid Lands Ecology Reserve. Analysis of appropriate borrow sources has been addressed adequately in DOE/EA-1403, *Environmental Assessment, Use of Existing Borrow Areas, Hanford Site, Richland, Washington.* Borrow materials will undergo proper engineering evaluations before site selection. Borrow material does occur in environmentally sensitive areas; obtaining sufficient capping material could affect areas of ecological significance and is a consideration in evaluating the relative risk reduction gained by installing the engineered barrier.

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.

Specific to direct exposure and ecological protection, the RAOs would be achieved with the engineered barrier alternative as soon as the engineered barrier construction was completed and the institutional controls were implemented. These controls would be required for up to 141 years when the Cs-137 decays to acceptable levels at the 216-U-8 Crib (Table 4-2). Additional institutional controls could be required to adequately maintain control regarding groundwater protection associated with the deep contamination at the sites.

5.3.4.6 Implementability

An engineered barrier has been implemented at the Hanford Site (CP-14873, *200-BP-1 Prototype Hanford Barrier Annual Monitoring Report for Fiscal Year 2002).* Other types of barriers 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. The activities at the waste sites that are proposed to be incorporated with the 221-U Facility barrier can be coordinated easily.

Construction of the engineered barriers would follow standard procedures that have been thoroughly field tested. The barrier 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 performance monitoring. Implementation of the engineered barrier alternative would require additional design data (e.g., ground penetrating radar) and possibly confirmatory sampling, because existing data may not be adequate for determining the lateral extent of the engineered barriers.

Facilities and infrastructure in the vicinity of the waste sites could influence the implementability of a surface barrier option at a particular site. Implementing remedial actions at these sites would require additional coordination efforts.

However, as discussed in the other alternatives, the 241-U-361 Settling Tank, the analogous site to the 216-U-1 and 216-U-2 Cribs, poses an additional remedial challenge because of the sludge and liquid in the tank. Given the volume and nature of this material, removal of the sludge from the tank is assumed for this FFS. Removal of the sludge is implementable using proven techniques.

5.3.4.7 Cost

Table 5-5 shows the estimated costs of Alternative 4 for each applicable waste site; additional detail regarding the cost basis can be found in Appendix F. Included in the costs are stabilization of the existing site; excavation or import, transportation, and placement of material; compaction of the engineered barrier; prime contractor oversight; performance monitoring; and maintenance for the necessary attenuation period. 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 (i.e., blues and no respirators) during construction. These costs are based on an individual waste site and do not reflect economies of scale that might be obtained by implementing a common alternative or aggregated remedies across multiple waste sites. The present-worth costs assume a 3.2 percent discount rate (based on current Office of Management and Budget information), and the estimated number of years for natural attenuation to meet the RAOs for monitoring and maintenance.

5.4 NATIONAL ENVIRONMENTAL POLICY ACT OF 1969 VALUES EVALUATION

The NEPA process is intended to help Federal agencies make decisions that are based on understanding environmental consequences and then to take actions that protect, restore, and enhance the environment. Secretarial policy (DOE 1994) and DOE O 451.1B 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.

5.4.1 Description of National Environmental Policy Act of 1969 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 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 DOE has considered in this evaluation include the following.

- Transportation Impacts. This value considers impacts of the proposed remedial action on local traffic (i.e., 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 in the Central Plateau.

- Noise, Visual, and Aesthetic Effects. This value considers increases in noise levels or impaired visual or aesthetic values in the Central Plateau during or following 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 in 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.

5.4.2 Detailed Evaluation of the National Environmental Policy Act of 1969

5.4.2.1 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 Alternative 4, engineered barrier, impacts would result from hauling cover material to the Central Plateau. For Alternative 3, removal, treatment, and disposal, these impacts would result from hauling waste to the ERDF and hauling clean fill to the waste sites. For Alternatives 3 and 4, impacts could be expected from increased traffic bringing supplies, equipment, and workers to the sites. To mitigate these 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 treatment would be expected to be minor.

5.4.2.2 Air Quality

No current air quality impacts are associated with the no-action alternative; 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, maintain existing soil covers, institutional controls, and natural attenuation. Potential near-term impacts to air quality associated with Alternatives 3 and 4 are expected to be minor and could be mitigated through appropriate engineering controls. However, the potential is present for adverse impact to air quality from the release of radioactive material in the immediate vicinity of an excavation.

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 (both 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.

5.4.2.3 Natural, Cultural, and Historical Resources

The no-action alternative would not disturb or destroy natural, cultural, or historical resources; however, in some sites, biologic resources could be exposed to contaminants with potential

impacts. Alternative 2 would limit access to these resources. Alternatives 3 and 4 could affect cultural or natural resources, although the impacts could be mitigated. Therefore, adverse impacts to cultural resources could occur, if such resources were encountered and appropriate mitigating actions were not taken. Adverse impacts would be minimized by avoiding known cultural resources and traditional-use areas whenever possible. Most of the waste sites are located within areas previously disturbed by operations, so the potential for unknown cultural resources is low. Therefore, although cultural resources could be encountered with Alternatives 3 and 4 during the excavation and construction of staging areas, the probability is low. A cultural resource mitigation plan would be established before remediation begins. Known cultural resources and traditional-use areas would be avoided whenever possible. 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) could 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. Alternatives 3 and 4 also would have positive impacts on natural resources. The potential for exposure to contaminants would be minimized through either waste removal or barrier construction, and the sites would be revegetated.

