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DOE/RL-2004-24
Draft B

Feasibility Study for the 200-CW-5 Cooling Water Operable Unit

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

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

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J. D. Aardal 07/01/2008
Release Approval Date

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TERMS

AD	soil sampling analytical data
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
BCA	bias-corrected accelerated bootstrap method
BCG	biota concentration guide
bgs	below ground surface
BRA	baseline risk assessment
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CLARC	*Cleanup Levels and Risk Calculations under the Model Toxics Control Act Regulation* (CLARC Version 3.1) (Ecology 94-145)
CLT	central limit theorem
COC	contaminant of concern
COPC	contaminant of potential concern
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
ERDF	Environmental Restoration Disposal Facility
ET	evapotranspiration
FS	feasibility study
FY	fiscal year
GRA	general response action
GW	groundwater
HCP	DOE/EIS-0222-F, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*
HEPA	high-efficiency particulate air (filter)
HH	human health
HQ	hazard quotient
IC	institutional controls
Implementation Plan	DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*
ISV	in situ vitrification
K_d	distribution coefficient
MCL	maximum contaminant level
MESC	maintain existing soil cover
MESC/MNA/IC	maintain existing soil cover/monitored natural attenuation/institutional controls
MNA	monitored natural attenuation
N/A	not applicable
NEPA	*National Environmental Policy Act of 1969*
ORP	U.S. Department of Energy, Office of River Protection

OU	operable unit
PCB	polychlorinated biphenyl
PFP	Plutonium Finishing Plant
PRG	preliminary remediation goal
Proposed Plan	DOE/RL-2004-26, *Proposed Plan for the 200-CW-5 Cooling Water Operable Unit*
PVC	polyvinyl chloride
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
RESRAD	RESidual RADioactivity (dose model)
RI Report	DOE/RL-2003-11, *Remedial Investigation Report for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units*
RI/FS Work Plan	DOE/RL-99-66, *Steam Condensate/Cooling Water Waste Group Operable Units RI/FS Work Plan; Includes: 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 Operable Units*
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RL	U.S. Department of Energy, Richland Operations Office
RLS	radionuclide logging system
ROD	record of decision
RTD	removal, treatment, and disposal
STOMP	Subsurface Transport Over Multiple Phases (code)
TMV	toxicity, mobility, or volume through treatment
Tri-Parties	U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989)
TRU	Radioactive waste as defined in DOE G 435.1-1, *Implementation Guide for Use with DOE M 435.1-1*
TSD	treatment, storage, and/or disposal (unit)
UCL	upper confidence limit
UPR	unplanned release
WAC	*Washington Administrative Code*
WIDS	*Waste Information Data System* database
WIPP	Waste Isolation Pilot Plant
XS	X-ray spectroscopy

METRIC CONVERSION CHART

Into Metric Units			Out of Metric Units		
If you know	*Multiply by*	*To get*	*If you know*	*Multiply by*	*To get*
Length			**Length**		
inches	25.40	millimeters	Millimeters	0.0394	inches
inches	2.54	centimeters	Centimeters	0.394	inches
feet	0.305	meters	Meters	3.281	feet
yards	0.914	meters	Meters	1.094	yards
miles (statute)	1.609	kilometers	Kilometers	0.621	miles (statute)
Area			**Area**		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.0929	sq. meters	sq. meters	10.764	sq. feet
sq. yards	0.836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.591	sq. kilometers	sq. kilometers	0.386	sq. miles
acres	0.405	hectares	Hectares	2.471	acres
Mass (weight)			**Mass (weight)**		
ounces (avoir)	28.349	grams	Grams	0.0353	ounces (avoir)
pounds	0.454	kilograms	Kilograms	2.205	pounds (avoir)
tons (short)	0.907	ton (metric)	ton (metric)	1.102	tons (short)
Volume			**Volume**		
teaspoons	5	milliliters	Milliliters	0.034	ounces (U.S., liquid)
tablespoons	15	milliliters	Liters	2.113	pints
ounces (U.S., liquid)	29.573	milliliters	Liters	1.057	quarts (U.S., liquid)
cups	0.24	liters	Liters	0.264	gallons (U.S., liquid)
pints	0.473	liters	cubic meters	35.315	cubic feet
quarts (U.S., liquid)	0.946	liters	cubic meters	1.308	cubic yards
gallons (U.S., liquid)	3.785	liters			
cubic feet	0.0283	cubic meters			
cubic yards	0.764	cubic meters			
Temperature			**Temperature**		
Fahrenheit	(°F-32)*5/9	Centigrade	Centigrade	(°C*9/5)+32	Fahrenheit
Radioactivity			**Radioactivity**		
picocurie	37	millibecquerel	millibecquerel	0.027	picocurie

1

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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," pursuant to the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). The 200 Area National Priorities List site consists of the 200 West Area and 200 East Area (Figure 1-1), which contain waste management facilities and inactive irradiated fuel reprocessing facilities; the 200 North Area, formerly used for interim storage and staging of irradiated fuel; and several waste sites in the 600 Area, which is located near the 200 Areas.

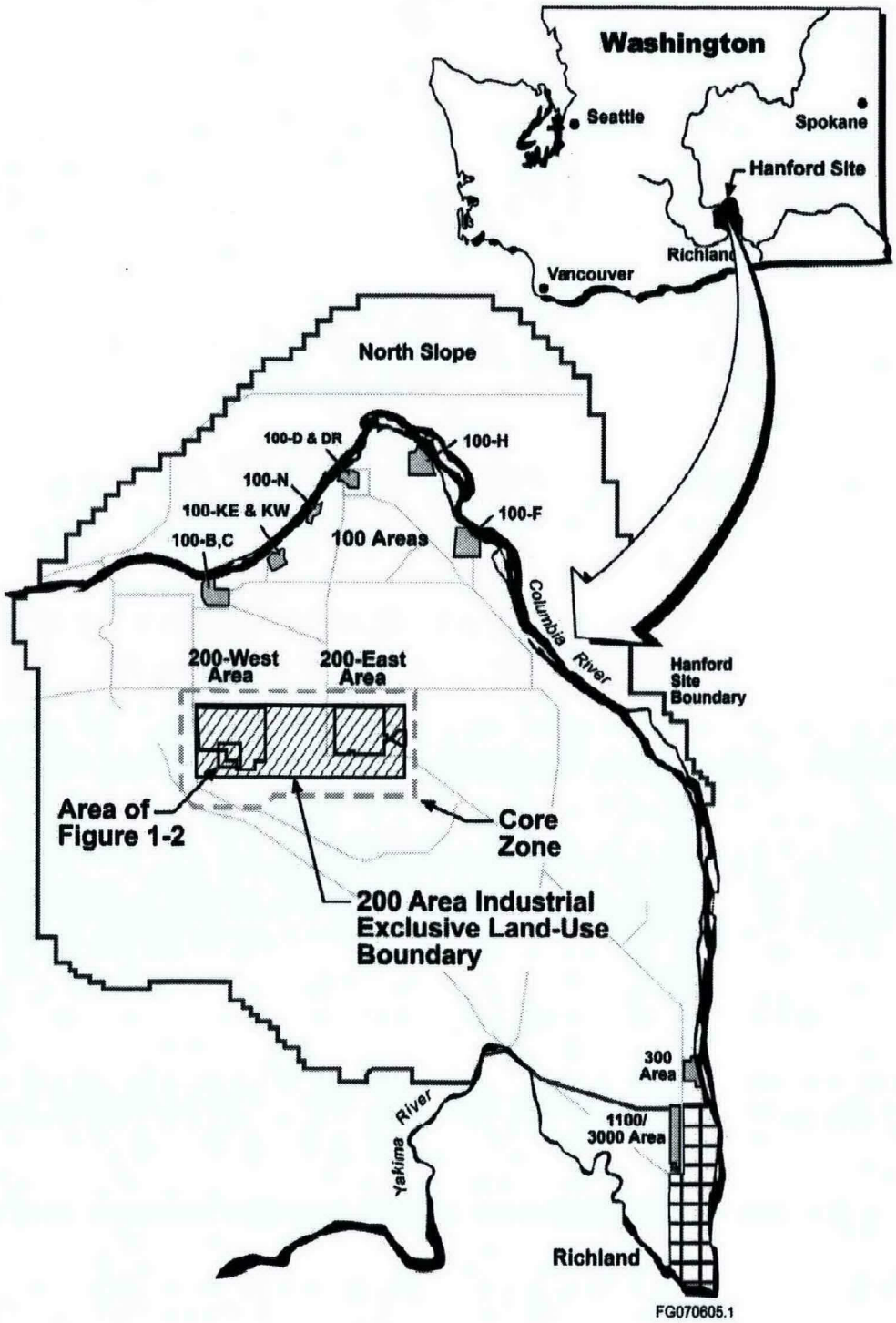
The 200 Areas consist of hundreds of waste sites grouped into operable units (OU). The 200-CW-5 Z-Ditches Cooling Water Waste Group OU is the focus of this Draft B feasibility study (FS). The 200-CW-5 OU is a CERCLA past-practice OU under the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al., 1989) having EPA as the lead regulatory agency. The 200-CW-5 OU is located in the 200 West Area of the Hanford Site's Central Plateau, as shown in Figure 1-1. The 200-CW-5 OU waste sites (located as shown in Figure 1-2) primarily received cooling water, steam condensate, and chemical sewer waste waters potentially containing radiological and chemical contaminants from Z Plant facilities of the 200 West Area. Figure 1-3 shows current conditions at the Z-Ditches that are the subject of this FS and the amount and type of vegetation present on and/or around the Z-Ditches waste sites that have been backfilled and surface stabilized, and are in proximity to one another.

1.1 OPERABLE UNIT ORGANIZATION

The nature and number of OUs at the Hanford Site have evolved as the Hanford Site investigation process has matured. The OUs were established using predominantly historical information based on process knowledge. The preliminary conceptual models developed from these early OUs provided both an initial prediction of the nature and extent of primary contaminants of concern (COC) and support for the selection of representative sites and prioritization of groups.

The Tri-Party Agreement establishes major milestones for completing the waste site investigation effort by December 31, 2011, and completing waste site remediation of non-tank farm OUs in the 200 Areas by September 30, 2024 (Milestones M-15-00C and M-16-00, respectively). In 2002, the U.S. Department of Energy, Richland Operations Office (RL), EPA, and Washington State Department of Ecology (Ecology) (the Tri-Parties) renegotiated the 200 Areas waste site cleanup milestones under the Tri-Party Agreement, further consolidating the OUs (Ecology, DOE, and EPA, 2002, *Hanford Tri-Party Agreement Modifications to 200 Area Waste Sites Cleanup Milestones, Tri-Party Agreement Change Requests and Comment and Response Document)*. The Tri-Parties agreed to combine the 200-CW-2 OU, 200-CW-4 OU, and 200-SC-1 OU with the 200-CW-5 OU for investigation and remedial decision making. Remedial investigation (RI) of these consolidated OUs occurred under DOE/RL-99-66, *Steam Condensate/Cooling Waste Group Operable Units RI/FS Work Plan, Includes: 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 Operable Unit* (RI/FS Work Plan).

Figure 1-1. Location of the Hanford Site and the 200-CW-5 Operable Unit in the 200 West Area.



Note: Core Zone boundary presented pertains to CERCLA risk analyses.

Figure 1-2. Location of the 200-CW-5 Operable Unit Waste Sites.

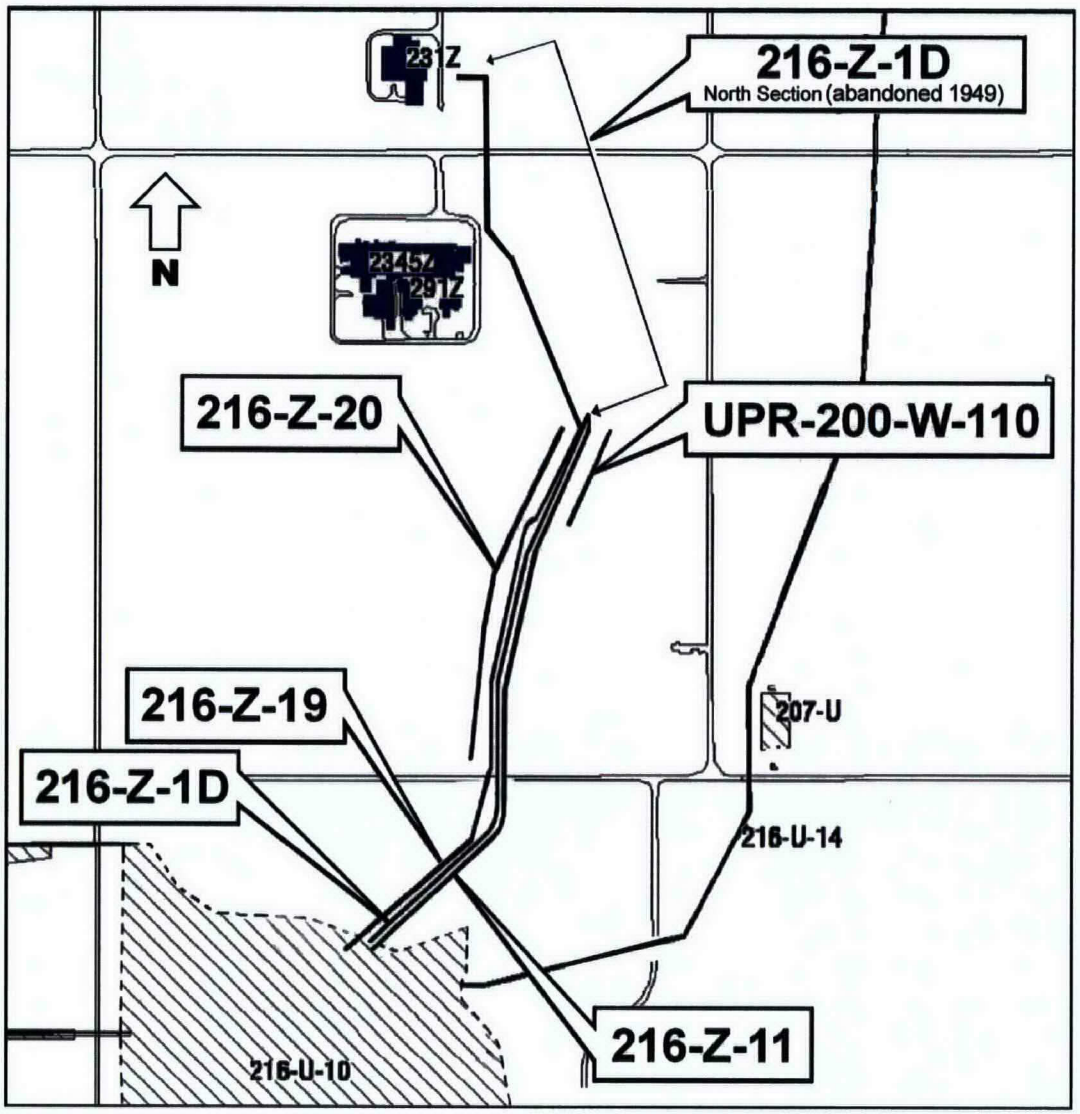


Figure 1-3. Photograph of the 216-Z Ditches.

In 2005 and 2006, the Tri-Parties modified the 2002 Tri-Party Agreement. These Tri-Party Agreement modifications changed the scope of the 200-CW-5 OU remedial investigation/ feasibility study (RI/FS) process by reassigning formerly consolidated waste sites of the 200-CW-2 OUs, 200-CW-4 OUs, 200-SC-1 OUs, and several 200-CW-5 OUs to other RI/FS processes. Table 1-1 identifies these modifications and provides a crosswalk to the RI/FS processes for the reassigned waste sites. Tri-Party Agreement Change Number M-15-07-03 modified the due date of Milestone M-15-40, "Submit a Revised Feasibility Study Report and a Revised Proposed Plan for 200-CW-5 OU to EPA," from April 30, 2008 to July 31, 2008. The change of due date allows additional analysis of exposure-point concentrations (EPC) within the Z-Ditches.

After the changes shown in Table 1-1, five 200-CW-5 OU waste sites remain within the scope of this FS. These sites include the 216-Z-1D Ditch, 216-Z-11 Ditch, 216-Z-19 Ditch, 216-Z-20 Tile Field, and UPR-200-W-110 (added from 200-PW-1). The 216-Z-1D Ditch has been further divided for remedial decision making into north and south sections (Chapter 2.0). The sites are shown in Figure 1-2. The 200-CW-5 OU waste sites are being addressed as CERCLA past-practice sites with EPA as the lead regulatory agency.

Draft A of this FS was submitted to the EPA for review in October 2004, in accordance with Tri-Party Agreement Milestone M-015-40C. Draft B incorporates information based on EPA's Draft A review comments. In addition, this FS incorporates information associated with changes

to the Tri-Party Agreement that focused on M-015 major and interim milestones and SGW-37174, *Z-Ditches Study for the 200-CW-5 Z-Ditches Cooling Water Operable Unit* (see Appendix A of this document). During the 2005–2006 Tri-Party Agreement M-15 Milestone negotiations, the Tri-Parties recognized the need for further site study to reduce uncertainty associated with excavation of areas of potentially elevated contamination. The evaluation would identify techniques and the regulatory framework (including DOE Orders) associated with excavation of areas that could generate waste contaminated with plutonium at concentrations greater than 100 nCi/g. Such waste is managed under the requirements of DOE O 435.1, *Radioactive Waste Management* [DOE G 435.1-1, *Implementation Guide for Use with DOE M 435.1-1*]). The study provides the range of site risk from the primary radionuclide COCs using revised EPC values that were recalculated after reevaluation of the data set for statistical outliers. The study would be expected to help refine the FS evaluation and detailed analysis of the removal, treatment, and disposal (RTD) alternative for the Z-Ditches.

1.2 200-CW-5 OPERABLE UNIT CHARACTERIZATION

The process for characterization and remediation of waste sites at the Hanford Site is addressed in the Tri-Party Agreement.

To support the RI/FS process in the 200 Areas, the Tri-Parties also developed the DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (Implementation Plan). This plan provides a strategy for conducting investigations in phases and presents background information, preliminary identification of potential applicable or relevant and appropriate requirements (ARAR), remedial action objectives (RAO), preliminary identification and screening of technologies, and preliminary development and screening of potential remedial alternatives. This FS builds from information provided in the Implementation Plan.

As documented in the RI/FS Work Plan, the Tri-Parties agreed that historical data were appropriate for use in the Z-Ditches characterization and that more data were needed for the 216-Z-11 Ditch. As a result, data were collected in 2002 under the 200-CW-5 OU RI/FS Work Plan to characterize the nature and vertical extent of chemical and radiological contamination and physical conditions in the vadose zone underlying the southern end of the 216-Z-11 Ditch. Initially, the 216-Z-11 Ditch had been selected as a representative site for 200-CW-5 OU. The scope of RI/FS Work Plan activities included drilling, surface and borehole geophysical surveys, and sampling and analysis of soil based on agreements reached in the supporting data quality objectives process (BHI-01294, *Data Quality Objective Summary Report for the 200-CW-5 U Pond/Z-Ditches System Waste Sites*). The RI results for the 216-Z-11 Ditch, were reported in DOE/RL-2003-11, *Remedial Investigation Report for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units* (RI Report).

Table 1-1. Reassignment of Previously Consolidated 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 Operable Unit Waste Sites to Other Operable Units. (2 Pages)

200-CW-5 OU [a]		200-CW-2 OU [a]		200-CW-4 OU [a]		200-SC-1 OU [a]	
Site	**Reassignment Status**	**Site**	**Reassignment Status**	**Site**	**Reassignment Status**	**Site/UPR**	**Reassignment Status**
216-U-9 Ditch	200-CW-1	216-S-17 Pond	200-CW-1	216-T-4A Pond	200-CW-1	216-S-5 Crib	200-SC-1
216-U-10 Pond	200-CW-1	216-S-16P Pond	200-CW-1	216-T-4B Pond	200-CW-1	216-S-6 Crib	200-SC-1 [b]
216-U-11 Ditch	200-CW-1	207-S Retention Basin	200-MG-2	216-T-1 Ditch	200-MG-2	216-A-6 Crib	200-SC-1 [b]
216-U-14 Ditch	200-MG-2	216-S-172 Control Structure	200-MG-2	216-T-4-1D Ditch	200-MG-2	216-A-30 Crib	200-SC-1 [b]
207-U Retention Basin	200-MG-2	2904-S-160 Control Structure	200-MG-2	216-T-4-2 Ditch	200-MG-2	216-S-25 Crib	200-MG-2
216-W-LWC Crib	200-MG-1 [c]	2904-S-170 Control Structure	200-MG-2	207-T Retention Basin	200-MG-2	UPR-200-E-19	200-SC-1 [b]
200-W-84 Process Sewer	200-MG-2	216-S-171 Control Structure [d]	200-MG-2	200-W-88 Process Sewer [e]	TBD [f]	UPR-200-E-21	200-SC-1 [b]
UPR-200-W-111	200-MG-2	216-S-16D Ditch	200-MG-2	216-T-12 Trench	200-MG-2	UPR-200-E-29	200-SC-1 [b]
UPR-200-W-112	200-MG-2	UPR-200-W-124	200-CW-1			200-E-113 Process Sewer [e]	200-IS-1
200-W-102 Process Sewer [e]	TBD [f]					216-A-37-2 Crib	200-SC-1 [b]
UPR-200-W-18	200-CW-1 [g]					216-B-55 Crib	200-SC-1 [b]
UPR-200-W-104	200-CW-1 [g]					216-B-64 Retention Basin	200-SC-1 [b]
UPR-200-W-105	200-CW-1 [g]					216-T-36 Crib	200-SC-1 [b]
UPR-200-W-106	200-CW-1 [g]					200-W-79 Pipeline	200-IS-1
UPR-200-W-107	200-CW-1 [g]					207-Z Retention Basin	200-MG-2
UPR-200-W-139	200-CW-1 [g]					207-A North Retention Basin	200-MG-2

Table 1-1. Reassignment of Previously Consolidated 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 Operable Unit Waste Sites to Other Operable Units. (2 Pages)

200-CW-5 OU [a]		200-CW-2 OU [a]		200-CW-4 OU [a]		200-SC-1 OU [a]	
Site	**Reassignment Status**	**Site**	**Reassignment Status**	**Site**	**Reassignment Status**	**Site/UPR**	**Reassignment Status**

[a] Waste site status is in accordance with the *Hanford Federal Facility Agreement and Consent Order Action Plan*, Appendix C (Ecology, EPA, and DOE, 1989b), unless noted otherwise.