5.4.2.4 Noise, Visual, and Aesthetic Effects

Alternatives 1 and 2 would have little to no impact on current noise, visual, or aesthetic site characteristics. Alternative 3 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 remaining site structures (e.g., retention basins, small shack). Likewise, the engineered barrier alternative would increase noise levels and impair visual values in the short term during construction of the engineered barrier. These two 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 Central Plateau, no impacts would be expected from the alternatives.

5.4.2.5 Socioeconomic Impacts

The no-action alternative would have no socioeconomic impacts. The other three 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.

5.4.2.6 Environmental Justice

Under Alternative 3, environmental justice issues would not be a concern, because future surface uses in the Central Plateau would not be restricted beyond the Central Plateau-wide restrictions.

Under Alternatives 1, 2, and 4, 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.

5.4.2.7 Irreversible and Irretrievable Commitment of Resources

Alternatives 3 and 4 would require some irreversible or irretrievable commitment of natural resources. All of the alternatives with the exception of no action would result in some temporary land-use loss. Alternatives 3 and 4 would require additional soils, including silt materials that could 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 Central Plateau until RAOs and goals were met through the natural attenuation process. 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 until the necessary attenuation period met RAOs. Alternative 3 generally would allow land use from ground surface to a depth of 4.6 m (15 ft) bgs immediately following implementation. Alternative 4 would allow surface use of the sites but would not allow any subsurface site use until the end of the necessary attenuation period to meet RAOs. This use would be limited based on potential impacts to surface-barrier integrity.

For Alternative 3, the ERDF would need to be expanded to accommodate the additional waste. The implementation of the alternative also would require limited waste disposal to the ERDF. The waste volumes from the aboveground structure demolition in Alternatives 3 and 4 are relatively small and are not anticipated to specifically require additional ERDF capacity.

Alternatives 3 and 4 would require an irretrievable and irreversible commitment of resources in the form of geologic materials and petroleum products (e.g., diesel fuel, gasoline). With the removal, treatment, and disposal alternative, excavated material would be replaced with a stockpile of clean soil cover removed from the site, 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 Fitzner-Eberhardt Arid Lands Ecology Reserve or from off Site.

5.4.2.8 Cumulative Impacts

The proposed remedial action alternatives 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 facility, 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 for the no-action alternative would require long-term land-use restrictions.

To varying levels, Alternatives 2, 3, and 4 would result in the loss of some land uses in the Central Plateau, but the cumulative impacts with respect to loss of land use are not expected to be significant. The removal, treatment, and disposal alternative also would require a commitment of land use as a result of the ERDF expansion in the Central Plateau. This would be in addition to numerous other Hanford Site projects that would commit land use in the Central Plateau.

Under Alternatives 3 and 4, 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 and has been addressed adequately in DOE/EA-1403.

5.4.2.9 Mitigation

The no-action alternative would not include mitigation. Mitigation measures under Alternative 2 would include surveillance, physical controls, and potential interim remedies. Mitigation measures taken under Alternatives 3 and 4 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.

5.4.2.10 Summary of National Environmental Policy Act of 1969 Evaluation

Remedial actions at the 200-UW-1 OU waste sites would result in some insignificant impacts. The short-term impacts are relatively more significant than the long-term impacts. It is anticipated that there will be transient disturbance of approximately 0.84 km^2 (0.32 mi^2) of already disturbed industrial area of low to marginal habitat quality. Impacts to borrow areas have been identified previously in the borrow assessment evaluations (DOE/EA-1403). Impacts to other NEPA values will be relatively less significant than the above transient disturbances of the U Plant Area and the impacts to associated borrow areas.

5.5 REFERENCES

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National Environmental Policy Act of 1969, 42 USC 4321, et seq.

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WAC 173-303-610(2), "Dangerous Waste Regulations," "Closure and Post-Closure," "Closure Performance Standard," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-303-610(7), "Dangerous Waste Regulations," "Closure and Post-Closure," "Post-Closure Care and Use of Property," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-303-610(8), "Dangerous Waste Regulations," "Closure and Post-Closure," "Post-Closure Plan; Amendment of Plan," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-303-610(9), "Dangerous Waste Regulations," "Closure and Post-Closure," "Notice to Local Land Authority," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-303-610(10), "Dangerous Waste Regulations," "Closure and Post-Closure," "Notice in Deed to Property," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-303-646(2), "Dangerous Waste Regulations," "Closure and Post-Closure," "Corrective Action," "Requirements," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-303-665(6), "Dangerous Waste Regulations," "Closure and Post-Closure," "Landfills," "Closure and Post-Closure Care," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-340, "Model Toxics Control Act -- Cleanup," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 246-272-18501, "Department of Health," "On-Site Sewage Systems," "Abandonment," *Washington Administrative Code*, as amended, Washington State Department of Health, Olympia, Washington.

Table 5-1. Crosswalk Between RCRA Treatment, Storage, and Disposal Postclosure Plan Requirements and Supporting Documentation.

RCRA Treatment, Storage, and Disposal Postclosure Plan Section	Information Contained	Location in Supporting Documents
Modified Postclosure Institutional Controls and Periodic Assessments	Includes institutional controls, periodic assessments and inspections	Will be incorporated through the U Plant Area Operations and Maintenance Plan.
Landfill Postclosure Requirements	Includes maintenance and monitoring of cover, maintain effectiveness of cover run-on and run-off	Will be incorporated through the U Plant Area Operations and Maintenance Plan.
Groundwater Monitoring Postclosure Requirements	Includes maintaining and monitoring of groundwater monitoring system, inspection, and replacement of wells	Will be incorporated through the U Plant Area Operations and Maintenance Plan. Groundwater monitoring requirements will be contained in the groundwater monitoring plan.
Personnel Training During Postclosure	Includes surveillance personnel, groundwater sampling and analysis task leader and sampling personnel, and additional training descriptions for landfill closure	Will be incorporated through the U Plant Area Operations and Maintenance Plan.
Security	Includes 24-Hour Surveillance System Barrier, Means to Control Entry, and Warning Signs	Will be incorporated through the U Plant Area Operations and Maintenance Plan.
Postclosure Contact	Includes name, address, and telephone number of contact person	Director, Environmental Assurance, Permits, and Policy Division*; U.S. Department of Energy – Richland Operations Office; PO Box 550; Richland, WA 99352 ---------- * or its equivalent, should there be a future reorganization of the U.S. Department of Energy – Richland Operations Office.

The postclosure requirements for the 216-U-12 Crib are contained in:

WAC 173-303-665(6)(b), "Dangerous Waste Regulations," "Landfills," "Closure and Post-Closure Care", and WAC 173-303-610(7), "Dangerous Waste Regulations," "Closure and Post-Closure," "Post-Closure Care and Use of Property";

(8), "Post-Closure Plan; Amendment of Plan";

(9), "Notice to Local Land Authority"; and

(10), "Notice in Deed to Property."

Table 5-2. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation. (4 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 ($1000)**
Representative Site							
216-U-1 and 216-U-2 Cribs	Protective of human health exposure over the 150-year timeframe, but exceeds the groundwater protection values.	Does not comply	Does not provide long-term effectiveness or permanence, because contaminants are not remedied and remain after the industrial land-use timeframe.	Reduction through natural attenuation of radionuclides.	Minimal short-term risks to workers.	Readily implementable	$393
Waste Site Analogous to 216-U-1 and 216-U-2 Cribs							
241-U-361 Settling Tanks	Protective of human health and the environment.	Complies.	Provides some long-term effectiveness and permanence, because it is assumed that the sludge within the tank is removed and minimal contamination is expected beyond the tank itself.	Reduction through natural attenuation of radionuclides	Minimal short-term risks to workers.	Readily implementable	$5,148
Representative Site							
216-U-8 Crib	Protective of human health exposure over the 150-year timeframe, but exceeds the groundwater protection values.	Does not comply	Does not provide long-term effectiveness or permanence, because contaminants are not remedied and remain after the industrial land-use timeframe.	Reduction through natural attenuation of radionuclides	Minimal short-term risks to workers.	Readily implementable	$393
Waste Site Analogous to 216-U-8 Crib							
200-W-42 VCP/ UPR-200-W-163	Protective of human health exposure over the 150-year timeframe.	Does not comply.	Provides long-term effectiveness and permanence.	Reduction through natural attenuation of radionuclides	Minimal short-term risks to workers.	Readily implementable	$393

Table 5-2. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation. (4 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 ($1000)**
Representative Site							
216-U-12 Crib	Protective of human health exposure over the 150-year timeframe, but exceeds the groundwater protection values.	Does not comply.	Does not provide long-term effectiveness or permanence, because contaminants are not remedied and remain after the industrial land-use timeframe.	Reduction through natural attenuation of radionuclides	Minimal short-term risks to workers.	Readily implementable	$393
Waste Sites Analogous to 216-U-12 Crib							
216-U-5, 216-U-6, and 216-U-15 Trenches	Protective of human health and the environment.	Complies.	Provides moderate effectiveness and permanence through natural attenuation, institutional controls, and groundwater monitoring.	Reduction through natural attenuation of radionuclides	Minimal short-term risks to workers.	Readily implementable	$1,167
216-U-16 and 216-U-17 Cribs	Protective of human health and the environment.	Complies.	Provides moderate effectiveness and permanence through natural attenuation, institutional controls, and groundwater monitoring.	Reduction through natural attenuation of radionuclides	Minimal short-term risks to workers.	Readily implementable	$917
Representative Site							
216-U-4 Reverse Well and 216-U-4A French Drain	Protective of human health exposure over the 150-year timeframe. This alternative has the added benefit that the 216-U-4 Reverse Well and 216-U-4A French Drain waste sites are under the proposed 221-U Facility engineered barrier.	Complies. The proposed 221-U Facility engineered barrier would accelerate achieving the ARARs, because the pathway for exposure would be removed.	Provides moderate effectiveness and permanence through natural attenuation, institutional controls, and groundwater monitoring.	Reduction through natural attenuation of radionuclides	Minimal short-term risks to workers.	Readily implementable	$193 if implemented alone. $74 if implemented with 221-U Facility barrier.

Table 5-2. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation. (4 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 ($1000)**
Waste Site Analogous to 216-U-4 Reverse Well and 216-U-4A French Drain							
216-U-4B French Drain	Protective of human health exposure over the 150-year timeframe.	Complies.	Provides moderate effectiveness and permanence through natural attenuation, institutional controls, and groundwater monitoring.	Reduction through natural attenuation of radionuclides	Minimal short-term risks to workers.	Readily implementable	$193
Representative Site							
UPR-200-W-19	Protective of human health exposure over the 150-year timeframe	Complies.	Provides moderate effectiveness and permanence through natural attenuation, institutional controls, and groundwater monitoring.	Reduction through natural attenuation of radionuclides	Minimal short-term risks to workers.	Readily implementable	$184
Waste Sites Analogous to UPR-200-W-19							
200-W-77, 200-W-85, 200-W-87, 200-W-89 Foundation, UPR-200-W-33, UPR-200-W-48, UPR-200-W-55, UPR-200-W-60, and UPR-200-W-117	Protective of human health exposure over the 150-year timeframe	Complies.	Provides some effectiveness and permanence through natural attenuation, institutional controls, and groundwater monitoring.	Reduction through natural attenuation of radionuclides	Minimal short-term risks to workers.	Readily implementable	$368
2607-W5 Septic Tank and Tile Field and 200-W-71 Pit Solid Waste Dump	Protective of human health exposure over the 150-year timeframe	Complies.	Provides some effectiveness and permanence through natural attenuation, institutional controls, and groundwater monitoring.	Reduction through natural attenuation of radionuclides.	Minimal short-term risks to workers.	Readily implementable	$92