[b] Waste sites reassigned to a separate OU RI/FS process in accordance with Tri-Party Agreement Change Number M-15-07-01 (Ecology, EPA, and DOE, 1989a), which created new interim Milestone M-15-040E for completion of 200-SC-1 OU RI/FS documents at a later date.

[c] Reassigned to 200-MG-1 OU in accordance with the pending Tri-Party Agreement Change Request C-07-02.

[d] This site also is known as 2904-S-171 (WIDS).

[e] Also identified in WIDS as a pipeline.

[f] Site to be reassigned from the 200-SC-1 OU RI/FS process. The decision by the Tri-Parties is pending whether the site will be reassigned to the 200-IS-1 OU or closed under miscellaneous waste regulations (WAC 173-216 or WAC 173-218).

[g] UPRs consolidated with sites that have been reassigned to the 200-CW-1 OU via approved Milestone M-15 changes and are outside the scope of this FS. However, these sites remain shown in the *Hanford Federal Facility Agreement and Consent Order Action Plan*, Appendix C, as assigned to the 200-CW-5 OU. These sites will be removed administratively from the 200-CW-5 OU upon approval of Tri-Party Agreement Change Request C-07-02.

Ecology, EPA, and DOE, 1989a, *Hanford Federal Facility Agreement and Consent Order.*
Ecology, EPA, and DOE, 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan.*
WAC 173-216, "State Waste Discharge Permit Program."
WAC 173-218, "Underground Injection Control Program."
Waste Information Data System, Hanford Site database.

FS = feasibility study.
OU = operable unit.
RI/FS = remedial investigation/feasibility study.
TBD = to be determined.
Tri-Parties = U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology.
UPR = unplanned release.
WIDS = *Waste Information Data System* database.

The RI Report included all historical and RI analytical data that was used to help characterize the nature and extent of contamination at the Z-Ditches, to provide contamination modeling information, to aid the discussion of analogous site relationships, and to provide the analytical basis for the baseline risk assessment (BRA). Based on RI data and proximity of 216-Z-1D, 216-Z-11, and 216-Z-19 Ditches, the RI Report grouped these ditches together into a single, contiguous characterization and contamination area under the term Z-Ditches. The new Z-Ditches group replaced the single 216-Z-11 Ditch as the 200-CW-5 OU representative site for establishing analogous site relationships. However, the FS alternative evaluation process identified that because of site proximity, an excavation or barrier action for the original Z-Ditches area would encroach physically on analogous site boundaries, making a separate action at these sites difficult. Consequently, this FS grouped all of the 200-CW-5 OU waste sites into one decision unit, with the Z-Ditches recommended alternative being applied to all 200-CW-5 OU sites, except the 216-Z-1D North Section.

1.3 PURPOSE

The purpose of this FS is to develop and evaluate alternatives for remediation of the waste sites in the 200-CW-5 OU. This FS refines preliminary potential ARAR, RAO, and general response actions (GRA) identified in the Implementation Plan. Technology screening and alternatives development initially documented in the Implementation Plan are reviewed and refined, as necessary, based on the 200-CW-5 OU RI Report and other sources of existing information. The alternatives considered provide a range of potential response actions (e.g., no action; maintain existing soil cover with monitored natural attenuation and institutional controls; RTD; barrier; RTD with barrier; RTD with full site barrier; in situ vitrification [ISV] with barrier and RTD; ISV with barrier) that are appropriate to address site-specific risk conditions. The alternatives are evaluated against the threshold and balancing CERCLA evaluation criteria defined in EPA/540/G-89/004, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final*, OSWER 9355.3-01. The Tri-Parties will use decision documents contained in the Administrative Record, including this FS, as the basis for selecting a recommended remedy to mitigate potential site risks to human health and the environment. Recommended remedial alternative(s) will be presented to the public for review and comment in DOE/RL-2004-26, *Proposed Plan for the 200-CW-5 Cooling Water Operable Unit.*

1.4 SCOPE

Cleanup of the 200-CW-5 OU is a source-control action that addresses contaminated soil and structures (e.g., 216-Z-20 Tile Field buried piping) of the Z-Ditches group waste sites. Other than the requirement for source-control action to be protective of human health and the environment, the scope does not include remediation of groundwater that may be beneath these waste sites. Contaminated groundwater in the 200 West Area is being addressed by the 200-UP-1 and 200-ZP-1 Groundwater OUs.

1.5 REPORT ORGANIZATION

The essential elements of the FS process are presented in Chapters 1.0 to 8.0, and are summarized as follows.

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

- Chapter 2.0 presents descriptions of the physical setting, waste sites, and site contamination and compares analogous sites with the representative sites.

- Chapter 3.0 summarizes previous risk assessments, discusses land-use assumptions, and develops the overall cleanup objectives and media-specific goals for the waste sites.

- Chapter 4.0 refines the technologies identified for these OUs and waste sites in the Implementation Plan by evaluating new information on existing technologies or relevant emerging technologies. The technologies are screened broadly for applicability to the waste sites in the FS. Screening considerations include effectiveness (likelihood of meeting RAOs for the specific contaminants present at the site), implementability relative to specific site conditions, status of technology development, and relative cost.

- Chapter 5.0 describes the remedial alternative development process (conducted as part of the Implementation Plan) and combines that information with site-specific data from the RI to refine the remedial alternatives to be advanced for detailed and comparative analyses.

- Chapter 6.0 presents a detailed analysis of each of the remedial alternatives against seven CERCLA evaluation criteria (protection of human health and the environment; regulatory compliance; long-term effectiveness; reduction of toxicity, mobility, or volume; short-term effectiveness; implementability; and cost) as defined in EPA/540/G89/004. This chapter also assesses each alternative relative to *National Environmental Policy Act of 1969* values, as required by DOE policy.

- Chapter 7.0 presents the comparative analysis of the seven remedial alternatives and identifies their relative advantages and disadvantages, based on the seven CERCLA evaluation criteria. The results of this analysis provide a basis for selecting a remedial alternative for each representative waste site and its analogous waste sites.

- Chapter 8.0 summarizes the conclusions of this FS. This chapter also presents the preferred alternatives and path for remediation of the 200-CW-5 OU waste sites.

- Chapter 9.0 contains all references for the main body of the report; each appendix contains its own reference section.

- Appendix A was initiated to further evaluate characterization data and associated risks to help refine evaluation and detailed analysis of RTD alternatives for Z-Ditches.

- Appendix B presents an analysis of regulatory requirements and available guidance with respect to the 200-CW-5 OU.
- Appendix C presents the human health and ecological risk evaluations, including the methodology, results, and uncertainties for analogous sites with data.
- Appendix D presents the basis for the comparative cost estimates. Detailed cost estimates are provided for each representative site, including applicable alternatives and derived costs for analogous sites.
- Appendix E presents the risk analysis for a potential intruder to the representative site and analogous sites with characterization data.
- Appendix F presents the site-specific data sheets that support conceptual site models.

2.0 BACKGROUND INFORMATION

This chapter generally presents 200-CW-5 OU background information regarding the way the 200-CW-5 OU was organized, how OU waste sites were characterized, characterization results, and use of the data in identifying site risk for remedial decision making. Specifically, this chapter describes the OU liquid-waste-generating processes waste; site construction and operating history; and the physical setting, natural and cultural resources, historical and RI characterization activities, and nature and extent of Z-Ditches contamination.

2.1 200-CW-5 OPERABLE UNIT BACKGROUND AND HISTORY

This section identifies the 200-CW-5 OU waste-producing facilities and processes, describes the 200-CW-5 OU, and describes the construction and operations of the 200-CW-5 OU ditch waste sites.

2.2 WASTE-PRODUCING FACILITIES AND PROCESSES

The Hanford Site, established in 1943, was designed, built, and operated to produce plutonium for nuclear weapons using production reactors and chemical reprocessing plants. Operations in the 200 Areas took place in eight main processing areas. One of these processing areas located in the 200 West Area was the Z Plant Complex, which was the primary waste-contributing facility for the 200-CW-5 OU waste sites. However, from 1944 to 1949 and before Z Plant (Building 234-5Z) construction, only cooling water and steam condensate from Building 231-Z were discharged to a ditch that drained to the 216-U-10 Pond and that later would be identified as the first of the Z-Ditches, 216-Z-1D. At Z Plant, dibutyl butyl phosphonate, tributyl phosphate, carbon tetrachloride, and acids were used to chemically separate and/or recover special nuclear materials, primarily americium and plutonium, from concentrated plutonium product or scrap materials. These operations produced cooling water and steam condensate waste streams that were not designed to contact process materials directly and so generally were not expected to be contaminated. However, in later years these streams became contaminated with radionuclides, primarily cesium, plutonium, and americium, through equipment failures and accidental releases caused by operator error. Such low contamination waste streams, along with other miscellaneous noncontaminated streams such as storm water runoff, were disposed to the ground at ponds or ditches as low-level waste that eventually accumulated into significant inventories in Z-Ditches soils. Operations in the Z Plant Complex continued until 1989 and such waste discharges to the ground ceased in 1995. The following Z Plant buildings and processes discharged effluent waste streams to the 200-CW-5 OU waste sites:

- Process cooling water, steam condensate, and laboratory waste from Building 231-Z
- Cooling water, process sewer effluent, storm sewer, and steam condensate from Building 234-5Z

- Miscellaneous drain waste and vacuum pump seal water from the Building 291-Z
- Miscellaneous drain waste from Buildings 232-Z and 236-Z.

2.2.1 200-CW-5 Operable Unit Description

The 200-CW-5 OU is a process-based OU established to addresses waste sites that received equipment or vessel cooling water and steam condensate liquid waste streams from Z Plant facilities in the 200 West Area. The exception was UPR-200-W-110, which did not receive effluent but was a one-time use disposal trench for spoils from the 216-Z-1D Ditch, which contained these waste stream contaminants.

Initially, cooling water waste streams were not anticipated to become contaminated. The cooling water and steam condensate was designed to be entirely separate from contaminated process liquids. This was accomplished with physical barriers, which typically were the walls of a heating or cooling pipe coil. Steam and cooling water were circulated through coils inside process vessels to adjust the temperatures in the vessels. The spent steam was condensed with cooling water after exiting the process vessel. The condensed steam and cooling water were released to plant sewers or piping systems that discharged to ditches and ponds (Implementation Plan [DOE/RL-98-28]).

Although these cooling water streams did not come into contact with process materials or chemicals under normal operating conditions, these streams sometimes contained low concentrations of radionuclides and/or chemicals. Over time, coils that circulated steam and cooling water inside chemical process tanks were known to develop pinholes and hairline cracks because of the corrosive chemicals and high thermal gradients in these tanks. These minor defects usually did not lead to contamination of the steam and cooling water because the pressure in the pipe coils was greater than the pressure in the process or condenser vessels. However, whenever the pressure in the coils was reduced or suspended, minor leakage through the flaws into the coils led to waste stream contamination. Other accidental releases from causes such as operator error also have contributed to contamination of the effluents discharged to the waste facilities in these OUs.

The Z-Ditches radiological contaminant inventory is difficult to identify with certainty because contaminant inventory estimates (where available) based on historical waste stream chemistry diverge significantly from the expected inventory based on soil sampling data. However, the soil sampling data provide a more reliable indication of the nature and extent of Z-Ditch contamination. The initial waste stream inventory estimates from DOE/RL-96-81, *Waste Site Grouping for the 200 Areas Soil Investigations*, are based on limited waste stream discharge sampling collected over more than 35 years of continuous operation that identified the 216-Z-11 Ditch as the most contaminated Z-Ditch. These inventory estimates may not be accurate because they are based on waste stream chemistry that converted alpha counts to plutonium concentrations, a process that could significantly overestimate the quantity of plutonium. Conversely, periodic waste stream sampling likely would not reflect intermittent, short-term higher concentration discharge incidents and, thus, would underestimate the total plutonium released to the ditches. Also, these estimates could have overlooked inventory from periods when no discharge records exist (e.g., for 1961 through 1966 when the Space Nuclear

Auxiliary Power program was operating in Z Plant producing purified Np-237 and Pu-238). Based on 1959 sampling data, the results of the Z-Ditch characterization in 1979, and information obtained in 1971 when the head end of the 216-Z-1D Ditch mistakenly was unearthed during excavation of the 216-Z-19 Ditch, WHC-EP-0707, *216-U-10 Pond and 216-Z-19 Ditch Characterization Studies*, concluded that the historical plant operations inventory estimates for the Z-Ditches likely were erroneous. WHC-EP-0707 concluded that the lower portion of the 216-Z-1D Ditch, not the 216-Z-11 Ditch, contains the majority of the Z-Ditches plutonium inventory with both the 216-Z-11 and 216-Z-19 Ditch inventories an order of magnitude lower.

2.2.2 Construction and Operations of 200-CW-5 Operable Unit Waste Sites

The 200-CW-5 OU waste sites within the scope of this FS include the 216-Z-1D Ditch, 216-Z-11 Ditch, 216-Z-19 Ditch, 216-Z-20 Tile Field, and UPR-200-W-110. For purposes of this FS and for reasons discussed later in this section, the north and south sections of the 216-Z-1D Ditch as shown in Figure 1-3 are evaluated as separate sites because they operated during different time periods and contamination conditions for each have been shown to be different.

The Z-Ditches are a series of three parallel, shallow unlined and open-air ditches that operated in chronological sequence from 1944 to 1981. The ditches routed cooling water and other wastewaters from Z Plant to the 216-U-10 Pond for disposal. From 1944 to 1956, the ditch system was used to convey cooling water effluents from the 231-Z Plutonium Isolation Plant where concentrated plutonium from the bismuth phosphate process at the 221-T Plant was processed from a wet nitrate form to a solid plutonium nitrate form for offsite shipment. The startup of the Z Plant in 1949 provided for additional processing steps to convert plutonium nitrate into more stable and safer forms, including oxalate, oxide, and pure metal. Additional process modifications were required to adapt the plant to handle inputs from a larger number of reactors and from new chemical separations plants (Reduction-Oxidation Plant and Plutonium-Uranium Extraction Plant). Machining of plutonium produced large quantities of scrap. After 1956 when the bismuth phosphate process was shut down, the 231-Z Plutonium Isolation Plant was converted for use on other projects, including metallurgical studies, weapons component fabrications, and reactor fuel development. The recovery of uranium and plutonium by extraction (RECUPLEX) process in the Z Plant initially was used for scrap reclamation. Later, adjacent recovery facilities such as the 236-Z Plutonium Reclamation Facility, the 232-Z Waste Incinerator Facility, and the 242-Z Waste Treatment Facility were added. These processes generated process equipment and vessel cooling water and steam condensate waste streams that, due to coil failures and occasional process upsets, sometimes were radiologically contaminated and so were sometimes low-level waste.

The collective Z-Ditches area was deactivated and stabilized in 1981 following construction of the 216-Z-20 Tile Field as the primary Z-Plant wastewater disposal facility. The concrete headwalls, vegetation, and miscellaneous unsalvageable equipment were disposed into the 216-Z-19 Ditch bottom. At this time, the previously buried 216-Z-1D and 216-Z-11 Ditches

received an additional 0.15 to 0.30 m (0.5 to 1.0 ft) of clean fill. The entire area was re-posted as an Underground Radioactive Area.

2.2.2.1 216-Z-1D Ditch (1944 to 1959)

The 216-Z-1D Ditch operated from 1944 to 1959. It was 1,295 m (4,249 ft) long and 0.6 m (2 ft) deep, with a bottom width of 1.2 m (4 ft), side slopes of 2.5:1, and a minimum grade of 0.05 percent (WHC-EP-0707). Originally, the ditch flowed from a headwall located approximately 60 m (196 ft) east of Building 231-Z. In 1949, after approximately 4 years of operations and as part of Building 234-5Z (Z Plant) construction, the north 526 m (1,725-ft) section of this ditch was abandoned, backfilled, and replaced with process sewer piping that was routed around 234-5Z facility security fencing. A new headwall was constructed approximately 457 m (1,500 ft) downstream where the new pipeline emptied into the remaining south portion of the ditch. The south portion continued to operate until 1959 and had the potential to have received cooling water waste having constituents associated with the additional processes that occurred at the 231-Z Plutonium Isolation Plant after 1949.

The north portion of the 216-Z-1D Ditch reportedly did not contain significant contamination when it was abandoned in 1949 and according to data gathered in 1981, is significantly less contaminated than the south portion of the 216-Z-1D Ditch. The coil failures that were a major source of cooling water waste stream contamination in later years had not yet developed and no reports of process-upset discharges have been identified. Open ditches were routinely surveyed for radiological contamination to closely control the potential for spread of windblown contamination. The north portion was not abandoned due to such contamination, as were the other Z-Ditches in later years. In 1981, sampling at the north end of the 216-Z-1D Ditch identified a maximum plutonium concentration of less than 70 pCi/g (RI Report [DOE/RL-2003-11]). The early plutonium purification process in the 231-Z Plutonium Isolation Plant that produced the early the 216-Z-1D Ditch waste streams was a tightly controlled process due to the high value of the concentrated plutonium product being processed. At that time, process waste streams were segregated with regard to their potential to contain plutonium with major plutonium-containing waste streams being recycled directly back to 224-T Concentration Facility. The cooling water waste streams did not have a recognized potential to contain plutonium. All other secondary waste streams having a potential to contain plutonium were sent to the 231-W-151 Sump where they were analyzed, neutralized, and either recycled back to the 224-T Concentration Facility for reprocessing, or, if the plutonium not considered recoverable, disposed to the 216-Z-4 Trench, 216-Z-5 Crib, 216-Z-6 Crib, and/or 216-Z-10 Injection/Reverse Well. Waste containing plutonium was not expected to have been disposed to the 216-Z-1D Ditch (SGW-35060, *Inventory Estimates for Liquid Discharges From the 231-Z Facility*).

2.2.2.2 216-Z-11 Ditch (1959 to 1971)

The 216-Z-11 Ditch operated from 1959 to 1971 and was constructed to replace the 216-Z-1D Ditch after high plutonium contamination was discovered in the portion below the new headwall. As with the other Z-Ditches, it is presumed that the 216-Z-11 Ditch was retired due to evidence of unacceptable levels of surface contamination obtained during operations. The 216-Z-11 Ditch was excavated immediately east of and parallel to the south portion of the 216-Z-1D Ditch and was of similar length (approximately 797 m [2,615 ft] long), width (1.2 m

[4 ft] at the bottom), and depth (0.6 m [2 ft] deep). Material excavated for 216-Z-11 Ditch construction was used to backfill the 216-Z-1D Ditch to grade.

Site information is not consistent with regard to whether the 216-Z-11 Ditch may have merged back into the original 216-Z-1D Ditch at the lower end between the 216-U-10 Pond delta region and 16th Street crossing. In this configuration, the ditch would have had the upper 36.5 m and lower 202.6 m (120 ft and 665 ft, respectively) in common with the original 216-Z-1D Ditch.

2.2.2.3 216-Z-19 Ditch (1971 to 1981)

In April 1971, the 216-Z-11 Ditch was retired and replaced with the 216-Z-19 Ditch. The 216-Z-19 Ditch was dug west of and parallel to the 216-Z-1D and 216-Z-11 Ditches and operated from 1971 to 1981. Excavation material was used to backfill the 216-Z-11 Ditch to grade. The 216-Z-19 Ditch was similar to that of the previous ditches, except that it was 1.2 m (4 ft) deep (DOE/RL-91-58, *Z Plant Source Aggregate Area Management Study Report*).

In 1971, during construction of the 216-Z-19 Ditch, contaminated sediments approximately 130 m (427 ft) from the 216-Z-1D Ditch were inadvertently excavated. Consequently, this portion of the ditch was shifted approximately 10.6 m (35 ft) west. The contaminated sediments were re-buried in a trench dug parallel to and east of the 216-Z-11 Ditch currently designated UPR-200-W-110, now a 200-CW-5 OU waste site.

A temporary alignment resulted in the 216-Z-19 Ditch reentering the existing 216-Z-11 Ditch to use the only culvert beneath 16th Street. In October 1971, a new culvert was installed 15 m (49 ft) to the west, and the 216-Z-19 Ditch was realigned and continued approximately 305 m (1,000 ft) to the 216-U-10 Pond.

In late March 1976, an accidental release of contamination occurred in the 216-Z-19 Ditch and efforts were made to contain the contaminants in the ditch. A series of three earthen dams were constructed at intervals along the portion of the ditch above 16th Street to raise the ditch water level above the original contaminated water line and to stop contaminated wastewater from reaching the 216-U-10 Pond. A water sprinkler system was installed between the lowermost dam and the 216-U-10 Pond to control the spread of windblown contamination by preventing this portion of the ditch from drying out. Thereafter, wastewater never reached the pond. In March 1978, the sprinklers were shut down and the dams were removed, but the remaining surface water infiltrated the soil column before reaching the pond. Consequently, from 1976 until 1981 when the 216-Z-19 Ditch ceased receiving effluent, waste stream contaminants were disposed to the soil column. Wastewater was diverted from the 216-Z-19 Ditch to the 216-Z-20 Tile Field shortly afterward.

Deactivation and stabilization of the Z-Ditches area began in 1981, following construction of the 216-Z-20 Tile Field as the primary Z Plant wastewater disposal facility. Woody vegetation in the 216-Z-19 Ditch was killed with herbicides (glyphosate and dicamba) before backfill operations were initiated. The 216-Z-19 Ditch was covered with 0.6 to 1 m (2 to 3 ft) of clean soil. The concrete headwalls, vegetation, and miscellaneous unsalvageable equipment were incorporated into the ditch bottom. At the same time, the previously buried 216-Z-1D and 216-Z-11 Ditches received an additional 0.15 to 0.30 m (0.5 to 1.0 ft) of clean fill. The Z-Ditch area likely has 0.30 to 0.6 m (1 to 2 ft) of accumulated stabilizing soil cover over the ditch

backfill material. The entire Z-Ditch Complex was reposted as an Underground Radioactive Materials Area.