Table 5-2. Detailed Analysis Summary for Alternative 2 – Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation. (4 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 ($1000)**
UPR-200-W-118 and UPR-200-W-78	Protective of human health exposure over the 150-year timeframe	Complies. The proposed 221-U Facility engineered barrier would accelerate achieving the ARARs, because the pathway for exposure would be removed.	Provides some effectiveness and permanence through natural attenuation, institutional controls, and groundwater monitoring.	Reduction through natural attenuation of radionuclides	Minimal short-term risks to workers.	Readily implementable	$230 if implemented alone. $110 if implemented with 221-U Facility barrier.
2607-W7 Septic Tank and Tile Field and Solid Waste Sites 200-W-56 Dump, 200-W-57 Dump, and Unplanned Release UPR-200-W-8 Burning Ground	Protective because the sites have been either cleaned up or no known hazardous substances were disposed.	Complies. The proposed 221-U Facility engineered barrier would accelerate achieving the ARARs, because the pathway for exposure would be removed.	Provides for long-term effectiveness and permanence because the sites comply with ARARs and would also be included in the 221-U Facility engineered barrier.				$184 if implemented alone. $160 if implemented with 221-U Facility barrier.

ARAR = applicable or relevant and appropriate requirement. RAO = remedial action objective.

Table 5-3. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (5 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 ($1000)
Representative Site							
216-U-1 and 216-U-2 Cribs	Protective because contaminants are removed to meet RAOs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet RAOs. Excavation proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	Very high short-term risks to workers; dose to workers estimated to be 948 rem, ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources because of the large excavation area.	Implementable but not practicable. Excavation to 220 ft is necessary to remove contaminants to RAOs.	$52,973
Waste Site Analogous to 216-U-1 and 216-U-2 Cribs							
241-U-361 Settling Tanks	Protective because contaminants are removed to meet RAOs	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet RAOs. Excavation proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	Medium short-term risks to workers primarily because of radiation exposures. Ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources because of the large excavation area	Readily implementable.	$5,078
Representative Site							
216-U-8 Crib	Protective because contaminants are removed to meet RAOs	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet RAOs. Excavation proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	High short-term risks to workers; dose to workers estimated to be 103 rem, ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources exists because of the large excavation area	Implementable but not practicable. Excavation to 200 ft is necessary to remove contaminants to RAOs. Requires a significantly large excavation that is difficult to implement, but can be done.	$62,266

Table 5-3. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (5 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 ($1000)
Waste Site Analogous to 216-U-8 Crib							
200-W-42 VCP/ UPR-200-W-163	Protective because contaminants are removed to meet RAOs	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet RAOs. Excavation proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	Moderate short-term risks to workers primarily because of radiation exposures. Ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources exists because of the large excavation area	Readily implementable.	$4,039
Representative Site							
216-U-12 Crib	Protective because contaminants are removed to meet RAOs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet RAOs. Excavation proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	Moderate to high short-term risks to workers; dose to workers estimated to be 0.006 rem, ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources because of the large excavation area	Implementable but not practicable. Excavation to 200 ft is necessary to remove contaminants to RAOs. Requires a significantly large excavation that is difficult to implement, but can be done.	$42,950
Waste Sites Analogous to 216-U-12 Crib							
216-U-5, 216-U-6, and 216-U-15 Trenches	Protective because contaminants are removed to meet RAOs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet RAOs. Excavation proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	Moderate short-term risks to workers primarily because of radiation exposures. Ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources because of the large excavation area	Implementable.	$1,201
216-U-16 and 216-U-17 Cribs	Protective because contaminants are removed to meet RAOs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet RAOs. Excavation proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	Moderate short-term risks to workers primarily because of radiation exposures. Ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources because of the large excavation area	Implementable.	$6,412

Table 5-3. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (5 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 ($1000)
Representative Site							
216-U-4 Reverse Well and 216-U-4A French Drain	Protective because contaminants are removed to meet RAOs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet RAOs. Excavation proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	Moderate short-term risks to workers primarily because of radiation exposures. Ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources because of the large excavation area	Readily Implementable.	$124
Waste Site Analogous to 216-U-4 Reverse Well and 216-U-4A French Drain							
216-U-4B French Drain	Protective because contaminants are removed to meet RAOs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet RAOs. Excavation proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	Moderate short-term risks to workers primarily because of radiation exposures. Ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources because of the large excavation area	Readily Implementable.	$115
Representative Site							
UPR-200-W-19	Protective because contaminants are removed to meet RAOs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet RAOs. Excavation proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	Moderate short-term risks to workers primarily because of radiation exposures. Ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources because of the large excavation area	Readily Implementable.	$5,184

Table 5-3. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (5 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 ($1000)
Waste Sites Analogous to UPR-200-W-19							
200-W-77, 200--W-85, 200-W-87, 200-W-89 Foundation, UPR-200-W-33, UPR-200-W-48, UPR-200-W-55, UPR-200-W-60, and UPR-200-W-117	Protective because contaminants are removed to meet RAOs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet RAOs. Excavation proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	Moderate short-term risks to workers primarily because of radiation exposures. Ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources because of the large excavation area	Readily Implementable.	$1,198
2607-W5 Septic Tank and Tile Field and 200-W-71 Pit Solid Waste Dump	Protective because contaminants are removed to meet RAOs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet RAOs. Excavation proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	Moderate short-term risks to workers primarily because of radiation exposures. Ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources because of the large excavation area	Readily Implementable.	$2,252
UPR-200-W-118 and UPR-200-W-78	Protective because contaminants are removed to meet RAOs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet RAOs. Excavation proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	Moderate short-term risks to workers primarily because of radiation exposures. Ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources because of the large excavation area	Readily Implementable.	$4,144

Table 5-3. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (5 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 ($1000)
2607-W7 Septic Tank and Tile Field and Solid Waste Sites 200-W-56 Dump, 200-W-57 Dump, and Unplanned Release UPR-200-W-8 Burning Ground	Protective because contaminants are removed to meet RAOs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet RAOs. Excavation proven technology, with little chance of failure.	Contaminants are moved to a less mobile environment. Reduction through natural attenuation of radionuclides	Moderate short-term risks to workers primarily because of radiation exposures. Ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources because of the large excavation area	Readily implementable.	$3,421

ARAR = applicable or relevant and appropriate requirement

Table 5-4. Detailed Analysis Summary for Alternative 4 – Engineered Barrier. (4 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 ($1000)
Representative Site							
216-U-1 and 216-U-2 Cribs	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Barrier is effective for the design life of the engineered barrier until RAOs are achieved.	Reduction through natural attenuation of radionuclides and reduction of water infiltration.	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$1,347
Waste Site Analogous to 216-U-1 and 216-U-2 Cribs							
241-U-361 Settling Tanks	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Barrier is effective for the design life of the engineered barrier until RAOs are achieved.	Reduction through natural attenuation of radionuclides and reduction of water infiltration.	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer	Readily implementable; source of fine grain capping materials has not been identified.	$5,674
Representative Site							
216-U-8 Crib	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Barrier is effective for the design life of the engineered barrier until RAOs are achieved.	Reduction through natural attenuation of radionuclides and reduction of water infiltration.	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$1,598
Waste Site Analogous to 216-U-8 Crib							
200-W-42 VCP/ UPR-200-W-163	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Barrier is effective for the design life of the engineered barrier until RAOs are achieved.	Reduction through natural attenuation of radionuclides and reduction of water infiltration.	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$2,906
Representative Site							
216-U-12 Crib	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Barrier is effective for the design life of the engineered barrier until RAOs are achieved.	Reduction through natural attenuation of radionuclides and reduction of water infiltration.	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$1,106

Table 5-4. Detailed Analysis Summary for Alternative 4 – Engineered Barrier. (4 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 ($1000)**
Waste Sites Analogous to 216-U-12 Crib							
216-U-5, 216-U-6, and 216-U-15 Trenches	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Barrier is effective for the design life of the engineered barrier until RAOs are achieved.	Reduction through natural attenuation of radionuclides and reduction of water infiltration.	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$2,900
216-U-16 and 216-U-17 Cribs	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Barrier is effective for the design life of the engineered barrier until RAOs are achieved.	Reduction through natural attenuation of radionuclides and reduction of water infiltration.	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$3,193
Representative Site							
216-U-4 Reverse Well and 216-U-4A French Drain	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion. Institutional controls will need to be in place for 125 years, the time required for the constituents to naturally decay.	Complies with ARARs because the barrier is in place.	Barrier is effective for the design life of the engineered barrier until RAOs are achieved.	Reduction through natural attenuation of radionuclides and reduction of water infiltration.	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$695
Waste Site Analogous to 216-U-4 Reverse Well and 216-U-4A French Drain							
216-U-4B French Drain	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Barrier is effective for the design life of the engineered barrier until RAOs are achieved.	Reduction through natural attenuation of radionuclides and reduction of water infiltration.	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$692

Table 5-4. Detailed Analysis Summary for Alternative 4 – Engineered Barrier. (4 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 ($1000)
Representative Site							
UPR-200-W-19	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion. Institutional controls will need to be in place for 129 years, the time required for the constituents to naturally decay.	Complies with ARARs because the barrier is in place.	Barrier is effective for the design life of the engineered barrier until RAOs are achieved.	Reduction through natural attenuation of radionuclides and reduction of water infiltration..	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$2,541
Waste Sites Analogous to UPR-200-W-19							
200-W-77, 200-W-85, 200-W-87, 200-W-89 Foundation, UPR-200-W-33, UPR-200-W-48, UPR-200-W-55, UPR-200-W-60, and UPR-200-W-117	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Barrier is effective for the design life of the engineered barrier until RAOs are achieved.	Reduction through natural attenuation of radionuclides and reduction of water infiltration.	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$6,078
2607-W5 Septic Tank and Tile Field and 200-W-71 Pit Solid Waste Dump	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place s	Barrier is effective for the design life of the engineered barrier until RAOs are achieved.	Reduction through natural attenuation of radionuclides and reduction of water infiltration.	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$2,930
UPR-200-W-118 and UPR-200-W-78	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place	Barrier is effective for the design life of the engineered barrier until RAOs are achieved.	Reduction through natural attenuation of radionuclides and reduction of water infiltration.	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$2,292

Table 5-4. Detailed Analysis Summary for Alternative 4 – Engineered Barrier. (4 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 ($1000)
2607-W7 Septic Tank and Tile Field and Solid Waste Sites 200-W-56 Dump, 200-W-57 Dump, and Unplanned Release UPR-200-W-8 Burning Ground	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place.	Barrier is effective for the design life of the engineered barrier until RAOs are achieved.	Reduction through natural attenuation of radionuclides and reduction of water infiltration..	Limited short-term risks to workers; no ecological risks expected; site will be capped and clean soil placed as the final layer.	Readily implementable; source of fine grain capping materials has not been identified.	$4,390

ARAR = applicable or relevant and appropriate requirement

RAO = preliminary remediation goal.