2.2.2.4 216-Z-20 Tile Field (1981 to 1995)

The 216-Z-20 Tile Field, also called the 216-Z-20 Ditch Replacement Tile Field, operated from 1981 to 1995 disposing of similar effluent that had previously been routed via the ditches to the 216-U-10 Pond for disposal. The 216-Z-20 Tile Field is an unlined, subsurface disposal site that is 463 by 3 m (1,519 by 10 ft) at the bottom with a depth of 2.9 m (9.5 ft). Three perforated polyvinyl chloride pipes run the length of the ditch in a bed of gravel that was backfilled with clean gravel and soil. The 216-Z-20 Tile Field received cooling water, steam condensate, storm sewer runoff, and/or building and chemical drain waste from Building 234-5Z (Z Plant), 231-Z Plutonium Isolation Plant, Building 291-Z, 232-Z Waste Incinerator Facility, 236-Z Plutonium Reclamation Facility, and 2736-Z Plutonium Storage Building.

The site received effluent volume of 3,800,000,000 L with an effluent volume to soil-pore-volume ratio of 173:1. The estimated site inventory for plutonium is less than 1 g and inventories for cesium, americium, and strontium are estimated at 1 Ci or less. A total of 1 Ci of Am-241 and 2 Ci of Pu-239 were released to the crib in 1985 from contamination of process cooling. Further, such releases were prevented by installation of secondary coolant loops. No potential exists for this site to contain plutonium or americium at concentrations greater than 100 nCi/g (WHC-EP-0674). The site is documented to have received a nitric acid release of 3,400 kg (7,600 lb).

2.2.2.5 Construction and Operations of UPR-200-W-110 (1971)

UPR-200-W-110 is a narrow, one-time use disposal trench located immediately east of and parallel to the 216-Z-11 Ditch. This trench was used to dispose of spoils containing 216-Z-1D Ditch sediments and clean backfill material inadvertently excavated from the 216-Z-1D Ditch during 216-Z-19 Ditch construction in 1971. The trench is 129.5m (425 ft) long and 4.6 m (15 ft) deep. The bottom 2 m (7 ft) of the trench was filled with the spoils material and filled to grade with clean backfill. Consequently, this site contains similar waste constituents as the other Z-Ditches. No inventory is reported for this site. This trench is within the same underground radioactive material zone as the other Z-Ditches.

2.3 200-CW-5 OPERABLE UNIT PHYSICAL SETTING

The following sections briefly describe the meteorology, topography, and hydrogeologic frameworks for the 200-CW-5 OU waste sites. Additional discussions are provided in PNNL-16346, *Hanford Site Groundwater Monitoring for Fiscal Year 2006*; PNNL-16623, *Hanford Site Environmental Report for Calendar Year 2006*; PNNL-6415, *Hanford Site National Environmental Policy Act (NEPA) Characterization*; RI/FS Work Plan (DOE/RL-99-66); and the RI Report.

2.3.1 Hanford Site Meteorology

The Hanford Site lies east of the Cascade Mountains and has a semiarid climate caused by the rain shadow effect of the mountains. Climatological data are monitored at the Hanford Meteorological Station and other locations throughout the Hanford Site. From 1946 through 2007, 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 –0.7 °C (31 °F) in January to a high of 24.7 °C (76 °F) in July. The annual average relative humidity is 55 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). Annual average precipitation is 17 cm (6.8 in.). Because this area typically receives less than 25.5 cm (10 in.) of precipitation a year, the climate is considered to be semiarid (PNNL-6415).

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

2.3.3 Geology

The Hanford Site is underlain by basalt of the Columbia River Basalt Group and a sequence of suprabasalt sediments. From oldest to youngest, the major geologic units of interest are the Elephant Mountain Basalt Member, the Ringold Formation, the Cold Creek unit (formerly, Plio-Pleistocene unit, early "Palouse" soil, caliche layer, or pre-Missoula gravels), and the Hanford formation. A generalized stratigraphic column for the 200 West Area is shown in Figure 2-1. Figure 2-2 is a geological cross section of the entire length of the Z-Ditches from the 231-Z Plutonium Isolation Plant down to the 216-U-10 Pond.

Figure 2-1. Generalized Stratigraphic Column for the 200 West Area.

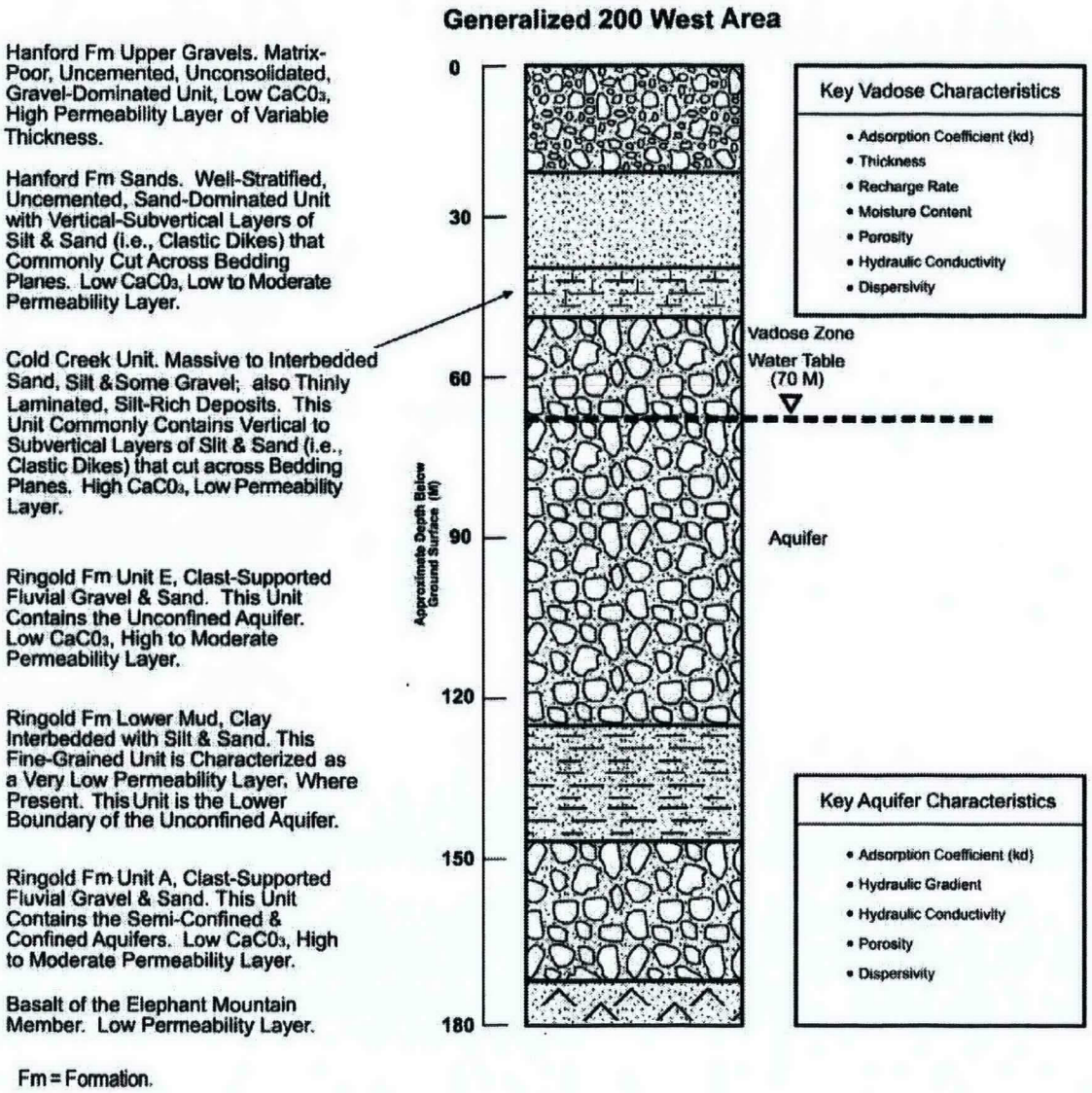
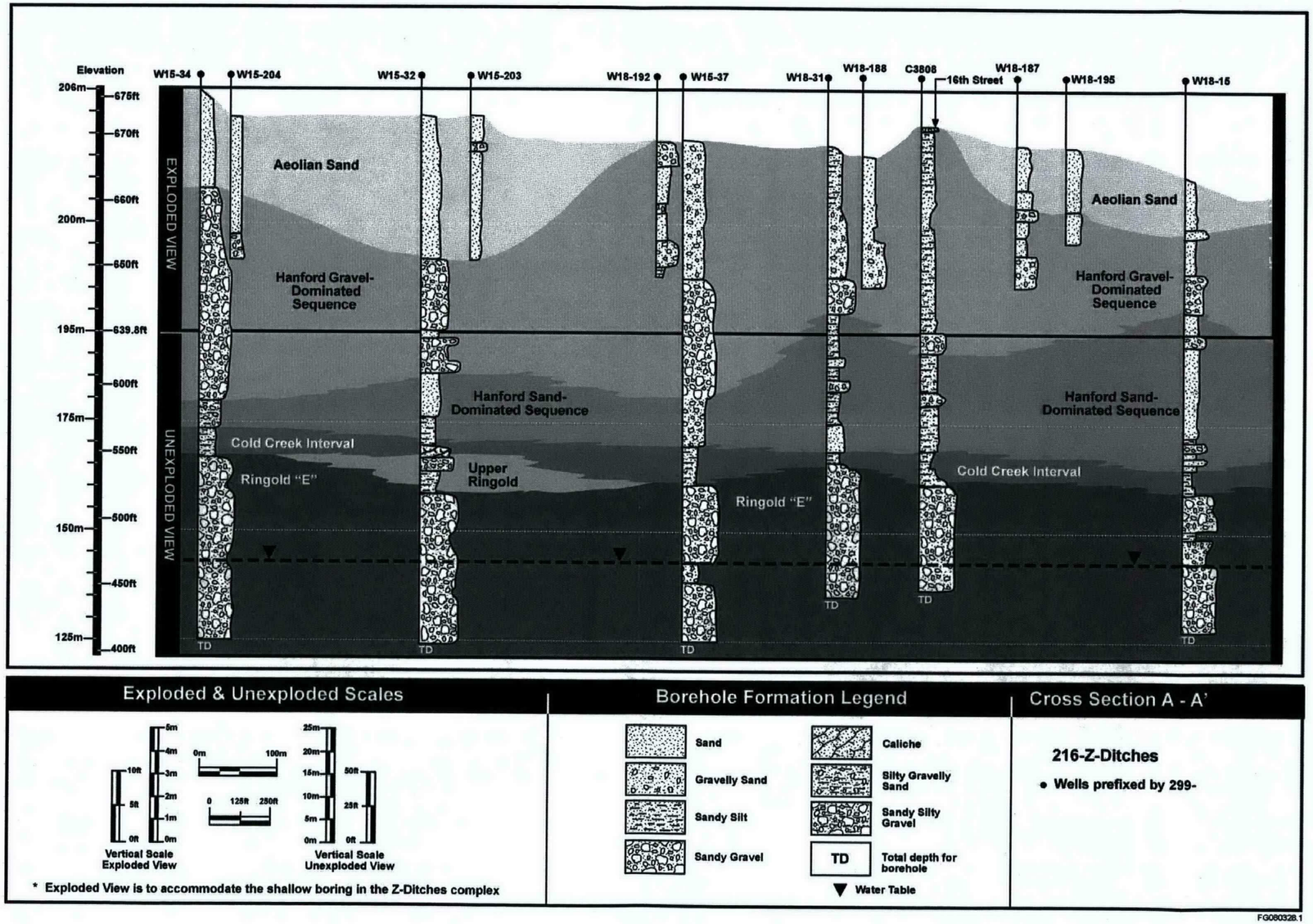


Figure 2-2. Geologic Cross Section, Z-Ditches in the 200 West Area.



The Elephant Mountain Basalt Member is bedrock beneath the OUs and consists of a medium- to fine-grained tholeiitic basalt with abundant microphenocrysts of plagioclase (DOE/RW-0164-F, *Consultation Draft, Site Characterization Plan, Reference Repository Location, Hanford Site, Washington*). Basalt is overlain by the Ringold Formation over all of the 200 West Area. The Ringold Formation consists of an interstratified sequence of unconsolidated clay, silt, sand, and granule to cobble gravel deposited by the ancestral Columbia River. The fluvial-lacustrine Ringold Formation is informally divided into several units; these are (from oldest to youngest) the fluvial gravel and sand of unit A, the buried soil horizons and lake deposits of the lower mud sequence, the fluvial sand and gravel of unit E, and the lacustrine mud of the upper Ringold unit.

The Cold Creek unit overlies the Ringold Formation in the 200 West Area (DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for Post-Ringold Formation Sediments Within the Central Pasco Basin*) and is divided into five lithofacies. Descriptions of the five lithofacies units, depositional environments, and association with previous site nomenclature are shown in Table 2-1 and are further described in DOE/RL-2002-39. The five lithofacies units are differentiated based on grain size, sedimentary structure, sorting, fabric, and mineralogy as follows:

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

The Hanford formation overlies the Cold Creek unit in the 200 West Area. The Hanford formation consists of unconsolidated gravel, sand, and silt deposited by cataclysmic floodwaters. These deposits consist of gravel- and sand-dominated facies. The gravel-dominated facies consist of cross-stratified, coarse-grained sands and granule to boulder gravel. The gravel is uncemented and matrix poor. The sand facies consist of well-stratified fine- to coarse-grained sand and granule gravel. Silt content is variable and may be interbedded with the sand. Where the silt content is low, an open-framework texture is common. An upper and lower gravel unit and a middle sand facies are present in the study area. The cataclysmic floodwaters that deposited sediments of the Hanford formation also locally reshaped the topography of the Pasco Basin. The floodwaters deposited a thick sand and gravel bar that constitutes the higher southern portion of the 200 Areas, informally known as the 200 Area Plateau.

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 they 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.

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

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

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

2.3.4 Hydrostratigraphy

A detailed discussion of the hydrostratigraphy in the Z-Ditches area is contained in the RI Report and is summarized in this section. The vadose zone is the unsaturated region between the ground surface and water table. Near the 200 West Area, the vadose zone thickness is 62 m (206 ft). Details of performance of the aquifer and recharge rates are contained in PNL-10285, *Estimated Recharge Rates at the Hanford Site,* and in PNL-5506, *Hanford Site Water Table Changes 1950 Through 1980 – Data Observation and Evaluation.* Recharge to the unconfined aquifer in the 200 Areas is from artificial and natural sources.

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. Soil texture can be affected by soil disturbances, such as that occurring at waste sites, and by the type and density of vegetation. For areas where the ground cover is assumed to be undisturbed, a recharge rate of 1.44 mm/yr was assumed, which is within the range of values reported for shrub-steppe ground cover. For the disturbed areas, such as at waste sites where backfill material and stabilization cover exists, a recharge rate of 3.5 cm/yr has been assumed, which is a factor when considering vadose zone contaminant transport (PNNL-10285).

Artificial recharge has occurred in the past when effluents such as cooling water and process wastewater were disposed to the ground. PNL-5506 reports that between 1943 and 1980,

6.33×10^{11} L (1.67×10^{11} gal) of liquid wastes were discharged to the soil column. Discharges to soil near the Z-Ditches from 200 Area facilities ceased in 1995 and sitewide, most sources of artificial recharge have been halted.

While the liquid waste disposal facilities (e.g., 216-Z-20 Tile Field) 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, particularly in and above fine-textured, low permeability layers, may remain held up for extended periods. This is shown by 200 Area sampling that generally confirms elevated moisture levels at such layers coupled with the presence of more mobile contaminants (if in the waste streams) that would have traveled with the moisture front. In the absence of artificial recharge, natural recharge becomes a primary driving force for contaminant movement in the vadose zone making control of natural recharge important in controlling vadose zone contaminant transport.

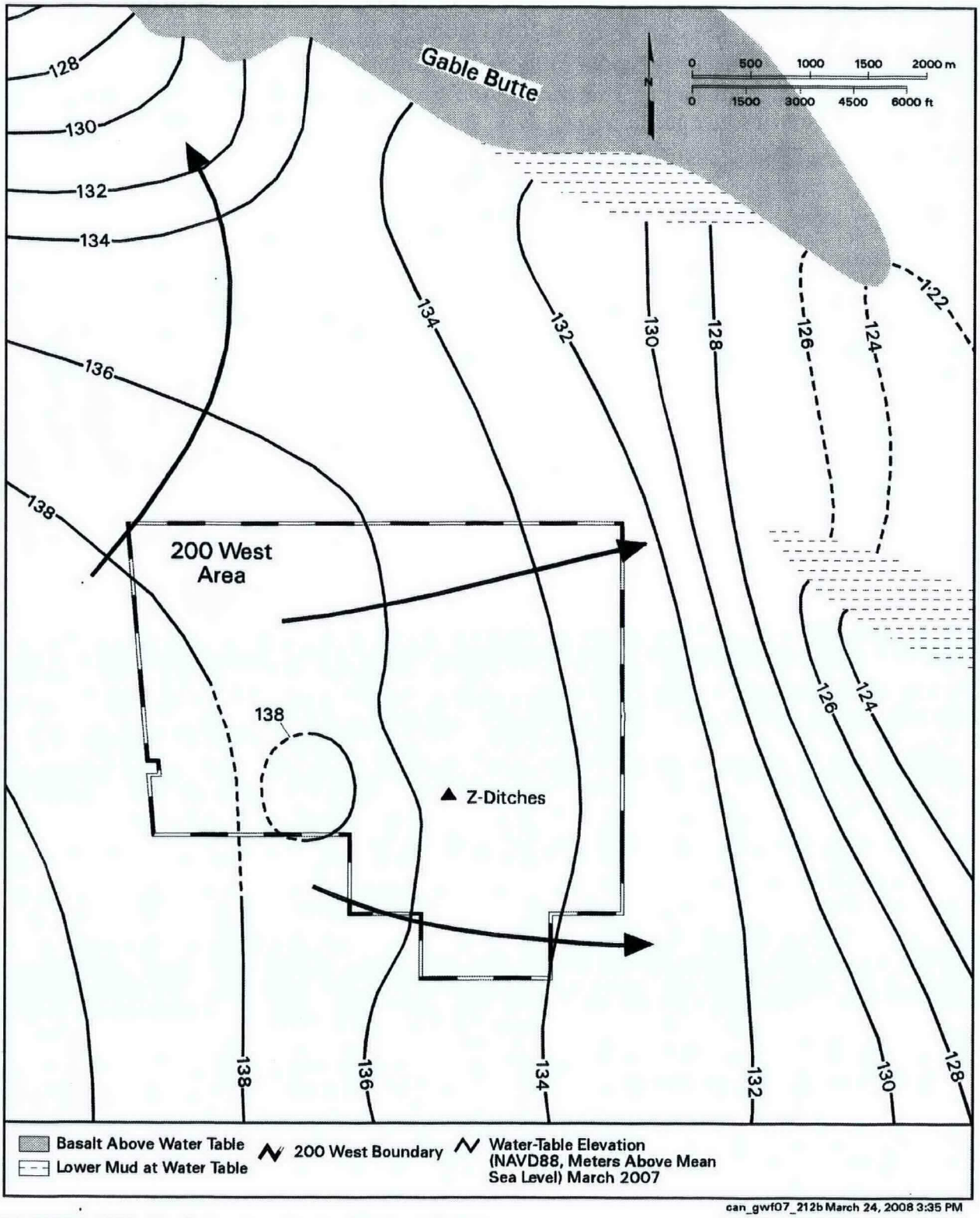
The unconfined aquifer in the 200 Areas occurs in the Hanford formation, the Cold Creek unit, and the Ringold Formation. Groundwater in the unconfined aquifer flows from areas where the water table is higher (west of the Hanford Site) to areas where it is lower (the Columbia River) (PNNL-13788, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*). In general, groundwater flow through the 200 Areas Central Plateau occurs in a predominantly easterly direction, from the 200 West Area to the 200 East Area (Figure 2-3).

Historical discharges to the ground greatly altered the groundwater flow regime. This occurred especially around the 216-U-10 (U Pond) disposal system in the 200 West Area that included the Z-Ditches and resulted in a groundwater mound developing in excess of 26 m (85 ft). As the hydraulic effects of this artificial recharge diminishes, groundwater flow has, as predicted in BHI-00469, *Hanford Sitewide Groundwater Remediation Strategy – Groundwater Contaminant Predictions,* acquired a more easterly course through the 200 Areas, with some flow possibly continuing through Gable Gap.

2.4 NATURAL AND CULTURAL RESOURCES

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

Figure 2-3. Water Table Map Encompassing the 200-CW-5 Operable Unit.



NAVD88, 1988, *North American Vertical Datum of 1988.*

As discussed later in this section dealing with ecological risk, 200 Areas Central Plateau survey data were collected in 2000 and 2001 in support of Central Plateau ecological evaluations (DOE/RL-2001-54, *Central Plateau Ecological Evaluation*). These data included plant community descriptions, identification of plant and wildlife species, and avian census data. Also at that time, designated levels of habitat under DOE/RL-96-32, *Hanford Site Biological Resources Management Plan*, including rare plant populations, were identified and mapped. Although this information was collected before the Command 24 fire in 2000, this fire, and no fire since then, has reached the Z-Ditches.

2.4.1 Vegetation

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

Many of the waste disposal and storage sites in the 200 Areas 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). The soil and vegetation associated with the waste sites addressed in this FS are highly disturbed. This disturbed habitat primarily is the result of mechanical and operational disturbance. Outlying habitats also have been disturbed as a result of range fires, clearing, and construction activities.

2.4.2 Wildlife

The largest mammal potentially frequenting the study area is the mule deer (*Odocoileus hemionus*). Mule deer are much more common along the Columbia River; the few that forage throughout the 200 Areas make up a distinct group called the Central Population (PNNL-11472, *Hanford Site Environmental Report for Calendar Year 1996*). A large elk herd (*Cervus canadensis*) currently resides on the Fitzner-Eberhardt Arid Lands Ecology Reserve. The Rattlesnake Hills herd of elk that inhabits the Hanford Site primarily occupies the Arid Lands Ecology Reserve and private lands that adjoin the reserve to the south and west and do not forage on the 200 Area Plateau where the Z-Ditches are located (PNNL-6415).

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

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

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

Reptiles common to the study area include gopher snakes (*Pituophis melanoleucus*) and sideblotched lizards (*Uta stansburiana*). Rattlesnakes (*Crotalus viridis*) also have been observed. Reptile sightings are not widespread, with only 23 observations of side-blotched lizards at 316 sites surveyed during a 2001 Ecological Compliance Assessment Project survey (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, not the Central Plateau. 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 of 1918*.