RCRA = *Resource Conservation and Recovery Act of 1976.*

Table 5-5. Net Present Worth Cost Estimates (in $1,000). (2 Pages)

Waste Site/Group	Alternative 1: No Action	Alternative 2: Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation	Alternative 3: Removal, Treatment, and Disposal	Alternative 4: Engineered Barrier
Representative Site				
216-U-1 Crib / 216-U-2 Crib	-	$393	$52,973	$1,347
Process Waste Group Analogous Site to be Evaluated by the 216-U-1 and 216-U-2 Crib Model				
241-U-361 Settling Tank	-	$5,148	$5,078	$5,674
Representative Site				
216-U-8 Crib	-	$393	$62,266	$1,598
Process Waste Group Analogous Site to be Evaluated by the 216-U-8 Crib Model				
200-W-42 VCP/UPR-200-W-163	-	$393	$4,039	$2,906
Representative Site				
216-U-12 Crib	-	$393	$42,950	$1,106
Process Waste Group Analogous Sites to be Evaluated by the 216-U-12 Crib Model				
216-U-5 Trench	-	$389	$552	$1,007
216-U-6 Trench	-	$389	$494	$994
216-U-15 Trench	-	$389	$155	$899
216-U-16 Crib	-	$528	$4,928	$1,998
216-U-17 Crib	-	$389	$1,484	$1,195
Representative Site				
216-U-4 Reverse Well/ 216-U-4A French Drain[a]	-	$193/ $74[b]	$124	$695
Reverse Well/French Drain Group Analogous Site to be Evaluated by the 216-U-4/216-U-4A Model				
216-U-4B French Drain	-	$193	$115	$692
Representative Site				
UPR-200-W-19	-	$184	$5,184	$2,541
Septic System Group Analogous Sites to be Evaluated by the UPR-200-W-19 Model				
2607-W5 Septic System	-	$46	$1,407	$1,927
2607-W7[a] Septic Tank	-	$46/ $22[b]	$648	$1,257

Table 5-5. Net Present Worth Cost Estimates (in $1,000). (2 Pages)

Waste Site/Group	Alternative 1: No Action	Alternative 2: Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation	Alternative 3: Removal, Treatment, and Disposal	Alternative 4: Engineered Barrier
Solid Waste Group Analogous Sites to be Evaluated by the UPR-200-W-19 Model				
200-W-56 Dump	-	$46	$105	$695
200-W-57 Dump	-	$46	$167	$781
200-W-71 Pit	-	$46	$845	$1,003
UPR-200-W-8	-	$46	$2,501	$1,657
Unplanned Release Group Analogous Site to be Evaluated by the UPR-200-W-19 Model				
UPR-200-W-118[a]	-	$184/ $88[b]	$4,040	$1,596
Shallow/Surface Waste Site Group Analogous Sites to be Evaluated by the UPR-200-W-19 Model				
200-W-77	-	$46	$106	$696
200-W-85	-	$46	$111	$705
200-W-87	-	$46	$167	$785
200-W-89	-	$46	$274	$928
UPR-200-W-33	-	$46	$106	$702
UPR-200-W-48	-	$46	$121	$721
UPR-200-W-55	-	$46	$105	$695
UPR-200-W-78[a]	-	$46/$22[b]	$104	$696
UPR-200-W-117 / UPR-200-W-60	-	$46	$208	$846

NOTES:

Cost details are in Appendix F.

Net present worth is taken over the timeframe needed to reach industrial and ecological preliminary remediation goals.

[a] These waste sites are anticipated to be under the boundary of the barrier anticipated for the 221-U Facility.

[b] The costs shown in the left column are based on maintaining the required institutional controls at the given site for the full implementation period of Alternative 2 (that is, 125 years for 216-U-4/216-U-4A). Potentially, however, Alternative 2 for these sites may be combined with the implementation of the proposed barrier over the 221-U Facility. If, as anticipated, the barrier were to be placed within the next 20 years, maintaining institutional controls at the site correspondingly would be reduced to 20 years. The costs shown on the right column are based on the reduced institutional controls costs resulting from this potential combination of Alternative 2 and the proposed barrier.