Several threatened, endangered, and candidate species are found in and near the 200 Areas. These species include the ferruginous hawk (*Buteo regalis*), burrowing owl, loggerhead shrike, long-billed curlew, and sage sparrow. Plant species of concern (which include those listed as state endangered, threatened, sensitive, and monitored) that may occur in the study area include

dwarf evening primrose and Piper's daisy (*Erigeron piperianus*) (WNHP, 1998, *Washington Rare Plant Species by County*).

Plant and animal species of concern, their designations, and the places of their occurrence can change over time. At this time, it is not anticipated that remediation of the 200-CW-5 OU will affect any species of concern, 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 was designated as Level 3 habitat in DOE/RL-96-32, which requires mitigation of any disturbance (e.g., through avoidance and minimization) and possibly rectification and compensation. More detailed direction on protecting Level 3 habitats and species of concern is provided in DOE/RL-96-32. In addition, site-specific environmental surveys, required before ground disturbance can occur, serve as a final check to ensure that ecological resources are adequately protected.

2.4.4 Cultural Resources

A comprehensive archaeological survey of the 200 Areas found artifacts in conjunction with areas of high topographic relief and in the vicinity of sources of permanent water, but few artifacts associated with open, inland flats (PNL-7264, *Archaeological Survey of the 200 East and 200 West Areas, Hanford Site, Washington*). PNL-7264 addressed only undisturbed portions of the 200 Areas, not including the highly disturbed and contaminated Z-Ditches, and did not address facilities and structures. In the 200 West Area, the only culturally sensitive area identified is the historic White Bluffs Road that crosses the northwest corner of the site. The report concluded that additional cultural resource reviews are required only for proposed projects within 100 m (328 ft) of this road. None of the waste sites associated with the OUs involved in this FS are within 100 m (328 ft) of this road (PNL-7264).

Between 1994 and 1996, RL, the Washington State Historic Preservation Office, and the Advisory Council on Historic Preservation negotiated DOE/RL-96-77, *Programmatic Agreement Among the U.S. Department of Energy, Richland Operations Office, The Advisory Council on Historic Preservation, and the Washington State Historic Preservation Office for the Maintenance, Deactivation, Alteration, and Demolition of the Built Environment on the Hanford Site, Washington*, that would satisfy all requirements of the *National Historic Preservation Act of 1966* for remediation of the Hanford Site by the following: (1) documenting a representative sample of 190 buildings/structures, and (2) writing a single, integrated document chronicling the unique history of the Hanford Site, its technology, and the people who worked at the Hanford Site. Section I(C) of DOE/RL-96-77 states the following: "Completion of the Site-wide Treatment Plan established under this PA [Programmatic Agreement] satisfies all Section 106 requirements for identification, evaluation, and treatment necessary for all undertakings, up to and including demolition, which may affect Manhattan Project and Cold War Era properties." RL established a Historic Buildings Task Group, as required by Section II(A) of DOE/RL-96-77, and charged them with the responsibility "to identify, inventory, and evaluate all historic buildings and structures on the Hanford Site not evaluated previously or otherwise exempt by Stipulation III.A.1-6 of this agreement." Over a 2-year period, the Task Group met regularly and evaluated approximately 1,000 buildings and structures, making both a determination of which were contributing and which were non-contributing properties within the Hanford Site

Manhattan Project and Cold War Era Historic District and which properties would be individually documented as significant buildings or as representatives of property types. Other than listing in the *Hanford Site Historic Buildings* Database, no documentation was required for buildings/structures not selected as significant or representative (see Section II(C) of DOE/RL-96-77).

On January 15, 1998, RL issued the final version of DOE/RL-97-56, *Hanford Site Manhattan Project and Cold War Era Treatment Plan*. Appendix C of DOE/RL-97-56 lists the waste sites selected for documentation on Historic Property Inventory Forms. The documented representative waste sites included the following: 216-U-10 (U Pond); 218-E-14 and 218-E-15 Storage Tunnels; 218-WR; AW, T, TX, and TY Tank Farms; 244-UR Vault; BC Cribs; and the 216-B-5 Injection/Reverse Well. No additional documentation is required for the 200-CW-5 OU waste site.

However, the *National Historic Preservation Act of 1966,* Section 106 cultural resource reviews will be required for access areas (e.g., new or improved roads) and laydown areas (e.g., equipment storage) for required infrastructure for remediation of the 200-CW-5 OU.

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) above mean sea level, forms the southwestern boundary of the Hanford Site, and Gable Mountain and Gable Butte are the highest landforms on the Hanford Site 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

Activity on the Hanford Site plays a dominant role in the socioeconomics of the Tri-Cities and other parts of Benton and Franklin counties. The agricultural community also has a significant effect on the local economy. Any major changes in Hanford Site activity potentially would affect the Tri-Cities and other areas of Benton and Franklin Counties. Unless otherwise specifically cited, data in this section are collected from PNNL-6415.

The Hanford Site is the largest single source of employment in the Tri-Cities. During fiscal year (FY) 2004, an average of 10,247 employees were employed by the DOE Office of River Protection (ORP) and its prime contractor CH2M HILL Hanford Group, Inc.; RL and its prime

contractor Fluor Hanford, Inc.; Battelle Memorial Institute; Bechtel Hanford, Inc.; and AdvanceMed Hanford. The FY 2004 year-end employment at the Hanford Site was 10,225, down from 10,288 at the end of FY 2003. In addition to these totals, Bechtel National, Inc., and its prime subcontractor Washington Group International, employed 3,780 at the end of FY 2004. In December 2000, ORP awarded a contract to Bechtel National, Inc., to design, build, and start up waste treatment facilities for the glassification of liquid radioactive waste. According to the Washington State Labor Market and Economic Analysis, the annual average number of employees at the Hanford Site is down considerably from a peak of 19,200 in FY 1994, but still represents 14 percent of the 99,000 total jobs in the economy.

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

- Energy Northwest
- The agricultural community (including the largest single agricultural employer ConAgra/Lamb Weston food processing plants)
- Tyson Fresh Meats (formerly Iowa Beef Processing)
- Boise Cascade Corporation Paper and Corrugated Container Division
- AREVA (formerly Framatome – Advanced Nuclear Products)
- Wal-Mart.

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

An estimated total of 155,100 people lived in Benton County and 57,000 lived in Franklin County during 2004, for a total of 212,100, which is up approximately 11 percent from 2000. According to the 2000 Census, population totals for Benton and Franklin Counties were 142,475 and 49,347, respectively. Both Benton and Franklin counties grew at a faster pace than Washington as a whole did in the 1990s. The population of Benton County grew 26.6 percent, up from 112,560 in 1990. The population of Franklin County grew 31.7 percent, up from 37,473 in 1990.

Based on the 2000 U.S. census (Census, 2000), the 80 km (50-mi) radius area surrounding the Hanford Site had a total population of 482,300 and a minority population of 178,500.[1] The U.S. census indicates Asians and individuals of Hispanic origin from Benton and Franklin counties represent lower and higher proportions of the population, respectively, than in the state

[1] PNNL-6415 shows the total population "within" 80 km (50 mi) as 511,500, which was estimated by a geographical information system from the populations of individual census block groups, the smallest geographic area for which both minority and poverty status were estimated in the 2000 Census. The higher number resulted because the total population of a census block group previously was assigned to the 80 km (50 mi) area if *any part* of the block group lay within 80 km (50 mi) of the Hanford Meteorological Station in the middle of the Hanford Site. The new estimate splits boundary block groups to include only those portions within 80 km (50 mi), which should result in a lower and more accurate estimate.

of Washington as a whole. During 2004, county-level estimates of minority populations in Benton, Franklin, Grant, Adams, and Yakima counties demonstrate similar trends. PNNL-6415 provides maps and tables depicting distributions of minority and low-income populations.

2.5 SUMMARY OF 200-CW-5 OPERABLE UNIT CHARACTERIZATION

This section summarizes RI and historical data-collection activities at 200-CW-5 OU waste sites. The activities include RI sampling and analysis activities at the 216-Z-11 Ditch in 2002 and existing historical characterization activities at other Z-Ditch locations that have provided information and data used in FS evaluation processes.

2.5.1 Remedial Investigation Data-Collection Activities (2002)

The RI activities for the 200-CW-5 OU were conducted in 2002 in accordance with DOE/RL-99-66 and DOE/RL-2002-24, *200-CW-5 U Pond/Z Ditches Cooling Water Group Operable Unit Remedial Investigation Sampling and Analysis Plan*. The 200-CW-5 OU RI focused on characterization of the 216-Z-11 Ditch, which was identified for further RI characterization initially as a 200-CW-5 OU representative waste site by DOE/RL-96-81; BHI-01294, *Data Quality Objective Summary Report for the 200-CW-5 U Pond/Z Ditches System Waste Sites;* and the Implementation Plan. During the 200-CW-5 OU data quality objective process, the 216-Z-11 Ditch was selected for RI evaluation to complete the contamination picture of the Z-Ditches areas because a large body of historical characterization data existed for the 216-Z-1D and 216-Z-19 Ditches but less was known about the 216-Z-11 Ditch. The 216-Z-11 Ditch waste-stream inventories, effluent volumes received, and the current level of characterization all suggested that high contaminant inventories are present in the subsurface beneath this receiving site. Consequently, the 216-Z-11 Ditch was expected to present 200-CW-5 OU worst case (upper bound) and/or typical waste-site contaminant conditions.

The RI was conducted from January to October 2002 and began with soil probe investigations to optimize placement of a single borehole at the highest anticipated contamination area of the 216-Z-11 Ditch. Soil probes were placed at transects along the 216-Z-11 Ditch and ground-penetrating radar was used to identify the location of the backfilled and parallel 216-Z-1D and 216-Z 19 Ditches for inclusion in the investigation.

Borehole C3808 was drilled at the 216-Z-11 Ditch at the location of highest contamination found by the soil probes. These efforts are summarized in CP-12134, *Borehole Summary Report for Borehole C3808 in the 216-Z-11 Ditch, 200-CW-5, U-Pond/Z-Ditches Cooling Water Operable Unit*, and were presented in the RI Report. Borehole C3808 was logged in 2002 with a small-diameter gross gamma/passive neutron tool with spectral gamma logging to depths of 4.9 m and 68.6 m (16 ft and 225 ft), respectively.

For purposes of remedial decision making and based on RI results, the RI report grouped the 216-Z-1D (south portion), 216-Z-19, and 216-Z-11 Ditches together into a single, contiguous

characterization and contamination area (Z-Ditches) thereby replacing the 216-Z-11 Ditch as the 200-CW-5 OU representative site with the collective Z-Ditches. This was done because these three ditches represent one large, contiguous contamination area that received the same waste streams; are parallel and side-by-side; sometimes shared common areas along their length; ditch boundaries have been obscured by site stabilization activities and essentially are indiscernible; and because of uncertainty associated with the exact location of boreholes relative to individual ditch locations. Further, comparison of 216-Z-11 Ditch RI data with historical data from the other Z-Ditches showed that the 216-Z-11 Ditch potentially was not as contaminated as the neighboring 216-Z-1D and 216-Z-19 Ditches and so was not representative of these sites with regard to radiological contamination.

2.5.2 Prior Z-Ditches Area Characterization (1959–1981)

This section identifies characterization activities at the Z-Ditches area before the 2002 RI.

2.5.2.1 216-Z-1D Ditch Sediment Sampling (1959)

A total of 90 sediment grab samples ("mud samples") were collected from the bottom of the 216-Z-1D Ditch in 1958 and 1959 to investigate radiological surface contamination. Samples were collected on 30 m (100-ft) centers in groups of three for the entire length of the ditch. Nine of these samples were collected from the 216-Z-1D Ditch and the remaining 81 samples were collected from the "234-235" Ditch, which may be an alias for the 216-Z-1D Ditch. The samples were analyzed for total alpha activity and Pu-239. Sample locations are shown in WHC-EP-0707 and analytical results are presented in the RI Report (DOE/RL-2003-11, Appendix A, Table A-4).

2.5.2.2 216-Z-19 Ditch Sediment Sampling (1976)

Eight sediment samples were collected from the bottom of the 216-Z-19 Ditch during March and April 1976 (WHC-EP-0707). The samples were analyzed for K-40, Sr-89/90, Cs-137, Ce-139, Pu-239, Am-241, and Ra-226. Samples were collected along the entire ditch alignment. Only descriptive locations are available for these samples (e.g., "west bank head," "U Pond inlet"). Analytical results are presented in the RI Report (DOE/RL-2003-11, Appendix A, Table A-4).

2.5.2.3 Routine Annual 216-Z-19 Ditch Sediment Sampling (1974–1979)

As part of the Rockwell Hanford Operations Environmental Surveillance Program, sediment samples were collected annually at the 216-Z-19 Ditch from 1974 through 1977 (WHC-EP-0707). One sediment sample was collected annually from 1974 to 1977, two were collected in 1978, and four were collected in 1979. Samples were analyzed for radionuclides, including Sr-90, Cs-137, Pu-239/240, and Am-241. Only descriptive locations are available for these samples. Analytical results are presented in the RI Report (DOE/RL-2003-11, Appendix A, Table A-4).

2.5.2.4 216-Z-19 Ditch Characterization Sampling (1979–1981)

In 1979, a characterization study was performed of the 216-Z-19 Ditch (and 216-U-10 Pond) to gather surface and near-surface samples from the 216-Z-19 Ditch. The 216-Z-19 Ditch was still operating at the time of the study and the portion of the ditch above 16th Street was dammed to prevent water from reaching the 216-U-10 Pond and portions containing standing water. A total of 246 samples were collected along nine transects placed over the length of the ditch, with each transect having seven sample points. The transect locations are shown in WHC-EP-0707. Vertical sample intervals generally were 5 to 10 cm (2 to 4 in.) in length, and samples were collected less than 1 m (3 ft) below the ditch bottom. Analytical results are presented in the RI Report (DOE/RL-2003-11, Appendix A, Table A-4).

Laboratory analyses were conducted at the Rockwell Laboratory (onsite) and two offsite laboratories (Eberline Services and Environmental Analysis Laboratory). Only laboratory analyses were used in the RI Report to evaluate the concentrations of the radioactive constituents. Forty-five of the 246 samples were analyzed using a developmental and unreliable analytical process (Dev Van IA) and so the results were not used. The remaining samples used for the transect investigation were analyzed for Cs-137, Pu-239/240, Pu-238, Sr-90, and Am-241. Thirteen additional separate surface grab samples were collected from the bottom of the ditch from 16th Street to the delta region entering the 216-U-10 Pond to better characterize the lower end of the ditch.

In addition, 19 boreholes were drilled in the vicinity of the Z-Ditches in 1980 and 1981. Two deep monitoring wells (299-W18-177 and 299-W18-178) were drilled during March and April 1980 to evaluate the vertical distribution of contaminants. Seventeen shallow exploration wells were drilled between February and April 1981 to locate and sample the backfilled 216-Z-1D and 216-Z-11 Ditches. The shallow wells included 299-W15-203 and 299-W15-204 that were drilled in the 216-Z-1D Ditch North Section to a depth of 6.1 m (20 ft) below ground surface (bgs). Seventy samples were collected from these boreholes and analyzed for Pu-238, Pu-239/240, and Am-241. As with the transect data described earlier, results from the Dev Van IA detector are not included in the data set. Consequently, a total of 66 samples were analyzed (20 from two deep boreholes and 46 from 9 shallow boreholes). The results are presented in the RI Report (DOE/RL-2003-11, Appendix A, Table A-4). Figure 2-5, presented later in this chapter, indicates the location of these 19 boreholes and the boreholes at the 216-Z-1D Ditch North Section.

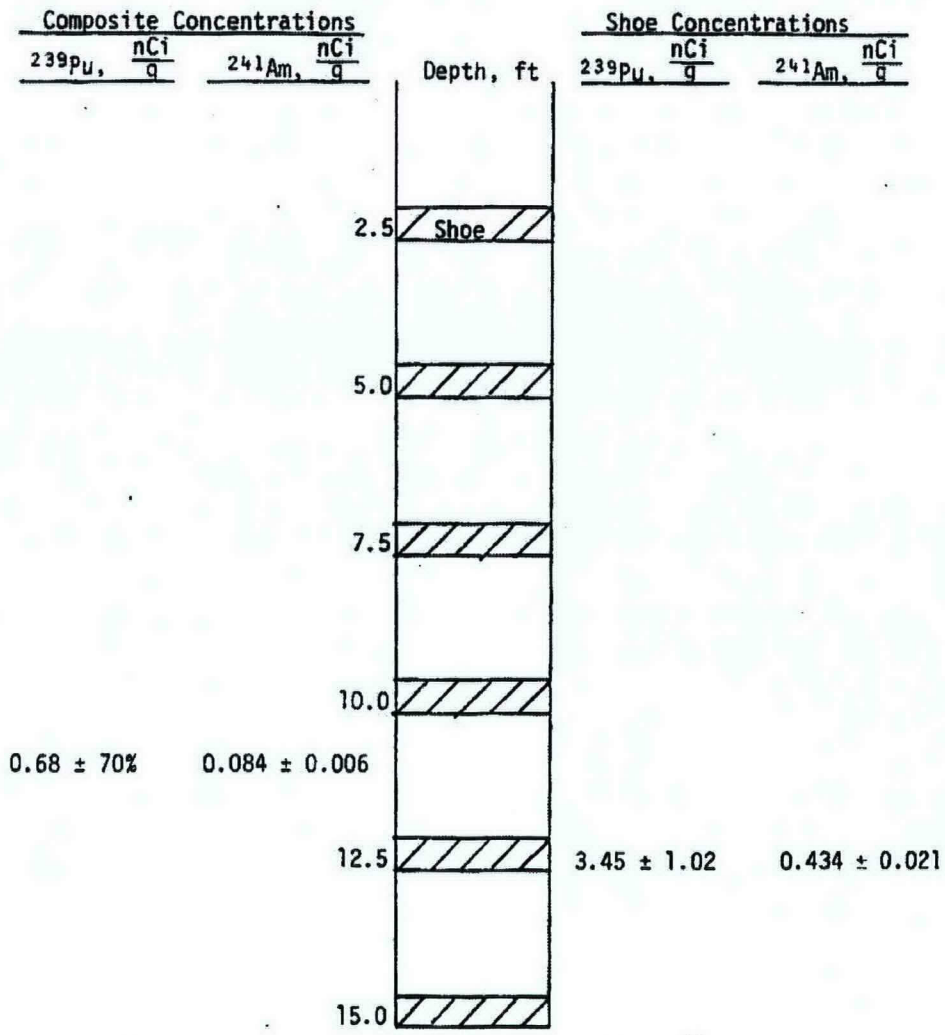
2.5.2.5 Field Screening in Support of 216-Z-20 Tile Field Construction and UPR-200-W-110 Location and Stabilization (1979-1980)

This activity included drilling of 44 boreholes to support design and construction of the 216-Z-20 Tile Field and stabilization of UPR-200-W-110. This activity was documented in Rockwell International report RHO-HS-VS-4, *Earth Science Investigations of the 216-Z-20 Crib, the UN-216-W-20 Spoil Trench, and the Storm Sewer*. This Rockwell report was not formally published but represents credible anecdotal information. Nine shallow boreholes were drilled in and around the backfilled UPR-200-W-110, at that time known as the UN-216-W-20 spoils trench, to determine the location and boundaries of the trench and to identify the extent of radiological contamination. Other boreholes were drilling in the vicinity of the planned

216-Z-20 Tile Field site; however, only the unplanned release (UPR) investigation data are used in the FS.

Analytical data were not generated from the UPR portion of this investigation and consequently, this information will not be used for risk assessment purposes. However, the field-screening information will be used to support discussion of a potential UPR analogous relationship with the heavily characterized Z-Ditches. Sediment samples were collected from groups of five or six cores taken from each of Boreholes 333 through 339 located in and around the trench. Samples were analyzed in the field using a system capable of assaying grab samples for Pu-239 and Am-241 using Si(Li) X-ray spectroscopy. This screening identified the presence of Am-241 and Pu-239 in Boreholes 333 through 339 (Figure 2-4) and the results are discussed later in this chapter.

Figure 2-4. UPR-200-W-110 Borehole 299-W18-233 Field-Screening Data. (From RHO-HS-VS-4)



2.6 Z-DITCHES CHARACTERIZATION RESULTS – NATURE AND EXTENT OF CONTAMINATION

The nature and vertical extent of contamination at the Z-Ditches characterization area was identified based on 216-Z-11 Ditch 2002 RI data obtained from Borehole C3808 and existing historical data from other Z-Ditch locations, that have been identified as sufficient to support risk evaluation in the 200-CW-5 OU. Contamination is defined in this section as the presence of chemical and radiological constituents that are not essential nutrients and that present potential risk because their concentrations exceed regulatory risk-based standards or other risk or dose-based screening levels described in later sections and detailed in the RI Report.

As discussed in Section 2.4.1, the Z-Ditches, consisting of the 216-Z-1D (south portion), 216-Z-11, and 216-Z-19 Ditches, are discussed in the FS collectively as a one contiguous contamination area. The sample results listed below reflect data presented in the RI Report (DOE/RL-2003-11, Appendix A) from 200-CW-5 OU RI Borehole C3808 sampling in 2002 (Section 2.4.1) and from previous sampling events (Section 2.4.2). Although contaminants were detected to a depth of 40 ft bgs, below approximately 5.3 m (17.5 ft) bgs, radionuclides were not detected above action levels. The sampling results show contamination is consistent with the Z-Ditches contaminant distribution model reflecting that these cooling water waste streams, generally contaminated from cooling coil failures, have relatively little chemical contamination and the primary radionuclides are relatively immobile in soil and so accumulated near the ditch bottoms (1 to 1.8 m [3 to 6 ft] bgs). Analytical sampling at Borehole C3808 did not identify chemicals, such as acids or solvents, in soils at the borehole location at levels sufficient to mobilize contamination in the soil column.

A summary of the maximum concentrations of contaminants in the Z-Ditches in the zone from 0.6 to 5.3 m (2 to 17.5 ft) is shown in Table 2-2.

Radionuclide contamination in the Z-Ditches begins at a depth of about 0.6 m (2 ft). Because the ditches had a 2.5:1 slope and so were much wider at the top than the bottom, detections at backfilled ditches (shown in the RI Report) shallower than the presumed ditch bottom could indicate that the sample was taken from the ditch sides not the ditch bottom. From 0.6 to 1.2 m (2 to 4 ft), there are small amounts of Cs-137 and Sr-90 and occasionally significant quantities of Pu-239/240 (40 nCi/g found at the 216-Z-11 Ditch in 1981) and Am-241 (9.5 nCi/g found at the 216-Z-19 Ditch in 1979). The highest concentrations of plutonium and americium were reported in the 216-Z-19 Ditch and the 216-Z-1D Ditch from 1.2 to 5.3 m (4 to 17.5 ft). Cesium-137 also is present at high concentrations (66,000 pCi/g) at this depth. The exception to these results is found at the north end of the 216-Z-1D Ditch where analytical sampling and geophysical logging at two locations show Pu-239/240 and Am-241 at concentrations of less than 100 pCi/g (WHC-EP-0707). Concentrations of all contaminants decrease with depth and below 5.3 m (17.5 ft); radionuclide contamination is less than 1 pCi/g.

The maximum Pu-239/240 concentration was reported as 13,000 nCi/g at the south end of the 216-Z-19 Ditch (U Pond delta). However, as described in the Z-Ditches Study (Appendix A), this concentration is orders of magnitude higher than contaminant levels generally reported for this area and appears to be a localized contamination effect and a statistical outlier.

The gross gamma and passive neutron detector logging results showed good agreement with the spectral gamma logging data, both of which identified a major zone of contamination at approximately 2.9 m (9.5 ft) bgs.

Table 2-2. Maximum Soil Concentrations from 0.6 to 5.3 m (2 to 17.5 ft).

Contaminant	Maximum Concentration	Sample Location (Ditch)	Sample Date	Sample Depth (ft bgs [a])
Radionuclides				
Cesium-137	66,000 pCi/g [b]	216-Z-19	1976	7
Americium-241	7,870,000 pCi/g [c]	216-Z-19	1976	7
Strontium-90	216 pCi/g	216-Z-19	3/24/76	7
Plutonium-238	5,500 pCi/g	216-Z-19	5/1979	7 to 6
Plutonium-239	780,000 pCi/g	216-Z-1D	1959	8
Plutonium-239/240	13,000,000 pCi/g	216-Z-19	5/1979	4
Thorium-230	8.4 pCi/g	216-Z-11	2002	10 to 12.5
Radium-226	5,200 pCi/g	216-Z-19	4/21/76	7
Nonradionuclides [d]				
Nitrite	43 mg/kg	216-Z-11	2002	12.5 to 15
Total petroleum hydrocarbon	27 mg/kg	216-Z-11	2002	10 to 12.5
Aroclor-1254	52 mg/kg	216-Z-11	2002	7.5 to 10
Aroclor-1260	78 mg/kg	216-Z-11	2002	7.5 to 10
Boron	24 mg/kg	216-Z-11	2002	7.5 to 10

[a] Sample depths shown are depths below ground surface at the time of sampling. Contamination now 1 to 0.6 m (2 ft) deeper at locations sampled before 1981 due to addition of stabilization material.

[b] Decayed value for Cs-137 used and is as of 2003 (DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-CS-1 Steam Condensate Group Operable Units*). Cesium-137 has a half-life of only 30 years and decayed value was used because concentrations have diminished significantly since sample collection.

[c] Americium value shown is the value measured at the time of sample analysis and does not reflect radioactivity decay or Pu-241 ingrowth since then.

[d] All nonradiological soil sample results from 2002 remedial investigation sampling of Borehole C3808.

Aroclor is an expired trademark.

bgs = below ground surface.

Aroclor-1254[2] and Aroclor-1260 are polychlorinated biphenyls that were reported at Borehole C3808 only at 2.3 to 3 m (7.5 to 10 ft) bgs at concentrations of 52 and 78 mg/kg, respectively. Total petroleum hydrocarbon was detected 3 to 3.8 m (10 to 12.5 ft) bgs at a concentration of 27 mg/kg but did not exceed screening levels. Molybdenum is the only inorganic metal that exceeded risk-based screening levels in soil samples from Borehole C3808. It was detected 46 to 47 m (152 to 154.5 ft) bgs at a concentration of 0.82 mg/kg. Boron, for which no risk-based screening level exists, was detected 7.5 to 10 ft bgs at a maximum concentration of 24 mg/kg with all other detections at or below 1 mg/kg.

[2] Aroclor is an expired trademark.

Nitrite was inaccurately reported by the RI Report at concentrations exceeding risk-based screening levels in soil samples collected from Borehole C3808. Nitrite was detected from 3 to 5.3 m (10 to 17.5 ft) bgs, ranging in concentration from 23 mg/kg to a maximum of 43 mg/kg at a depth of 3 m (10 ft). The reported nitrite concentrations exceed 4.0 mg/kg as the risk-based soil concentration considered protective of groundwater (WAC 173-340-747, "Deriving Soil Concentrations for Ground Water Protection"). However, upon further review, it was determined that the nitrate and nitrite values reported in the RI Report were reported inconsistently. By converting all of the data to nitrogen (N) in nitrate and to N in nitrite, and then reevaluating the data, it was determined that the actual nitrite values were significantly less than originally reported with the newer values ranging from nondetect to 5.3 mg/kg. Because the maximum nitrite concentration is now essentially at the risk-based screening level (4.0 mg/kg), nitrite is no longer considered a risk to groundwater.

For this FS, the nature and extent of contamination for UPR-200-W-110 is identified using field-screening data. These data will be used later in this chapter to support establishing an analogous relationship with the heavily characterized Z-Ditches. Analytical data were not generated from the UPR investigation. This field-screening information is not considered useable for risk assessment purposes. The screening results identified the presence of Am-241 and Pu-239 in Boreholes 333 through 339. Maximum plutonium concentration of 3.3 ($\pm$1.0) nCi/g and Am-241 of 0.4 nCi/g, were measured in Borehole 333 located near the center and bottom of the trench at 3.8 m (12.5 ft) bgs. Screening data showed less than 1 nCi/g at the other UPR boreholes. The screening results confirm the presence of plutonium and americium in this UPR but at lower concentrations than the Z-Ditches because of mixing contaminated sediments with clean backfill during the excavation and reburial activities. The screening evaluation indicates that UPR contamination is bounded by the representative Z-Ditches area contamination.

The contamination distribution model for the Z-Ditches is presented in Figure 2-5.

2.7 EVALUATION OF ANALOGOUS WASTE SITES

As described earlier in this chapter and in DOE/RL-96-81, the grouping of 200 Areas waste sites for remedial decision making is based on the processes that generated the waste received at the site. Sites that received waste associated with a certain process were grouped by waste category (e.g., cooling water) with the grouping further refined based on more specific process details (e.g., 200-CW-5 OU Z-Ditches cooling water). Within these waste categories, sites were chosen for characterization that were considered representative of other sites of the waste group and/or to fill specific data gap(s). This streamlining approach was implemented to reduce the amount of characterization required to support remedial action decision making for the remaining OU waste sites that are anticipated to have similar contamination characteristics. 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 worst case and typical OU conditions.

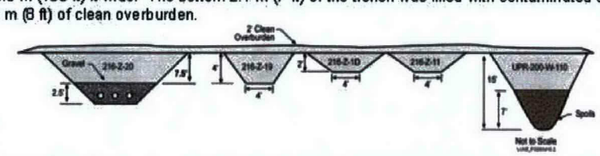
Figure 2-5. Z-Ditches and Analogous Waste Sites Conceptual Site Model. (2 Pages)

200-CW-5 Cooling Water | **Z-Ditches (216-Z-11, 216-Z-19, 216-Z-1D), 216-Z-20 Tile Field, and UPR-200-W-110** | **PFP Zone**

History

The 200-CW-5 OU waste sites include the Z-Ditches (216-Z-11, 216-Z-19, 216-Z-1D), 216-Z-20 Tile Field, and UPR-200-W-110. The Z-Ditches operated in chronological sequence from 1944 to 1981 primarily to transfer cooling water and stream condensate effluent waste from the Z Plant's 231-Z, 234-5Z, and 291-Z Buildings to the 216-U-10 Pond. These streams were sometimes contaminated with low levels of radionuclides (primarily Am-241, Pu-239/240, Pu-238, Cs-137, and Sr-90) generally by cooling coil failures but sometimes through process upsets. In 1949 the upper 526 m (1,725 ft) (see Plan View Area A) of the ditch was backfilled and replaced with the 200-W-125 pipeline that discharged to a new concrete outfall structure that became the northern-most waste inlet point. After a release of plutonium and americium from 231-Z in 1959, the ditch was deactivated, backfilled, and replaced by the 216-Z-11 Ditch, which operated from 1959 to 1971. The 216-Z-11 Ditch was deactivated, backfilled, and replaced with the 216-Z-19 Ditch, which operated from 1971 to 1981. In 1971, during 216-Z-19 Ditch construction, spoils were inadvertently excavated from part of the backfilled 216-Z-11 Ditch and were placed in disposal trench UN-216-W-20, later designated UPR-200-W-110. The 216-Z-19 Ditch was initially a waste transfer ditch but after 1976 was dammed to contain a radionuclide release and thereafter operated as a disposal site. In 1981, the Z-Ditches were replaced with the 216-Z-20 Tile Field disposal site. By that time the ditches were backfilled and in 1981, the entire area was stabilized by addition of 0.3 m (1 ft) of clean soil and is now an Underground Radioactive Material Area.

CONSTRUCTION: The Z-Ditches (216-Z-11, 216-Z-19, 216-Z-1D), were shallow open ditches that were approximately 842 m (2,765 ft) long (216-Z-1D Ditch was initially 1,295 m (4,250 ft) long before being shortened), 1.2 m (4 ft) wide at the bottom, and 0.6 to 1.2 m (2 to 4 ft) deep with 2.5:1 sloped sides and a 0.05% grade toward the 216-U-10 Pond. The 216-Z-20 Tile Field crib structure consisted of three 15 cm (6 in.) perforated PVC distribution pipes that were capped at the ends and placed in an excavation that was 463 m (1,519 ft) long, 3 m (10 ft) wide at the bottom, and 2.7 to 8.8 m (9 to 29 ft) bgs deep due to irregular surface contour. The pipes lay in a 0.8 m (2.5 ft) deep gravel bed that was backfilled with soil to grade. Four sets of risers along the length of the unit (three in a row across the width of the unit) rose to a height of 0.46 m (1.5 ft) above grade. UPR-200-W-110 is 4.6 m (15 ft) deep, 129.5 m (425 ft) long, and up to 33.5 m (100 ft) ft wide. The bottom 2.1 m (7 ft) of the trench was filled with contaminated spoils and with 2.4 m (8 ft) of clean overburden.



WASTE VOLUME: Waste volume for Z-Ditches (216-Z-1D, 216-Z-11, 216-Z-19) and UPR 200-W-110 unknown (WIDS). Waste volume for 216-Z-20 Tile Field is 3,800,000,000 L.

DURATION (WIDS):

216-Z-1D - 1944 to 1959
216-Z-11 – 1959 to 1971
UPR-200-W-110 – 1971 (Occurrence date)
216-Z-19 – 1971 to 1981
216-Z-20 – 1981 to 1995

ESTIMATED DISCHARGED INVENTORY: Uncertain because contaminant inventory estimations based on waste stream chemistry during operations diverge from inventory based on soil sampling.

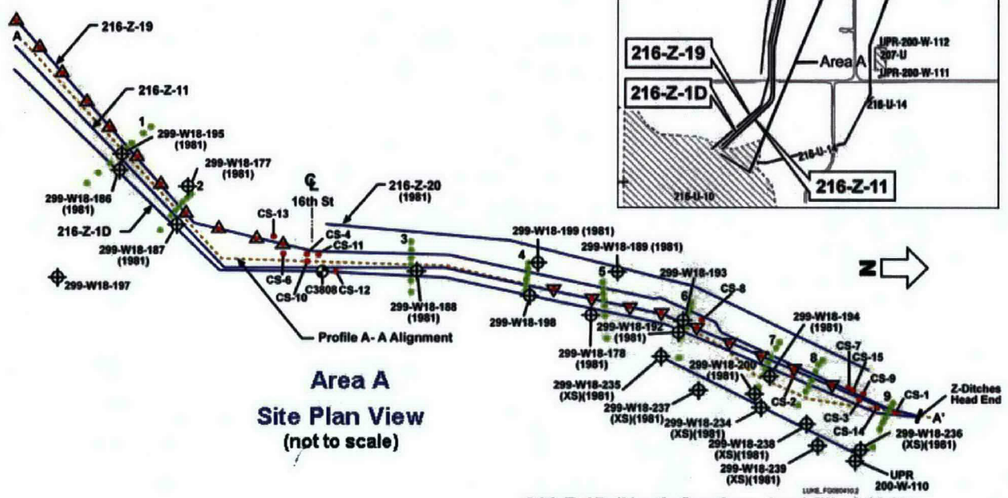
REFERENCES:

WIDS general summary reports
RHO-LD-114
DOE/RL-91-52
WHC-EP-0707
DOE/RL-2003-11
CP-12134
RHO-HS-VS-4

Basis of Knowledge (Data Types)

- Process History
- Soil Sampling Analytical Data (AD)
- X-ray Spectroscopy Field Screening - (XS)

Note: All data AD unless noted otherwise.

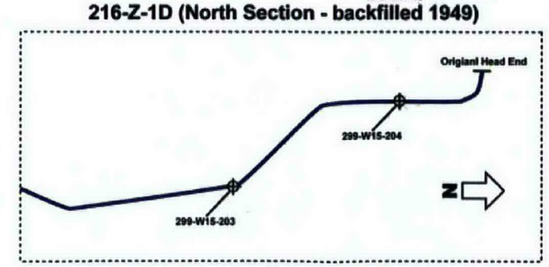


Area A
Site Plan View
(not to scale)

LEGEND

- Transect Data Points (5/1979)
- Soil Cores
- Existing Boreholes/Monitoring Wells (w/FS Data)
- 200-CW-5 Waste Sites (Ditches/Trench/Tile Field)
- RI Borehole (2002)
- 299-Z-19 Data Points 0-1000 (1979)
- 299-Z-11 Data Points 1900-1908 (1959)

216-Z-1D (North Section - backfilled 1949)



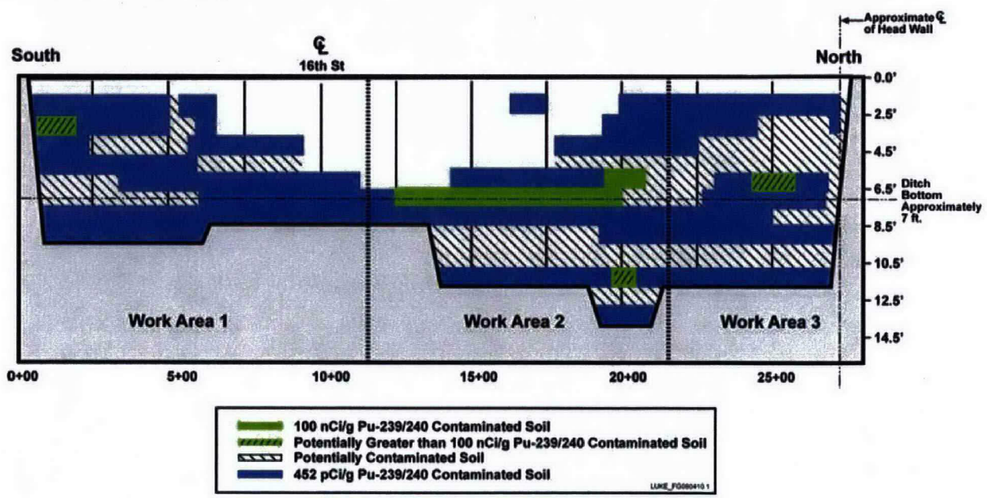
Area B

Figure 2-5. Z-Ditches and Analogous Waste Sites Conceptual Site Model. (2 Pages)

200-CW-5 Cooling Water — Z-Ditches (216-Z-11, 216-Z-19, 216-Z-1D), 216-Z-20 Tile Field, and UPR-200-W-110 — **PFP Zone**

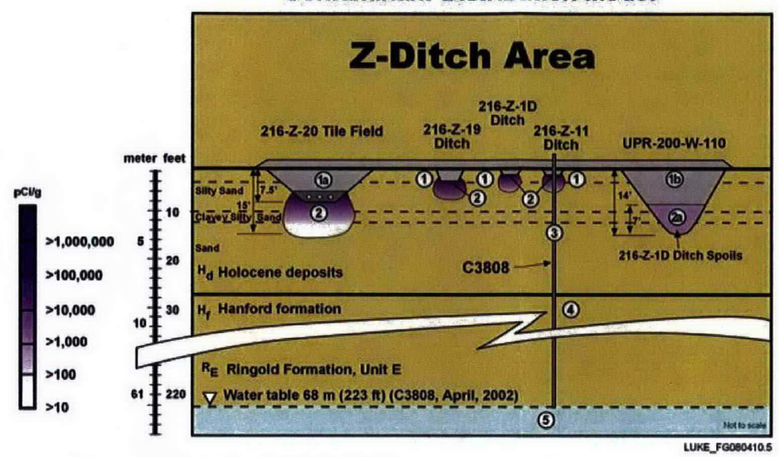
Characterization Summary

From 1959 to 1981, the ditches were intermittently sampled primarily for plutonium, americium, cesium, and strontium to ensure contamination control at open ditches or to characterize retired and backfilled ditches (DOE/RL-2003-11; WHC-EP-0707). In 1959, 90 sediment samples were taken from the open 216-Z-1D Ditch. During 216-Z-19 Ditch operations (1971 to 1981), 8 ditch bottom samples were taken in 1976, 9 ditch sediment samples in 1977-79, and 201 ditch bottom and surface soil samples in 1979-80 at 9 transects that crossed the backfilled 216-Z-1D and 216-Z-11 Ditches (WHC-EP-0707). In 1980-81, 70 samples were taken from deep Borehole 299-W18-177 at the 216-Z-11 Ditch and 299-W18-178 at the 216-Z-19 Ditch and from 17 shallow boreholes at the backfilled 216-Z-1D and 216-Z-11 Ditches (DOE/RL-2003-11). In 1981, the north end of the 216-Z-1D Ditch was sampled at Boreholes 299-W-15-203 and -204 and material from 9 shallow boreholes installed at UPR-200-W-110 underwent in-field x-ray spectroscopy (RHO-HS-VS-4). In 1981, Boreholes 299-W18-189, -193, -194, and -195 at the 216-Z-11 Ditch and 299-W18-188 and -192 at the 216-Z-1D Ditch were sampled for plutonium and americium. In 2002, data were collected for the 200-CW-5 OU RI that included spectral gamma/passive neutron geophysical logging of 24 soil probes at 5 transects and installation, sampling, and geophysical logging of Borehole C3808. Neutron moisture logging at Borehole C3808 suggests that elevated moisture was no deeper than 21 to 34 m (70 to 110 ft) bgs (CP-12134). RI analytical data showed only limited chemical contamination. RI and historical sampling data show that radiological contamination is variable along the length of the ditches; the major area of contamination is centrally located north of 16th Street and south of the Z-Ditches inlet structure; and the contamination is shallow (1.2 to 5.2 m [4 to 17 ft] bgs) with the maximum concentrations (americium at 7.8 million pCi/g and plutonium at 13 million pCi/g) reported just below the presumed ditch bottoms (1.2 to 1.8 m [4 to 6 ft] bgs), decreasing with depth to less than 1 pCi/g at 5.3 m (17.5 ft) bgs.



Section A-A of Site Plan View
(not to scale)

Contaminant Distribution Model



Notes apply to Contaminant Distribution Model:

1. The Z-Ditches (216-Z-1D, 216-Z-11, and 216-Z-19) were open, unlined ditches that operated in chronological sequence from 1944 to 1981 transferring primarily equipment and vessel cooling water sometimes containing plutonium and americium to the 216-U-10 Pond. The north end of the 216-Z-1D Ditch was abandoned and backfilled in 1949. Significant effluent migration into the soil column is not generally expected with the waste transfer ditch model. However, from 1976 to 1981, the 216-Z-19 Ditch was dammed from the concrete outfall to 16th Street and all waste was disposed to the soil column. From 1981 to 1995 the 216-Z-20 Tile Field was used to dispose of cooling water waste that was, by that time, expected to generally contain less contamination (Note 1a). UPR-200-W-110 was a one-time use disposal trench for sediments from the backfilled 216-Z-1D Ditch (Note 1b).
2. The plutonium and americium have large distribution coefficients (K_d) and readily sorb to soils. Soil sampling did not report organics or acids in ditch soils that could mobilize contaminants in the soil column. Consequently, the maximum concentrations have been found to exist near the ditch bottoms (approximately 1.2 to 2.3 m [4 to 7.5 ft] bgs), decreasing with depth to less than 1 pCi/g beyond 5.2 m (17 ft) bgs. Contamination was found to be variable along the ditches. Contaminant migration beyond UPR-200-W-110 trench walls is not expected to have occurred (Note 2a).
3. At Borehole C3808, the wetting front moved vertically downward beneath the ditches into the Hanford formation with gravity drainage (CP-12134). Any potential lateral spreading of liquids would mainly occur from contact with the Hanford formation gravel and sand or fine-grained lenses or from contact with the Cold Creek unit (formerly called the Plio-Pleistocene unit) if actually reached by the moisture front.
4. Moisture logging data for Borehole C3808 suggest that elevated moisture ceases between 21.3 m (70 ft) bgs and 33.5 m (110 ft) bgs. However, the moisture pathway deeper than approximately 5.2 m (17 ft) bgs was essentially non-contaminated. Because mobile contaminants were reported in Borehole C3808 at only very low concentrations, residual contamination is not expected in the vadose zone after gravity drainage.
5. Local groundwater contamination has not been attributed to Z-Ditches operations. Low contaminant concentrations in the groundwater could be attributed to older boreholes or clastic dikes that may have provided preferential pathways through the vadose zone.

As discussed earlier, the RI Report grouped the 216-Z-11 Ditch with the 216-Z-1D Ditch (south section) and the 216-Z-19 Ditch into one contiguous contamination area for purposes of remedial decision making, thereby replacing the 216-Z-11 Ditch with the collective Z-Ditches as the sole 200-CW-5 OU representative site. However, the remaining 200-CW-5 OU waste sites, 216-Z-20 Tile Field and UPR-200-W-110, have only limited site-specific data to support remedial decision making. These two sites are located in the same general area as the Z-Ditches, are unlined ditches, and are similar to or bounded by the Z-Ditches area with regard to waste received and contaminant distribution. Consequently, these sites reasonably could be evaluated based on an analogous relationship with the Z-Ditches. However, the FS alternative evaluation process further grouped all 200-CW-5 OU waste sites, except the 216-Z-1D Ditch North Section, into one decision unit, based primarily on physical proximity. Consequently, arriving at a remedial decision for the analogous sites is no longer solely dependent upon establishment of analogous relationships as described in the following sections.