CHAPTER 6.0

COMPARATIVE ANALYSIS OF ALTERNATIVES

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CONTENTS

6.0 COMPARATIVE ANALYSIS OF ALTERNATIVES 6-1
6.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT 6-1
6.2 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS 6-2
6.3 LONG-TERM EFFECTIVENESS AND PERMANENCE 6-3
6.4 REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT 6-4
6.5 SHORT-TERM EFFECTIVENESS 6-4
6.6 IMPLEMENTABILITY 6-5
6.7 COST 6-5
6.8 REFERENCES 6-5

TERMS

ARAR	applicable or relevant and appropriate requirement
CERCLA	*Comprehensive Environmental Response, Compensation and Liability Act of 1980*
OU	operable unit
RAO	remedial action objective

6.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

This chapter presents the comparative analysis of the four remedial alternatives for the 200-UW-1 Operable Unit (OU) waste sites to identify their relative advantages and disadvantages. This comparison is based on the seven *Comprehensive Environmental Response, Compensation and Liability Act of 1980* (CERCLA) evaluation criteria discussed in Section 5.1. The results of this analysis provide a basis for selecting a remedial alternative for each representative waste site and associated analogous waste sites. The list of representative sites and their associated analogous sites is presented in Tables 2-2 to 2-7. These remedial alternatives, as described in Chapter 4.0, are as follows:

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

6.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Alternative 1 would fail to provide overall protection of human health and the environment where contaminants above the remedial action objectives (RAO) would remain on site (as shown in Appendices C and D and summarized in Sections 2.7 and 2.8). However, there are four waste sites where, upon confirmatory sampling, the no-action alternative may be implemented. These four sites are the 200-W-56 and 200-W-57 Dumps; the UPR-200-W-8 Pit, and the 2607-W7 Septic Tank.

Alternative 2 would provide overall protection of human health and the environment for sites that show protection of groundwater and achieve human health protection within 150 years (as shown in Appendices C and D and summarized in Sections 2.7 and 2.8). All of the representative waste sites in the 200-UW-1 OU exceed the human health protection criteria when evaluated without considering the existing soil cover, and with the exception of the 216-U-4 Reverse Well / 216-U-4A French Drain and the UPR-200-W-19 unplanned release waste sites, they also exceed the groundwater protection criteria. Several of the analogous waste sites have a limited contaminant inventory, primarily located within the shallow zone. These analogous sites are assumed, based on the representative sites, to be protective of human health and the environment through maintenance of the existing soil cover. Confirmatory sampling would be used to validate the groundwater protection criterion and to determine the appropriate timeframe for decay of the constituents to acceptable levels. In addition, the 221-U Facility currently is undergoing a concurrent decision-making process. Implementation of the engineered barrier at the 221-U Facility would allow these sites to undergo institutional controls that, in concert with the proposed 221-U Facility engineered barrier, would be protective. These sites include the

216-U-4 Reverse Well, the 216-U-4A French Drain, unplanned releases UPR-200-W-118 and UPR-200-W-78, and the 2607-W7 Septic Tank.

Alternative 3 is considered protective of human health and the environment for those sites that do not have deep contamination concerns (i.e., protection of groundwater concerns) (as shown in Appendices C and D and summarized in Sections 2.7 and 2.8). Many of the analogous sites are small, with anticipated shallow contaminants. For those sites with deep contamination (e.g., representative sites 216-U-8 Crib, 216-U-12 Crib, 216-U-1/216-U-2 Cribs), an engineered excavation such as benching (similar to mining operations) would be required. Although protective of human health and the environment, the significant depth increases the remediation duration and therefore has an increased worker risk. As such, the amount of risk reduction achieved by implementing this alternative at these three representative sites is considered low, because these waste sites exceed the groundwater protection criteria.

Alternative 4 is considered protective of human health and the environment, because it would break potential exposure pathways to receptors through placement of a engineered surface barrier and institutional controls. Institution controls would be maintained at capped sites until the RAOs are achieved. 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 barrier performance. The engineered barrier would provide additional intrusion protection and 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) at depth. These sites include the 216-U-8 Crib, 216-U-12 Crib, and the 216-U-1 and 216-U-2 Cribs.

Alternative 4 is protective, provided that monitoring (e.g., monitored natural attenuation, barrier performance, groundwater protection) is implemented where groundwater protection criteria are exceeded. Alternatives 2 and 4 would leave contamination on site and would require institutional controls to be protective over the necessary timeframe. Alternative 3 would remove contaminants above the RAOs, where practicable and cost effective.

6.2 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Alternative 1 complies with applicable or relevant and appropriate requirements (ARAR) for those sites that meet the criteria for the no-action alternative. Alternative 1 does not comply with ARARs for the other waste sites.

Alternative 2 generally does not comply with the ARARs, because it is not protective of human health and the environment for three of the representative sites (i.e., the 216-U-8, 216-U-12, and the 216-U-1/216-U-2 Cribs). However, this alternative would comply with all ARARS for those sites that are in the effective boundary of the 221-U Facility proposed engineered barrier or those analogous waste sites that have limited inventory, primarily located within the shallow zone. Confirmatory sampling is planned before this alternative is implemented.

Alternative 3 complies with the ARARs by removing contaminants to levels that meet the RAOs. However, worker protection ARARs may be exceeded without adequate worker protections because of the extended remediation duration required for removal of contaminants at depths of nearly 61 m (200 ft) below ground surface.

Alternative 4 complies with the ARARs by breaking the exposure pathway and by reducing infiltration. Preliminary fate and transport modeling was conducted to simulate the reduced infiltration associated with the placement of the engineered barrier. This modeling indicates that the engineered barrier reduces the flux of contaminants into groundwater to an amount that, in the absence of other existing contaminant sources in groundwater, results in groundwater concentrations below the maximum contaminant level.

6.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

Alternative 1 is not effective in the long term where waste remains in place. In contrast, the other three alternatives would be effective and protective in the long term, but to different levels.

Alternative 2 would be an effective and permanent remedial action for the waste sites that will reach the RAOs within about 150 years (e.g., UPR-200-W-19, 2607-W5 Septic Tank and Tile Field, 200-W-71 Pit). Alternative 2 would not be an effective and permanent remedial action in the long term for those waste sites that do not meet the RAOs within this 150-year timeframe because of the extended period of time that contaminants would remain on site. An extended length of institutional control and monitoring would be required for the alternative to be effective.