As described earlier, the 216-Z-1D Ditch North Section is considered separately from the 216-Z-1D Ditch South Section because of significantly lower contamination levels at the north section. Consequently, the remedial decision for the 216-Z-1D Ditch North Section also is not dependent upon establishment of an analogous relationship with the Z-Ditches.

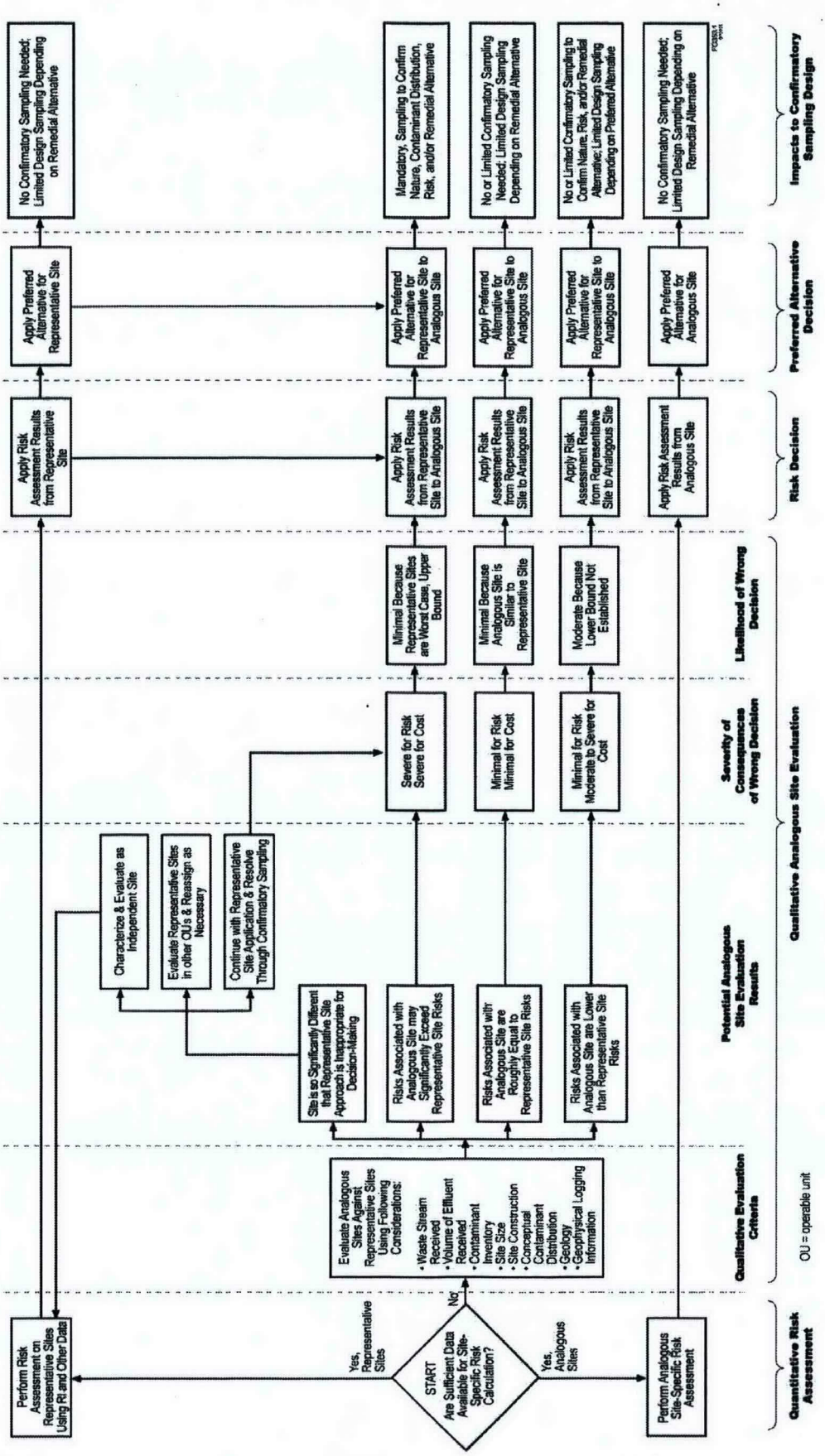
2.7.1 Rationale for Analogous Site Assignment

This section contains the rationale used to align potential analogous waste sites to the representative sites and other characterized waste sites. Key to the logic is the comparison of the characteristics of representative and potential analogous sites as well as the identification of potential remedial alternatives that may apply. Important considerations of the physical system include the following:

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

Figure 2-6 shows the process for evaluating the analogous sites against the representative sites for the RI/FS process through the confirmatory and design sampling processes.

Figure 2-6. Process for Evaluating an Analogous Site against the Representative Site.



2.7.2 200-CW-5 Operable Unit Analogous Site Grouping

Based on the analogous group assignment criteria above, the Z-Ditches site represents the 216-Z-20 Tile Field and UPR-200-W-110 by presenting similar or bounding contamination conditions. Table 2-3 summarizes site conditions as rationale for alignment of the 200-CW-5 OU representative and analogous sites, including the type and level of contamination received, contaminant inventory (where known), depth of waste discharge, expected contaminant distribution, and soil pore volume.

Contaminant inventory and distribution at the analogous 216-Z-20 Tile Field is expected to be similar to or bounded by the Z-Ditches. The Z-Ditches and 216-Z-20 Tile Field both received cooling water waste streams from Z Plant facilities containing similar contaminants. However, the Z-Ditches have significant radiological inventories from heating coil leaks during Z-Ditches operations while the waste stream to the 216-Z-20 Tile Field was significantly less contaminated because it operated after Z Plant facility upgrades to minimize radiological and chemical contaminants in these waste streams. This resulted in a much lower reported contaminant inventory of plutonium of less than 1 g and of americium, cesium, and strontium of less than 1 Ci. Although the 216-Z-20 Tile Field operated as a disposal site and received a high volume of effluent, contaminant distribution is expected to be similar to the representative Z-Ditches because of the immobility of plutonium and americium in soils. Plutonium and americium would tend to sorb to soils at the point of discharge (i.e., near the ditch bottom), regardless of the effluent driver, based on their very high distribution coefficients (K_d) of 200 and 300, respectively. Further, solvents or acids were not in cooling water waste streams to mobilize contaminants in the soil column. The similarity of 216-Z-20 Tile Field contaminant distribution with the Z-Ditches, regardless of effluent driver, is further demonstrated by 216-Z-19 Ditch soil sample results. These results indicate that disposal of effluent during the period of 216-Z-19 Ditch operations as a disposal site did not drive contamination any deeper than the contamination found at the other Z-Ditches that operated as conveyance sites.

Distribution of contaminants is expected to be similar to or bounded by the Z-Ditches for the analogous 216-Z-20 Tile Field and UPR-200-W-110. The UPR did not receive effluent but is the disposal site for soil and sediments from the 216-Z-1D Ditch, which contained the same Z Plant waste stream contaminants. The distribution of contaminants within UPR-200-W-110 that was a one-time use disposal site for contaminated soil and that received no effluent discharges, is shown to have remained within the disposal trench and so can reasonably be bounded by the representative Z-Ditches.

Table 2-3. 200-CW-5 Operable Unit Representative Site and Analogous Waste Sites. (2 Pages)

Analogous Sites [a] Comparison Parameters	Representative Site [b] *(Effluent Conveyance Site)*	216-Z-20 Tile Field *(Effluent Disposal Site)*	UPR-200-W-110 *(Soil Disposal Site)*
1. Configuration	Long, shallow (0.6 m (2 ft) deep except the 216-Z-19 Ditch at 1.2 m [4 ft] deep), narrow (1.2 m [4 ft] wide at bottom, 4.3 m (14 ft) wide at top during operations except for the 216-Z-19 Ditch up to 6.1 m (20 ft), currently backfilled ditches.	***(Not similar)*** Long, narrow, but deeper (2.7 to 6.1 m [9 to 20 ft]) and operated as a disposal crib with piping, gravel bed, and backfill.	***(Similar)*** Long, narrow, unlined, deeper (4.6 m [15 ft]), one-time use disposal trench with a 2 m (7-ft) layer of contaminated soil under 2.4 to 2.7 m (8 to 9 ft) of clean backfill. Site never received effluent.
2. Waste stream origin/volume	Sites received cooling water from multiple Z Plant operations. As conveyance ditches, the effluent volume is unknown.	***(Similar and Bounded)*** Received similar Z Plant cooling water waste streams but bounded for contaminants due to plant upgrades before beginning operations. Site soils retained effluents received (3.8 million m^3).	***(Bounded)*** Site received no effluent waste streams. However, UPR was a disposal site for 216-Z-1D Ditch spoils (mixture of contaminated ditch sediment and clean backfill) having same constituents but at reduced concentrations due to soil mixing during UPR trench filling.
3. Contaminant inventory	Primary contaminants are plutonium and Am-241. As conveyance ditches, the effluent volume and therefore the inventory of waste stream contaminants retained in the ditches are uncertain. However, maximum plutonium inventories at 216-Z-1D, 216-Z-11, and 216-Z-19 Ditches are 1.0, 10, and 1.0 kg, respectively.	***(Bounded)*** Retained effluent inventory high (3.8 million m^3) but with cleaner waste streams. Because of plant upgrades, the site has smaller plutonium inventory (0.15 kg).	***(Bounded)*** One-time use disposal site for 216-Z-1D Ditch spoils that did not receive effluent streams having no developed contaminant inventory. However, field measurements of trench borehole samples using X-ray spectroscopy identified plutonium concentrations the length of the ditch from 0.7 to 3.3 nCi/g, indicative of smaller waste inventory than the representative Z-Ditches where much higher plutonium concentrations were found.
4. Geology	The representative Z-Ditches are co-located in the 200 West Area.	***(Similar)*** Co-located.	***(Similar)*** Co-located.

Table 2-3. 200-CW-5 Operable Unit Representative Site and Analogous Waste Sites. (2 Pages)

Analogous Sites [a] Comparison Parameters	Representative Site [b] *(Effluent Conveyance Site)*	216-Z-20 Tile Field *(Effluent Disposal Site)*	UPR-200-W-110 *(Soil Disposal Site)*
5. Extent of contamination	Maximum concentrations of primary contaminants (plutonium and Am-241) limited to 3.8 m (12.5 ft) bgs with maximum chemical concentrations (nitrite) found to 5.3 m (17.5 ft) bgs.	***(Similar and Bounded)*** Although a disposal site, extent of contamination is similar to the Z-Ditches area waste because it operated similarly to the 216-Z-19 Ditch, which also was used as a disposal site and where waste distribution was similar to the remaining Z-Ditches area. It would be bounded because the waste streams contained less contaminants.	***(Similar)*** No effluent hydraulic contaminant driver so all contamination from one-time disposal use contained within the ditch. Plutonium maximum concentration found through field measurements of UPR borehole soil samples of less than 1 nCi/g at all boreholes except one at 3.3 nCi/g.
6. Groundwater impact	Groundwater impact limited (DOE/RL-99-07). Nearby groundwater monitoring well shows no radionuclide in groundwater above drinking water standards. Risk assessment modeling shows Z-Ditches contamination does not reach groundwater.	***(Bounded)*** Bounded because does not contain plutonium and americium above 100 nCi/g, as does the Z-Ditches. No breakthrough of radionuclides to perched water or groundwater has occurred (WHC-EP-0674).	***(Bounded)*** Similar, immobile radionuclide contaminants contained in the trench with the maximum (3.3 nCi/g) found at one borehole at 3.8 m (12.5 ft) bgs and generally not found at the 4.6 m (15-ft) trench bottom. Site could not impact groundwater since it received no effluent to drive contamination downward and the 2.4 to 2.7 m (8 to 9 ft) of clean backfill provide natural recharge (precipitation) evapotranspiration moisture control.
ANALOGOUS SITE? (Yes/No) [c]		**Yes**	**Yes**

[a] The site will be considered analogous with regard to individual parameters where the representative site-specific conditions are similar to or bound (exceed) the analogous site conditions.

[b] For the 200-CW-5 Operable Unit, the representative waste site is the aggregate Z-Ditches characterization area of the co-located portions of the 216-Z-1D, 216-Z-11, and 216-Z-19 Ditches.

[c] The overall determination of the analogous waste site relationship will be based on substantial agreement with the substantive comparison parameters but does not require an analogous determination for all parameters.

DOE/RL-99-07, *200-CW-1 Operable Unit RI/FS Work Plan and 216-B-3 RCRA TSD Unit Sampling Plan.*
WHC-EP-0674, *Groundwater Impact Assessment Report for the 216-Z-20 Crib, 200 West Area.*

UPR = unplanned release.

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3.0 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIATION GOALS

This chapter summarizes the BRA, defines the RAOs for the 200-CW-5 OU, and sets up preliminary remediation goals (PRG). The BRA was conducted as part of the RI Report (DOE/RL-2003-11). The RAOs are media-specific or OU-specific objectives for protecting human health and the environment. The RAOs are developed considering land use, contaminants of potential concern (COPC), potential ARARs, and exposure pathways. The RAOs 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 PRGs used to evaluate alternatives that will be finalized in the 200-CW-5 OU record of decision (ROD).

Determination of the feasibility of remedial actions requires the identification of PRGs. The PRGs are criteria by which aspects of a cleanup under CERCLA are measured. They include ARAR, guidance and advisories (to be considered materials), and risk-based concentrations of radionuclides and chemicals in environmental media that have been brought forward from the human health and ecological risk assessments (ERA) conducted for the 200-CW-5 OU sites.

3.1 BASELINE RISK ASSESSMENT SUMMARY

BRAs are conducted to evaluate whether the site presents unacceptable risk to human health and/or the environment that could require remedial action. Data evaluated for the Z-Ditch BRA included the sample results from the shallow-zone soils collected before and during the 2002 characterization effort and are presented in Appendix A of the RI Report. Risk information is used to help determine if remedial action is necessary and to support remedial alternative evaluations. The BRA conducted in the RI Report concluded there was a potential risk to human health and the environment based on the current and reasonably anticipated future industrial land use. Ecological risk at the Z-Ditches was identified in a screening-level ecological risk assessment (SLERA). The SLERA will be supplemented with future results of DOE/RL-2007-50, *Central Plateau Terrestrial Ecological Risk Assessment Report*, and will be used to support the RI/FS process for this and other Central Plateau OUs. Potential human-health risk because of inadvertent intrusion into the Z-Ditches area also was identified. Table 3-1 presents a summary of these assessments.

Table 3-1. Waste Site Risk Summary. (3 Pages)

Risk Element	Z-Ditches
Does the site meet human health preliminary remediation goals – chemicals?	
Are concentrations less than WAC 173-340-745?	Yes
Does the site meet human health preliminary remediation goals – radionuclides – under the industrial worker exposure scenario [without existing cover in place]?	
Does the waste site meet human health PRGs for radionuclides?	No
Dose at 0 years (mrem/yr)	4.5×10^4
Primary radionuclides that contribute dose, 0 years	Pu-239
Dose at 150 years (mrem/yr)	4.2×10^4

Table 3-1. Waste Site Risk Summary. (3 Pages)

Risk Element	Z-Ditches
Primary radionuclides that contribute dose, 150 years	Pu-239/240
Dose at 1,000 years (mrem/yr)	3.4×10^4
Primary radionuclides that contribute dose, 1,000 years	Pu-239/240
Does the site meet human-health preliminary remediation goals – radionuclides – under the industrial worker exposure scenario? Assumes that the existing cover provides some protection.	
Does the waste site meet human health PRGs for radionuclides?	Yes
Dose at 0 years (mrem/yr)	4.3×10^{-2}
Primary radionuclides that contribute dose, 0 years	Ra-226
Dose at 150 years (mrem/yr)	0.25
Primary radionuclides that contribute dose, 150 years	Ra-226
Dose at 1,000 years (mrem/year)	3.4×10^4
Primary radionuclides that contribute dose, 1,000 years	Pu-239/240
Does the site meet groundwater protection preliminary remediation goals – chemicals?	
Are groundwater protection standards exceeded based on initial screening?	Yes [a]
Chemicals predicted to reach groundwater above MCL	None [b]
Groundwater protection required?	No
Does the site meet groundwater protection preliminary remediation goals – radionuclides?	
Are groundwater protection standards exceeded based on initial screening?	No
Radionuclides predicted to reach groundwater above MCL	None [b]
Groundwater protection required?	No
Does the site meet ecological preliminary remediation goals – chemicals?	
Are concentrations less than ecological PRGs?	No
Constituents that exceed PRGs	Aroclor-1248, Aroclor-1260
Does the site meet ecological preliminary remediation goals – radionuclides?	
Are concentrations less than ecological PRGs?	No
Constituents that exceed PRGs	Am-241, Cs-137, Pu-238, Pu-239, Pu-239/240, Ra-226, Sr-90
Ecological protection required?	Yes
Does the site meet intruder exposure goals – radionuclides?	
Does the waste site meet intruder scenario goals for radionuclides after 150 years?	No
Does the waste site meet intruder scenario goals for radionuclides after 500 years?	No

Table 3-1. Waste Site Risk Summary. (3 Pages)

Risk Element	Z-Ditches

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 Section 4.6 of the Remedial Investigation Report (DOE/RL-2003-11). RESRAD input parameters are provided in Appendix C. Appendix E contains inadvertent intrusion risk analysis.

[a] WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties."
[b] STOMP modeling (PNNL-11217) results indicate that groundwater protection standards will not be exceeded.

DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-CS-1 Steam Condensate Group Operable Units.*
PNNL-11217, *STOMP Subsurface Transport Over Multiple Phases Theory Guide.*

Aroclor is an expired trademark.

STOMP = Subsurface Transport Over Multiple Phases (code).
MCL = maximum contaminant level.
PRG = preliminary remediation goal.
RESRAD = RESidual RADioactivity (dose model).

A fundamental risk assessment input parameter is the EPC. An EPC is the calculated contaminant concentration used to estimate the risk presented by the contaminant in a specified exposure scenario. For the direct-contact exposure routes, EPCs are represented by concentrations directly measured in soil. For the inhalation route, modeling is performed to estimate constituent concentrations in air from particulate or vapor emissions from soil. The EPCs for Z-Ditches COPCs were calculated for the BRA in conjunction with the conceptual site model depicted in Figure 2-5. The EPCs associated with the Z-Ditches were analyzed in accordance with EPA guidance (EPA, 1992, *Supplemental Guidance to RAGS: Calculating the Concentration Term*, OSWER Publication 9285.7-081) for developing risk assessment EPCs current at the time the RI Report was issued. After the BRA was issued, EPA revised its guidance on calculating EPC for environmental data sets (EPA, 2002, *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites*, OSWER 9285.6-10). In an effort to understand the uncertainties associated with the Z-Ditch data set, the RI data set was evaluated using EPA's revised methodology for calculating EPCs.

Evaluating the data set was accomplished by using EPA's ProUCL 4.0 analysis tool (EPA/600/R-07/038, *ProUCL Version 4.0 User Guide*). A revised Pu-239/240 EPC for the Z-Ditches was calculated using the statistical estimate provided by the ProUCL 4.0 analysis tool and is shown in Table 3-2.

Table 3-2. Nonparametric Upper Confidence Limit Statistics for Full Data Sets. (2 Pages)

Confidence coefficient	95%
Number of bootstrap operations	2,000
Total Plutonium (238, 239, and 239/240)	
Number of valid samples	417
Number of unique samples	233
Minimum	-0.032 pCi/g

Table 3-2. Nonparametric Upper Confidence Limit Statistics for Full Data Sets. (2 Pages)

Maximum	13,000,000 pCi/g
Mean	39,928 pCi/g
Median	4 pCi/g
Standard deviation	639087
Variance	4.08×10^{11}
Coefficient of variation	16.01
Skewness	20.15
Goodness of Fit: Data do not Follow a Discernable Distribution	
95% Useful UCLs	
Student's-t UCL	91,521
95% Adjusted-CLT UCL	124,405
95% Modified-t UCL	96,668
Nonparametric UCLs	
95% CLT UCL	91,406
95% Jackknife UCL	91,521
95% Standard bootstrap UCL	92,499
95% Bootstrap-t UCL	601,466
95% Hall's bootstrap UCL	413,973
95% Percentile bootstrap UCL	101,511
95% BCA bootstrap UCL	161,744
95% Chebyshev UCL	176,345
97.5% Chebyshev UCL	235,373
99% Chebyshev UCL	351,322
Potential UCL to Use	
95% Chebyshev UCL	176,345

BCA = bias-corrected accelerated bootstrap method.
CLT = central limit theorem.
UCL = upper confidence limit.

Several items of interest appeared as a result if recalculating the EPC. The first item pertains to the values assigned to the mean and median. The results show there are a few large numbers (concentrations) influencing the results. For example, the mean concentration for the plutonium in the soil is 39,928 pCi/g while the median (the point in the data set where half of the values are above this point) for the data set is 4 pCi/g. The second item is that the goodness-of-fit test indicates the data do not follow a discernable distribution, which suggests that the data set is nonparametric. This suggests the EPCs used in the 200-CW-5 OU RI (maximum detected value) would not be the value chosen today using the updated guidance from EPA. The third item is that the initial data analysis suggests using a 95 percent Chebyshev (mean) UCL for the EPC concentration of 176,345 pCi/g. This represents the starting point for additional data evaluation.

Current EPA guidance includes additional data evaluation to look for potential outliers in the data set. To identify if an outlier is present, Rosner's outlier test was performed. Table 3-3 shows the results of the outlier test.

Table 3-3. Rosner's Statistical Outlier Test of the Z-Ditches Plutonium Data Set at 5 Percent Significance.

Number of data points: 417			
Statistical Outlier #	**Mean**	**Standard Deviation**	**Potential Outlier (pCi/g)**
1	39927.98	638320.58	13,000,000
2	8773.96	60931.41	780,000
3	6915.59	47764.55	750,000
4	5120.7	30769.51	380,000
5	4213	24640.04	310,000
6	3470.8	19507.66	270,000
7	2822.31	14415.01	180,000
8	2390.17	11461.26	150,000
9	2029.26	8840.15	98,000
10	1794.04	7460.22	89,000

As stated before, the data set is nonparametric. Nonparametric data sets present a challenge because of the skewness of the data. This skewness is one factor in identifying potential outliers.

The results of the Rosner test identified 10 potential outliers at the 5 percent significance level. The 5 percent significance is considered the proper measure due to the uncertainties in the data set. Once these outliers (data points) were identified, the physical locations of these data points were examined. The location of the data points is important to conduct a spatial evaluation and to compare the nature of the contamination to environmental conditions and surrounding data and information. An evaluation of these data points revealed that two points appear to be outliers.

The first potential outlier (outlier #1) reports a plutonium concentration of 1.3×10^7 pCi/g. This point is located at the entrance to the U Pond. An evaluation of the surrounding data points and logging data reveal that the concentrations at these other locations are several orders of magnitude lower than the outlier. Furthermore, it is the only data point at this location to report a concentration of this magnitude. Its spatial location and the concentrations surrounding this point suggest it is an outlier in the data set.

The second potential outlier (outlier #2) shown in Table 3-3 is a plutonium concentration of 7.8×10^5 pCi/g. Additionally, five of the remaining potential outliers (#4, #5, #6, #7, and #8, having concentrations of 3.8×10^5, 3.1×10^5, 2.7×10^5, 1.8×10^5, and 1.5×10^5, respectively), are in proximity with this data point. In addition to the close spatial relationship, all these points are located at the same depth below ground surface and the magnitudes of concentrations are roughly the same. Although all six of the data points are two orders of magnitude higher than the other reported plutonium values, they should be included in calculation of the EPC.

The final data point considered is outlier #3 having plutonium concentration of 7.5×10^5 pCi/g, which is located near the northern headwall of the Z-Ditches. A similar evaluation of this data point was conducted and results reveal no supporting data to indicate widespread plutonium

contamination at this concentration. Therefore, this data point was considered an outlier and removed from the EPC calculation. Table 3-4 presents the statistical results after removing these two outliers. From visual inspection, the data set has not changed appreciably. It remains a nonparametric data set, which results in a 95 percent Chebyshev (mean) UCL of 17,451 pCi/g as the suggested EPC value.

Table 3-4. Nonparametric Upper Confidence Limit Statistics for Full Data Sets.

Confidence coefficient	95%
Number of bootstrap operations	2000
Plutonium Total	
Number of valid samples	415
Number of unique samples	237
Minimum	-0.016
Maximum	780000
Mean	6988
Median	4
Standard deviation	48901
Variance	2.39×10^9
Coefficient of variation	6.998
Skewness	11.82
Goodness of Fit: Data do not follow a Discernable Distribution	
95% Useful UCLs	
Student's-t UCL	10,945
95% UCLs (Adjusted for Skewness)	
95% Adjusted-CLT UCL	14,978
95% Modified-t UCL	13,596
Nonparametric UCLs	
95% CLT UCL	10,936
95% Jackknife UCL	10,945
95% Standard bootstrap UCL	10,882
95% Bootstrap-t UCL	15,250
95% Hall's bootstrap UCL	16,061
95% Percentile bootstrap UCL	11,422
95% BCA bootstrap UCL	13,061
95% Chebyshev UCL	17,451
97.5% Chebyshev UCL	21,979
99% Chebyshev UCL	30,872
Potential UCL to Use	
95% Chebyshev UCL	17,451

BCA = bias-corrected accelerated bootstrap method.
CLT = central limit theorem.
UCL = upper confidence limit.

Comparison of the current EPC value to the 2004 EPC value shows a reduction in concentration by two orders of magnitude from a maximum of 13,000,000 to 17,451 pCi/g. Because a change in EPC is roughly linear with a reduction in the associated risk, the risk associated with the Z-Ditches is reduced from 6.04×10^{-1} to approximately 6.04×10^{-3} for the first 50 years. However, the risk is not reduced below 1×10^{-4} during this same period.

For purposes of presenting a complete risk analysis, a range of plutonium concentrations and a range of risk estimates are presented for evaluation in this FS. This range includes the original data set and associated risks and the revised data set (without outliers) and associated risks. This provides a full range of information to decision makers for understanding risks and associated uncertainties.

Finally, the physical dimensions of the two data points identified as outliers (Table 3-3, outliers #1 and 3) were further examined. These two data points represent a small area of the Z-Ditches. The total area of the three Z-Ditches is approximately 10,725.4 m^2 or 1.07 ha (115,458 ft^2 or 2.7 acres). In comparison, the sample size is approximately 4.7 cm (12 in.) in diameter and approximately 5 cm (2 in.) in depth for both sample points. The sample size and volume represent an extremely small portion of the Z-Ditches. As such, it would be inappropriate to consider these two data points as representing a significant area at concentrations greater than 100 nCi/g. Rather it represents an area of the Z-Ditches where the plutonium contamination exceeds a value that is protective of human health and the environment and will require remediation.

3.2 LAND USE

To identify appropriate cleanup objectives, the reasonably anticipated 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.

3.2.1 Current Land Use

All current land-use activities associated with the 200 Areas and the Central Plateau are industrial in nature. The facilities located in the Central Plateau were built to process irradiated fuel from plutonium production reactors located in the 100 Areas. Most of the facilities directly associated with fuel reprocessing are now inactive and awaiting final disposition. Several waste management facilities operate in the 200 Areas, including permanent waste disposal facilities such as the Environmental Restoration Disposal Facility (ERDF), low-level radioactive waste burial grounds, and a mixed-waste trench permitted under the *Resource Conservation and Recovery Act of 1976* (RCRA). Construction of tank waste treatment facilities in the 200 Areas began in 2002, and the 200 Areas are the planned disposal location for the vitrified low-activity tank wastes. Past-practice disposal sites in the 200 Areas are being evaluated for remediation and likely are to include institutional controls (e.g., deed restrictions or covenants) as part of the selected remedy. Federal agencies other than the DOE, e.g., the U.S. Department of the Navy, use the Hanford Site 200 Areas nuclear waste treatment, storage, and disposal (TSD) facilities. A commercial low-level radioactive waste disposal facility, operated by US Ecology, Inc., currently operates on a portion of a tract in the 200 Areas leased to the State of Washington.

The DOE-selected land use for the 200 Areas, documented through the land-use ROD (64 FR 61615, "Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement (HCP EIS)," is industrial (exclusive) for sites located within the exclusive-use boundary.

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

3.2.2 Reasonably Anticipated Future Land Use

The reasonably anticipated future land use for the 200 Areas is continued industrial (exclusive) activities. Eventually, portions of this location may be used for non-DOE-related industrial uses. The DOE worked for several years with the Future Uses Working Group (Working Group) made up of representatives of cooperating agencies and stakeholders that included Federal, Tribal, state, and local governments with jurisdictional interests in the Hanford Site. The Working Group task was 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 the HCP and the associated ROD, 64 FR 61615, which were issued in 1999.

Consistent with the activities of the Working Group, the HCP was developed. The HCP was written to address the growing need for a comprehensive, long-term approach to planning and development on the Hanford Site because of DOE's separate missions of environmental restoration, waste management, and science and technology. The HCP analyzes the potential environmental impacts of alternative land-use plans for the Hanford Site and considers the land-use implication of ongoing and proposed activities. In the HCP, the land-use designation for sites inside the 200 Areas is industrial (exclusive [i.e., those areas suitable and desirable for TSD of hazardous, dangerous, radioactive, and nonradioactive wastes, and related activities]).

Under the preferred land-use alternative selected in the ROD (64 FR 61615), a portion of the 200 Areas 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 management of hazardous, dangerous, radioactive, and nonradioactive wastes. The HCP and associated 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 (i.e., US Ecology, Inc.), and demolish facilities that have no further beneficial use. Based on the HCP and associated ROD, and consistent with other Hanford Site waste management decisions, this FS uses an industrial land-use alternative for all the Z-Ditches, consistent with the HCP ROD. Risk assessments for the industrial land use are conducted considering a non-Hanford Site worker industrial receptor to bound the industrial land-use exposure possibilities.

3.2.3 Regional Land Use

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

3.2.4 Groundwater Use

The HCP indicates that contamination in the groundwater would restrict use. Groundwater in the Central Plateau currently is contaminated, although not from Z-Ditches operations, and is not withdrawn for beneficial uses. Fate and transport modeling conducted in the RI Report indicates that chemical or radiological contaminants present in the Z-Ditches will not reach groundwater at levels that could adversely impact groundwater.

3.3 CONTAMINANTS OF POTENTIAL CONCERN

Contaminants that contribute to site risk are referred to as COPCs. Identification of COPCs is an important process because it determines the list of contaminants for which further risk evaluations will be developed. Development of COPCs in the data evaluation and risk assessment process is discussed in EPA/540/1-89/002, *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual, (Part A) Interim Final*, OSWER 9285.7-02B. Those contaminants that are COPCs are determined by comparing contaminant concentrations with background; developing a set of data for use in risk assessment, and (if appropriate) limiting the number of contaminants to be carried through a risk assessment where risk-based screening levels do not exist; or by other methods. The evaluation of COPCs is presented in the RI Report for the 216-Z-11 Ditches.

3.4 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Appendix B identifies the potential ARARs for the 200-CW-5 OU waste sites.

3.5 SUMMARY OF RISK-BASED CONCERNS FOR THE FEASIBILITY STUDY

Section 3.1 summarizes the results of the BRA and provides an additional evaluation of the plutonium EPC at the Z-Ditches. Based on the BRA, this FS addresses the following risk-based concerns.

- Plutonium-239/240, Am-241, and Ra-226 present a threat to a future industrial worker though the direct-contact-exposure pathway. The primary contributors to dose and excess lifetime cancer risk (ELCR) are Pu-239/240 and Ra-226.

- Americium-241, Cs-137, Pu-238, Pu-239/240, Ra-226, and Th-228 are present at concentrations above the biota concentration guide (BCG) screening levels. Based on the comparison of concentrations to ecological screening concentrations, there is a concern that wildlife exposed to soils at the Z-Ditches may be at risk for adverse health effects.

- Aroclor-1254 and Aroclor-1260 and Pu-239/240 are reported at a single hot-spot location. Based on the comparison of concentrations from this location to ecological screening values (0.65 mg/kg), a concern exists that wildlife exposed to soils at this location may be at risk for adverse health effects.

3.6 REMEDIAL ACTION OBJECTIVES

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

- Media of interest (e.g., contaminated soil, solid waste)

- Types of contaminants (e.g., radionuclides, inorganic, and organic chemicals)

- Potential receptors (e.g., humans and wildlife)

- 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. RAOs specific to the 200 Areas for soils, solid wastes, and groundwater were developed in the Implementation Plan (DOE/RL-98-28). Specific RAOs for

this FS were defined based on the fate and transport of contaminants, projected land uses for the 200 Area, and the 200-CW-5 OU conceptual exposure model. The RAOs for this FS are as follows.

- RAO 1 – Mitigate unacceptable risk to human health and ecological receptors associated with radiological exposure to wastes or soil contaminated above risk-based criteria by removing the source or eliminating the pathway.

- RAO 2 – Mitigate unacceptable risk to ecological receptors associated with nonradiological exposure to wastes or soil contaminated above risk-based criteria by removing the source or eliminating the pathway.

- RAO 3 – Mitigate occupational health risks to workers performing remedial actions.

The RAOs will be finalized in the ROD for these waste sites. Achievement of the RAOs will be described in the remedial design/remedial action work plan to be prepared after the ROD is approved.

For the purposes of this FS, RAO 1 is satisfied for radionuclides by prevention or reduction of risks from exposure to waste or contaminated soil that exceeds 500 mrem/yr above background. This dose threshold is applied to DOE site workers for a period of 50 years. A dose threshold of 15 mrem/yr above background is applied to an individual who receives reasonable maximum exposure under an industrial-exposure scenario for the period from 50 to 1,000 years after final remediation. For ecological receptors, exposure to wastes or soil contaminated with radionuclides will be prevented or reduced such that dose rates will not exceed 0.1 rad/day for terrestrial organisms.

RAO 2 is satisfied when soil concentrations are below WAC 173-340-7490, "Terrestrial Ecological Evaluation Procedures." Exposure of ecological receptors to wastes or soil contaminated with nonradiological constituents will be prevented or reduced so that the hazard quotient (HQ) and the hazard index do not exceed one.

RAO 3 is achieved by implementing existing Hanford Site standards for radiological worker protection.

3.7 PRELIMINARY REMEDIATION GOALS

The PRGs are based on attainment of acceptable levels of human health and ecological risk. PRGs are preliminary numeric representations of the RAOs (i.e., preliminary cleanup levels) using the anticipated future land, applicable contaminants, and relevant exposure pathways. PRGs are considered preliminary until finalized in a ROD. Typically, PRGs are identified for individual hazardous substances identified as COCs. COCs are the subset of the contaminants listed as COPCs, in Appendix C, Table C-1 that exceed applicable standards. If multiple contaminants are present at a site, the suitability of using individual PRGs as final cleanup values protective of human health and the environment is evaluated based on site-specific information and the potential for contaminant interaction.

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, which for nonradionuclides are in milligrams per kilogram for soil or milligrams per cubic meter for air and for radionuclides are in picocuries per gram. Final remedial action goals developed from the PRGs will be specified in a ROD that identifies the selected remedial alternative for the 200-CW-5 OU.

Residual risks following completion of remediation of the waste sites must meet the 10^{-4} to 10^{-6} ELCR for radiological and carcinogenic chemical constituents and must be below a hazard index value of 1.0 for non-carcinogenic chemicals. Actual soil contaminant concentrations achieving these cleanup objectives will be presented in a cleanup verification package for the facility. The cleanup verification package will demonstrate how and where specific criteria have been applied and how the remedy protects receptors from the COCs identified for the waste sites. Tables 3-5 and 3-6 identify nonradiological and radiological PRGs, respectively, for the Z-Ditches.

Table 3-5. Summary of Nonradionuclide Soil Preliminary Remediation Goals for all Pathways. (2 Pages)

Constituent	Hanford Site Background [a] (mg/kg)	Direct Contact [b] (mg/kg)	Groundwater Protection [c] (mg/kg)	Terrestrial Wildlife Protection [d, e] (mg/kg)	Overall PRG [f] (mg/kg)
Contaminants of Concern – 216-Z-11 Ditch [g]					
Aroclor-1254	--	66	0.99	0.65	0.65
Aroclor-1260	--	66	0.99	0.65	0.65

[a] Background concentrations are 90th percentile values of the log normal distribution of sitewide soil background data from DOE/RL-92-24. Where the applicable PRG for a constituent is less than background, the background value is used as the PRG.

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

[c] Values represent deep vadose-zone soil concentrations that will be protective of groundwater. Values are calculated using the WAC 173-340 three-phase model for protection of drinking water (WAC 173-340-747[4], amended February 12, 2001).

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

[e] Constituents with values shown are those constituents that exceed their respective soil levels protective of terrestrial wildlife as shown in Appendix C, Table C-9.

[f] Listed values represent the most restrictive soil PRG derived from evaluation of direct contact and terrestrial wildlife protection. Overall PRGs selected based on terrestrial wildlife protection should be interpreted in light of the discussion later in this feasibility study.

[g] These contaminants of concern exceed groundwater protection risk-based soil concentrations; however, subsequent STOMP modeling (PNNL-11217) indicates that these contaminants would not exceed maximum contaminant levels in the groundwater.

Table 3-5. Summary of Nonradionuclide Soil Preliminary Remediation Goals for all Pathways. (2 Pages)

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

Aroclor is an expired trademark.

DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes.*
Ecology 94-145, *Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation; CLARC, Version 3.1.*
PNNL-11217, *STOMP Subsurface Transport Over Multiple Phases Theory Guide.*
WAC 173-340, "Model Toxics Control Act -- Cleanup."
WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties."
WAC 173-340-745(5), "Method C Industrial Soil Cleanup Levels."
WAC 173-340-747(4), "Deriving Soil Concentrations for Ground Water Protection," "Fixed Parameter Three-Phase Partitioning Model."
WAC-173-340-900, "Tables."

-- = No criteria established.
CLARC = *Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation; CLARC, Version 3.1* (Ecology 94-145).
FS = feasibility study.
PRG = preliminary remediation goal.
STOMP = Subsurface Transport Over Multiple Phases (code).

Table 3-6. Summary of Radionuclide Soil Preliminary Remediation Goals. (2 Pages)

Constituent	Industrial Direct Exposure [a] / Inadvertent Intruder [b]	Terrestrial Wildlife BCG [c] (pCi/g)	Overall PRG [d, e] (pCi/g)
Am-241	356/ 20,000	4,000	356
Cs-137	25/ N/A	20	20
Pu-239	452/ 27,000	6,000	452
Pu-240	452/ N/A	6,000	452
Ra-226	7.4/ 400	50	7.4

Table 3-6. Summary of Radionuclide Soil Preliminary Remediation Goals. (2 Pages)

Constituent	Industrial Direct Exposure [a] / Inadvertent Intruder [b]	Terrestrial Wildlife BCG [c] (pCi/g)	Overall PRG [d, e] (pCi/g)

[a] Direct-exposure values represent activities for individual radionuclides corresponding to a 15 mrem/yr dose rate for an industrial exposure scenario.

[b] The identified inadvertent intruder concentration is not a formal PRG but is a target dose goal since the inadvertent intruder assessment is not a portion of the baseline risk assessment. The inadvertent intruder scenario is described in Appendix E.

[c] Concentration in soil that could result in a 0.1 rad/day dose to terrestrial wildlife.

[d] Listed values represent the most restrictive PRG derived from evaluation of the direct-contact exposure to humans or terrestrial wildlife.

[e] Exposure-point concentration divided by the overall PRG will provide the fraction of the overall PRG. Potential remediation should be sufficient to reduce the sum of these fractions for the site to below one.

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

-- = no criteria established.
BCG = biota concentration guide (DOE-STD-1153-2002).
N/A = Not applicable. Not a contaminant of concern for the given exposure route (e.g., direct contact, intruder, or terrestrial wildlife exposure).
PRG = preliminary remediation goal.

3.7.1 Direct-Contact Exposure Preliminary Remediation Goals for Nonradioactive Contaminants

Development of the PRGs for direct-contact exposure to nonradioactive contamination for both human and ecological receptors is described in the following subsections.

3.7.1.1 Human Exposure

For human receptors, PRGs developed for direct-contact 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 risk equations. Risk-based standards for individual carcinogens in an industrial-exposure scenario are based on CERCLA guidelines of 10^{-4} to 10^{-6} ELCR. Risk-based standards for individual non-carcinogenic substances are set at concentrations that would result in no acute or chronic toxic effects on human health or the environment; this corresponds to an HQ of 1.0. Consistent with this approach, the methodology described for industrial properties under WAC 173-340-745(5), "Method C Industrial Soil Cleanup Levels," is used to calculate the risk-based standards.

Risk-based standards for some contaminants are calculated to be less than area background values or practical quantitation limits. Where risk-based standards are less than area background concentrations, PRGs may be set at concentrations that are equal to the agreed-upon site or area background concentrations. Area background values for selected nonradioactive contaminants in soil have been characterized for the Hanford Site (DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*). Similarly, where risk-based standards are less than practical quantitation limits, PRGs will default to the practical quantitation limits. Therefore, the PRGs for individual nonradioactive contaminants in solid waste and particulate reflect the value that is greatest among risk-based standards, area background values, or practical

quantitation limits. Table 3-5 lists the nonradiological PRGs for direct-contact exposure to humans for those COCs.

3.7.1.2 Ecological Exposure

The 200-CW-5 OU is within the industrial area identified in the HCP and within the area designated by the ROD (64 FR 61615) as industrial (exclusive). The industrial (exclusive) land-use designation allows for continued waste management operations within the 200 Areas consistent with past *National Environmental Policy Act of 1969* (NEPA), CERCLA, and RCRA commitments and, among other things, will allow for the development of new waste management facilities. Sites within the industrialized portion of the 200 Areas currently have limited habitat suitable for the establishment of ecological communities and food webs to support a hierarchy of terrestrial receptors. Maintenance of the industrial (exclusive) use will prevent future human inhabitation. However, cleanup to industrial land-use standards may not continue to be protective of ecological receptors if institutional controls are lost. A screening-level ERA has been used to develop soil PRGs for the protection of terrestrial wildlife.

Because the waste sites in the FS are all within the industrialized portion of the 200 Areas, only terrestrial wildlife exposure will be evaluated. Consistent with this approach, WAC 173-340-7490(3)(b), "Goal," specifies that for industrial or commercial properties, current or potential exposure to soil contamination only need be evaluated for terrestrial wildlife protection. Plants and soil biota need not be considered unless the species is protected under the Federal *Endangered Species Act of 1973*. Currently, no Federally listed threatened or endangered species are known to exist on the waste sites. Surveys conducted before field activities begin will confirm the presence or absence of protected species. For sites with institutional controls that 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), based on the conditional point of compliance requirements stated in WAC-173-340-7490(4), "Point of Compliance" (DOE/RL-2001-06, *Comments on Hanford 2012: Accelerating Cleanup and Shrinking the Site*). Priority chemicals of ecological concern and their soil-screening levels are listed in WAC 173-340-900, "Tables," Table 749-3. These soil-screening levels were used in conjunction with the risk assessment to develop PRGs for the COCs that are protective of ecological receptors, as indicated in Table 3-5.

3.7.2 Direct-Contact Exposure Preliminary Remediation Goals for Radionuclides

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

3.7.2.1 Human Exposure

For locations within the 200 Areas, the 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 restricted for an additional 100 years by enforcement of effective institutional controls. After the cessation of waste management operations, remediation goals for

radioactive wastes and radioactively contaminated soils for human receptor direct exposures are considered to be based on the U.S. Environmental Protection Agency (EPA) radionuclide soil cleanup guidance. As established by 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," CERCLA cleanup actions generally should achieve a level of risk within the 10^{-4} to 10^{-6} ELCR based on the reasonable maximum exposure for an individual. Furthermore, EPA policy has noted that the upper boundary of the risk range is not a discrete line at 10^{-4} and that a specific risk estimate around 10^{-4} may be considered acceptable, if justified based on site-specific conditions (EPA/540/R-99/006, *Radiation Risk Assessment At CERCLA Sites: Q&A*, Directive 9200.4-31P). The goal of remediation is to achieve the 10^{-4} to 10^{-6} risk range, using a dose of 15 mrem/yr above background as an operational guideline to achieve this goal. Demonstration that the 10^{-4} to 10^{-6} residual risk-range goal has been achieved will be accomplished through final verification sampling during closeout of individual sites.