Alternative 3 would provide the highest degree of effectiveness and permanence in the long term. With Alternative 3, contaminant concentrations above the RAOs would be removed. Thus, no long-term restrictions likely would be required after remediation is completed. The removed contaminated material would be disposed of at the Environmental Restoration Disposal Facility.

Alternative 4 provides the highest degree of overall effectiveness in the long term for many of the waste sites, because it addresses all the potential pathways: direct exposure of humans and terrestrial wildlife and protection of groundwater. Alternative 4 would be protective in the long term by breaking the exposure pathways and reducing the infiltration through the contaminated zone. Long-term effectiveness depends on maintaining the engineered barrier and associated monitoring (e.g., barrier performance, natural attenuation). For those waste sites where deeper contamination is identified as exceeding groundwater protection criteria, Alternative 4 would require additional monitoring (e.g., groundwater protection). Therefore, long-term restrictions would apply.

6.4 REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

None of the alternatives include treatment and, therefore, they do not reduce toxicity, mobility, or volume of the contaminants. All the alternatives incorporate natural attenuation in the form of radiological decay, which ultimately results in reduced toxicity and volume. Alternatives 3 and 4 provide an additional perceived reduction because they include a physical action that places the contaminants in a more managed environment, thereby reducing the forces (e.g., infiltration) that drive the contaminants toward groundwater.

6.5 SHORT-TERM EFFECTIVENESS

Alternative 1 would be effective in the short term, because it does not involve any remedial actions. Alternatives 2 and 4 would be more effective in the short term than Alternative 3, predominantly because of lower risk to remediation workers.

Alternative 3 would generate a large volume of contaminated soil and debris, which would create a potential for short-term worker impacts during excavation and transportation of the excavated materials. Risks to workers from potential exposure to contaminated soil and fugitive dust would be greater with Alternative 3 than with Alternative 4. However, for some of the sites, Alternative 4 also would entail aboveground structure demolition, transportation of contaminated debris, and filling of subsurface void spaces. Short-term impacts to vegetation and wildlife could be significant for Alternatives 3 and 4 because of disturbances at the waste site associated with removal or barrier construction and disturbances at the borrow sites for backfill and/or barrier materials. However, the U Plant Area is a highly disturbed area with limited habitat in close proximity to the waste sites. The actual short-term impacts to vegetation and wildlife will vary from site to site but are considered minimal because of the limited resources within the area. Alternatives 3 and 4 have the highest probability of affecting cultural resources in the short term because of the large land-area disturbance.

Alternative 4 would pose less risk to workers than Alternative 3, because the remove-and-dispose component of the engineered barrier alternative is limited to aboveground structures and below grade interference and would affect only a few of the waste sites. Limited waste would be handled, so the risks to remediation workers associated with this option would be lower than those related to the large-scale excavation, characterization, transportation, and disposal of waste with Alternative 3. Additional short-term risk to workers would be expected from the transportation of materials and construction of the caps, but these activities would pose less short-term risk than activities associated with the remove-and-dispose alternative. Furthermore, because of the smaller land area affected and the shorter duration to implement the engineered barrier alternative, Alternative 4 would be more effective than Alternative 3 in the short term with respect to reduced impact on potential cultural and ecological resources. If barriers are required for the waste sites, the need for fine-grained materials for cap construction becomes a concern. These materials are limited at the Hanford Site and tend to be located in potentially ecologically sensitive areas.

6.6 IMPLEMENTABILITY

Alternative 1 would be easily implemented, because no action is performed.

Alternative 2 is currently in use for all of the waste sites. The waste sites are in a surveillance and monitoring program and are posted with signs and/or the area is fenced. Access to the waste sites also is controlled through Hanford Site access requirements, an excavation permit program, and a radiation work area permit program. The addition of monitoring wells or boreholes is easily implementable.

Alternative 3 would be more complicated to implement in the near term because of the difficulties and safety requirements associated with the excavation, transportation, and disposal of soil and debris. For those sites with contamination at significant depth (i.e., 216-U-1/216-U-2, 216-U-8, and 216-U-12 Cribs) this remedy is not implementable or cost effective.

Alternative 3 would involve excavation and segregation of pipes, concrete structures, and other solid waste. The volume of waste generated by this alternative would require increased daily production capacity at the Environmental Restoration Disposal Facility.

Alternative 4 is implementable. An engineered barrier has been implemented at the Hanford Site and other types of barriers have been regulatory approved and implemented at other western arid sites and are easy to construction and maintain. Facilities and infrastructure in the vicinity of the waste sites could influence the implementability of a surface barrier option at a particular site.

6.7 COST

The cost to implement the alternatives is presented in Appendix F. Alternative 1 has no cost associated with it and has no additional benefit to human health and the environment over current risks. Alternative 2 has the lowest cost, because it is minimally invasive and does not include labor-intensive activities. Alternative 3 is the most cost effective for many of the waste sites because of shallow contamination. However, Alternative 3 is extremely costly for those sites that require excavation depths of nearly 61 m (200 ft) below ground surface because of the groundwater protection criteria being exceeded. Alternatives 2 and 3 are similar in cost for many low-volume, shallow waste sites. Alternative 4 tends to be cost effective for those deep contaminants that pose a threat to the groundwater. Because the risks are fairly low at the waste sites and groundwater protection issues tend to be at depth, the level of risk reduction is low and costs become a more significant discriminator among alternatives.

6.8 REFERENCES

Comprehensive Environmental Response, Compensation and Liability Act of 1980, 42 USC 9601, et seq.

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