The individual PRGs for the identified COCs corresponding to an industrial worker direct-contact exposure of 15 mrem/yr are calculated using the RESidual RADioactivity dose assessment model (ANL/EAD-4, *User's Manual for RESRAD, Version 6*) and are provided in Table 3-6. For radionuclide COCs, PRG numerical values corresponding to the 15 mrem/yr guidance limits will depend on the specific exposure scenario selected for remedial design and site-specific parameters (e.g., the area extent of the waste site).

The soluble salts of uranium present non-carcinogenic toxic effects are evaluated by an HQ, in addition to the incremental cancer risks presented by the radioactive isotopes of uranium. If the HQ exceeds one, the possibility exists for systemic toxic effects. However, the dose from total uranium would exceed the 15 or 500 mrem/yr guidance limits at an activity or concentration less than that corresponding to an HQ of one. Therefore, any remedial action, if necessary, to address the radioactivity hazard for uranium also would address the chemical toxicity hazard.

3.7.2.2 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 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 reports *Recommendations of the International Commission on Radiological Protection* (ICRP-26 and ICRP-60) and stating that chronic radiation dose rates below 0.1 rad/day 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 dose limits of 0.1 rad/day for animals and 1 rad/day 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. In this report, experts in radioecology and ERA concluded that the 0.1 rad/day limit for animals and the 1 rad/day limit for plants recommended by the International Atomic Energy Agency are adequately supported by the available scientific information. However, the workshop participants concluded that guidance on implementing the limits is needed and that the existing

data support application of the recommended limits for populations of terrestrial and aquatic organisms to representative rather than maximally exposed individuals.

In response to ORNL/TM-13141, the DOE produced DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*, which provides a graded approach to ERA for radionuclides and screening-level BCGs because no promulgated screening or cleanup levels are available for radionuclides. DOE-STD-1153-2002 provides a cost-effective, easy-to-implement methodology that can be used to demonstrate compliance with DOE dose limits and with findings of the International Atomic Energy Agency and 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 ERAs.

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 is consistent with the eight-step EPA approach for conducting ERAs. 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.

The BCGs contained in DOE-STD-1153-2002 include conservative screening concentrations that are judged protective of the most sensitive terrestrial organisms, assuming a dose of 0.1 rad/day.[1] Each radionuclide-specific BCG represents the limiting radionuclide concentration in environmental media (i.e., soil, sediment, or water) that would not exceed the 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.

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

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4.0 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

The Implementation Plan (DOE/RL-98-28) provided an initial framework to guide the RI in the 200 Areas. The Implementation Plan identified and screened technologies that could be used to address contaminants in the soil and solid waste in the arid 200 Areas environment.

Since the Implementation Plan was issued, additional site characterization information was obtained at the 216-Z-11 Ditch as a portion of the 200-CW-5 OU RI and presented in the RI Report (DOE/RL-2003-11). Site contamination information and risks identified in the RI Report and summarized earlier in this FS were used to refine the preliminary Implementation Plan evaluation of alternatives that will meet RAOs. A review of technologies was conducted to identify emerging technologies and to update technologies included in the Implementation Plan, either of which could effectively address potential site risk. If a technology was identified and evaluated in the Implementation Plan and no modifications have been identified, the technology is mentioned only briefly in this chapter and the Implementation Plan is referenced for detailed information.

4.1 GENERAL RESPONSE ACTIONS

The initial process of identifying viable remedial action alternatives is described in the Implementation Plan as consisting of the following steps.

1. Define RAOs.
2. Identify GRAs to satisfy RAOs.
3. Identify potential technologies and process options associated with each GRA.
4. Screen process options to select a representative process for each type of technology based on effectiveness, implementability, and cost.
5. Assemble viable technologies or process options retained in step 4 into alternatives representing a range of removal, treatment, containment, and institutional controls options, including no action.

Chapter 3.0 identified the RAOs for this FS. The Implementation Plan identified preliminary GRAs as follows:

- No action
- Institutional controls
- Containment
- RTD
- Ex situ treatment
- In situ treatment.

These GRAs are intended to cover the range of response options necessary to meet the RAOs. Modifications to these GRAs were not necessary, based on the new information collected and evaluated in the RI Report. Detailed descriptions of each GRA are included in the Implementation Plan.

4.2 SCREENING AND IDENTIFICATION OF TECHNOLOGIES

This section screens and identifies viable technologies for 200-CW-5 OU remedial actions. Technology types and process options were identified and screened in the Implementation Plan (in accordance with CERCLA guidance) using effectiveness, implementability, and relative cost as criteria to determine the most viable options. The initial identification and screening of remedial technologies described in Appendix D of the Implementation Plan is modified based on the information obtained from the RI and the additional risk assessment performed to support this FS. The following subsections summarize the technology screening conducted; discuss the screening of new technologies identified since the creation of the Implementation Plan; and discuss technologies that are retained for the 200-CW-5 OU. The technologies are discussed by GRA group. Table 4-1 represents a roadmap for technology selection between the Implementation Plan and this FS.

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

General Response Action	Technology Type	Process Option	Retained in Implementation Plan (DOE/RL-98-28)	Retained in Feasibility Study for 200-CW-5 Operable Unit
No action	None	Not applicable	Yes	Yes
Institutional controls	Land-use restrictions	Deed restrictions	Yes	Yes
	Access controls	Signs/fences	Yes	Yes
		Entry control	Yes	Yes
	Monitoring	Groundwater	Yes	Yes
		Vadose Zone	Yes	Yes
		Air	Yes	Yes
	Surface barriers	Existing soil cover	No	Yes
Containment, including ET barriers	Surface barriers	Hanford Barrier	Yes	Yes
		Modified RCRA and other ET Caps	Yes	No
		Standard RCRA Caps	No	No
		Asphalt, concrete, or cement-type cap	No	No
	Vertical barriers	Slurry walls	Yes	Yes
		Grout curtains	Yes	Yes
Removal	Excavation	Conventional	Yes	Yes
		High contamination	No	Yes

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

General Response Action	Technology Type	Process Option	Retained in Implementation Plan (DOE/RL-98-28)	Retained in Feasibility Study for 200-CW-5 Operable Unit
Disposal	Landfill disposal	Onsite landfill	Yes	Yes
		Offsite landfill/ repository	Yes	Yes
Ex situ treatment	Thermal treatment	Thermal desorption	Yes	No
		Vitrification	Yes	No
	Physical/chemical treatment	Vapor extraction	Yes	No
		Soil washing	Yes	No
		Mechanical separation	Yes	No
		Solidification/ stabilization	Yes	No
		Soil mixing	Yes	No
In situ treatment	Thermal treatment	Vitrification (Z-Ditches)	Yes	Yes
	Chemical/physical treatment	Vapor extraction	Yes	No
		Grout injection (pipelines and tanks)	Yes	Yes
		Deep soil mixing	Yes	No
		Dynamic compaction (component of barrier)	Yes	No
	Natural attenuation	Natural attenuation	Yes	Yes

DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program.*

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

ET = evapotranspiration.
RCRA = *Resource Conservation and Recovery Act of 1976.*

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

Because the initial screening in the Implementation Plan was preliminary, and because additional site-specific risk assessment and characterization information is available, the remedial technologies presented in the Implementation Plan were rescreened for application to the 200-CW-5 OU remedial action. The following is a brief discussion of the technology rescreening.

4.2.1.1 No Action

The National Contingency Plan (40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan") 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. This requires that a site does not pose an unacceptable threat to human health and the environment. The no-action alternative was retained in the Implementation Plan for 200-CW-5 OU and is carried forward in this FS.

4.2.1.2 Institutional Controls

Institutional controls are restrictions imposed on land use and/or site access to prevent or reduce public exposure to hazardous wastes or hazardous constituents at levels that exceed acceptable health risks. Institutional controls consist of the following:

- Physical and/or legal barriers to prevent access to contaminants
- Monitoring of the groundwater and/or the vadose zone
- Maintaining existing soil cover.

Institutional controls usually are required when contaminants remain in place at concentrations above cleanup levels; the controls likely will be a component of the remedial alternatives. Restrictions may include land-use restrictions, natural-resource use restrictions, well-restriction areas, deed restrictions, deed notices, declaration of environmental restrictions, access controls, monitoring requirements, site-posting requirements, information distribution, notification in closure letter, restrictive covenants, and Federal/state/county/local registries.

These activities are implemented at the Hanford Site through DOE/RL-2001-41, *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions*. Operations at the Hanford Site are expected to terminate in approximately 2050, and active institutional controls are assumed for approximately another 100 years following the termination of operations. Effective passive institutional controls will be designed to provide protection for at least 500 years, matching the period of effective institutional controls for ERDF, as recognized in the ERDF ROD (EPA/ROD/R10-95/100, *Declaration of the Interim Record of Decision for the Environmental Restoration Disposal Facility*).

Physical methods of controlling access to waste sites include access controls (such as signs, fences, and entry control), artificial or natural barriers, and active surveillance. Physical restrictions are effective in protecting human health by reducing potential contact with contaminated media. Site access controls also avoid adverse environmental, worker safety, and community safety impacts that arise from the potential release of contaminants associated with other remedial technologies (e.g., removal). If used alone, however, physical restrictions are not effective in achieving containment, removal, or treatment of contaminants. Physical restrictions also require ongoing monitoring and maintenance.

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

site transfers from the DOE to another party, because land-use restrictions use legal and administrative mechanisms already available to the community and the State.

The disadvantages of land-use restrictions are similar to those for access controls in that they also do not contain, remove, or treat contaminants. In addition, land-use restrictions are not self-enforcing. Land-use restrictions only can be triggered by an effective system for monitoring land use to ensure compliance with the imposed restrictions.

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

Depending on the remedial action and results of sampling and monitoring, it will be necessary to maintain the existing soil cover or cap in order to ensure continued isolation of the contaminants.

Based on the results of the RI activities, no changes have been made to this technology from what appeared in the Implementation Plan. The institutional controls technologies will be incorporated into remedial alternatives in Chapter 5.0 for evaluation.

4.2.1.3 Containment

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

4.2.1.3.1 Surface Barriers

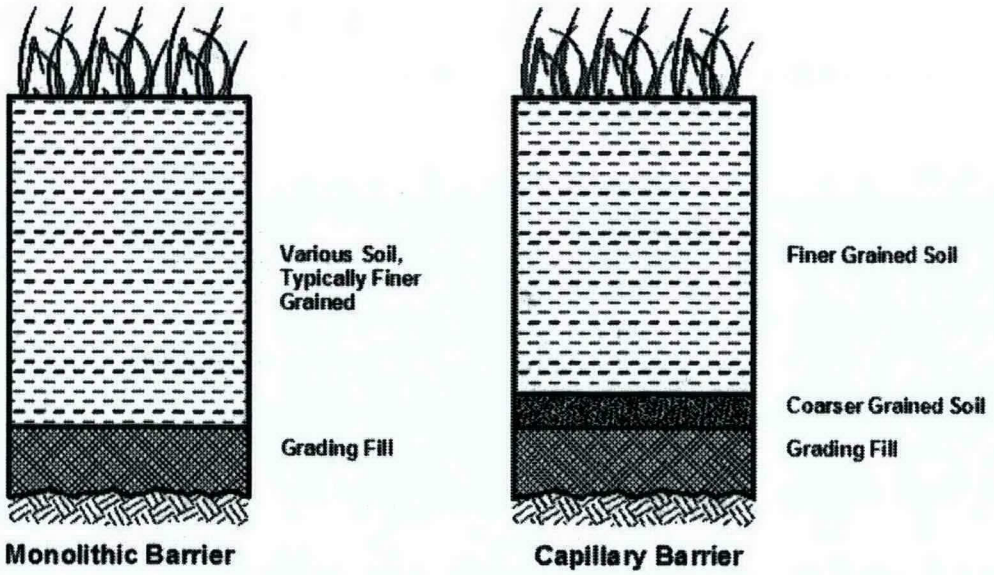
Surface barrier technologies are applicable for groundwater, human health, and ecological protection. Several different types of surface barriers have been evaluated for use at the Hanford Site. DOE/RL-93-33, *Focused Feasibility Study of Engineered Barriers for Waste Management Units in the 200 Areas*,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

Generally, this alternative consists of constructing surface barriers over contaminated waste sites to physically isolate the contamination; control the amount of water that infiltrates into contaminated media, which reduces or eliminates leaching of contamination to groundwater; and/or to prevent intrusion. Because groundwater risk has not been identified at the Z-Ditches, a barrier primarily would function to prevent ecological exposure as radiation attenuates.

However, because of the long attenuation period for plutonium, a Z-Ditches barrier will be considered that controls water infiltration into the contamination zone.

All surface barriers considered in this FS are evapotranspiration (ET) barriers. ET barriers rely predominantly on the water-holding capacity of soil in conjunction with 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 ET processes move the water back to the atmosphere. Such designs are particularly suitable for semiarid and arid climates with a low annual precipitation and relatively high ET potential. When precipitation exceeds ET, water is stored; when ET exceeds precipitation, water is released. 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 can be divided into two categories: capillary barriers and monolithic (also call monofill) barriers. Figure 4-1 presents a generalized schematic of the monofill and capillary barriers.

Figure 4-1. Generalized Conceptual Schematic of Evapotranspiration Barriers: Monofill Barrier and Capillary Barrier.



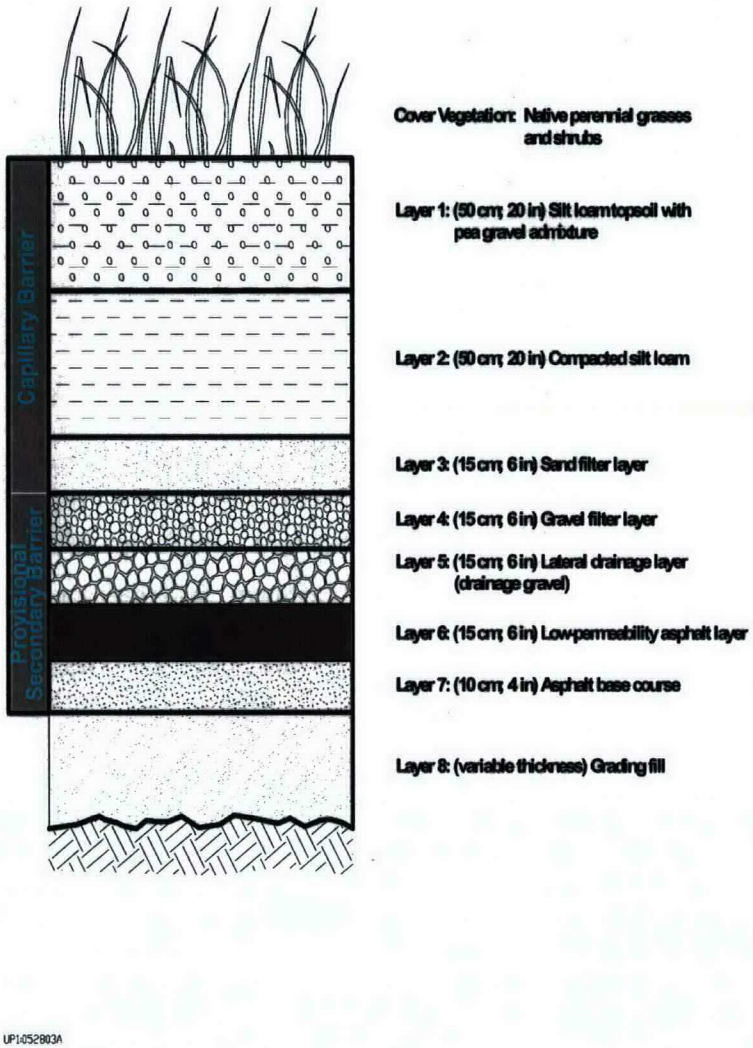
The ET-type barriers retained in the Implementation Plan (i.e., the Hanford Barrier, the Modified RCRA Subtitle C Barrier, and the Modified RCRA Subtitle D Barrier) are capillary barriers. Capillary barriers consist of a fine-grained soil layer overlying a relatively coarse-grained soil layer. The distinct textural interface between the two soil layers creates a capillary breach that functions to increase the water holding capacity of the fine-grained soil and produces relatively low moisture conditions in the coarse-grained soil. Alternately, the barrier can incorporate a synthetic membrane to inhibit vertical flow of infiltrating water. 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. A generalized conceptual schematic for the Modified RCRA Subtitle C Barrier is depicted in Figure 4-2. A conceptual schematic of the Hanford barrier is depicted in Figure 4-3.

Monolithic barriers (Figure 4-1) rely on a relatively thick single layer of fine-textured soil covered with native vegetation to control infiltration. 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.

The Hanford Barrier, the Modified RCRA Subtitle C Barrier, and the Modified RCRA Subtitle D Barrier, were designed to address various categories of contamination (e.g., plutonium at greater than 100 nCi/g, low-level, hazardous, and sanitary). These designs all include additional layers for added levels of containment or redundancy. The Modified RCRA C Barrier (Figure 4-2) design was developed for sites containing hazardous, low-level waste, or low-level mixed waste to provide long-term containment and hydrologic protection for a performance period of 500 years (DOE/RL-93-33). The Modified RCRA C Barrier also was developed because the conventional RCRA C cap design, aimed at areas with much higher precipitation, contains a clay component that desiccates under dry conditions and is not effective for arid climates. The design includes the components of a capillary barrier overlying a secondary barrier system using a low-permeability layer. The secondary barrier layers are provisional, depending on the site-specific need for redundancy in hydrologic protection, a vapor barrier, and/or a more robust biointrusion layer.

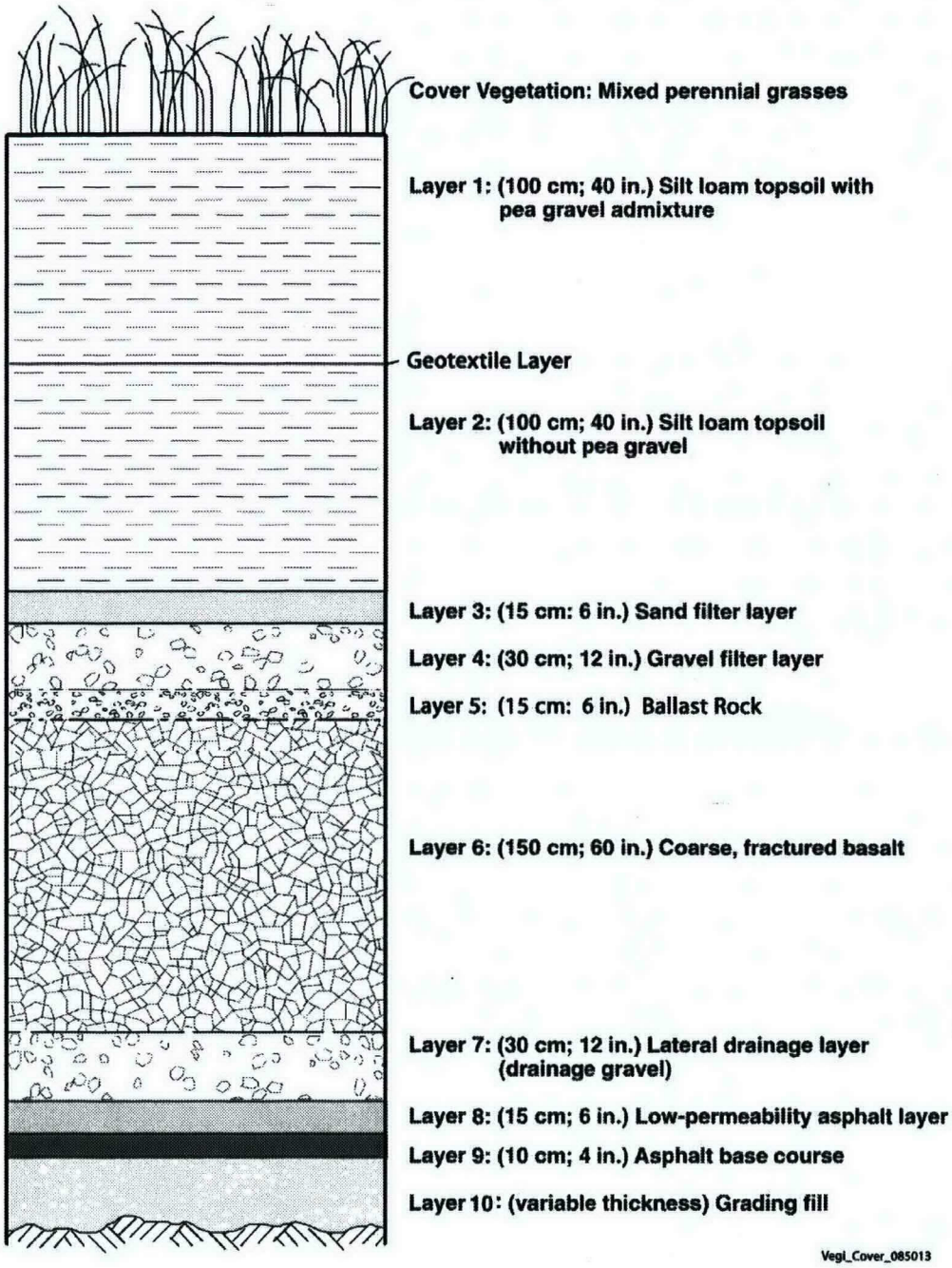
The Hanford Barrier design (Figure 4-3) is a capillary barrier that is more robust than the modified RCRA barriers and was developed for sites containing greater-than-Class-C low-level waste, and/or significant inventories of radiological constituents greater than 100 nCi/g. This barrier remains functional for a performance period of 1,000 years. In addition, the Hanford Barrier provides the maximum available degree of containment and hydrologic protection when compared to the other evaluated designs. The design is composed of multiple layers of durable material with a combined thickness of approximately 4.5 m (14.7 ft). The barrier layers are designed to maximize moisture retention and ET capabilities and to minimize moisture infiltration and biointrusion, which takes into consideration long-term variations in Hanford Site climate.

Figure 4-2. Conceptual Schematic: Capillary Modified RCRA Subtitle C Barrier.



RCRA = *Resource Conservation and Recovery Act of 1976.*

Figure 4-3. Conceptual Schematic: Capillary Hanford Barrier.



A 4-year (FYs 1995 to 1998) treatability test was completed successfully on a prototype of the Hanford Barrier constructed in fiscal year 1994 over the 216-B-57 Crib. The primary purpose of the test was to document surface barrier constructability, construction costs, and physical and hydrologic performance in support of remedial decision making and remediation at similar waste sites at the Hanford Site. The results of the treatability test are reported in DOE/RL-99-11, *200-BP-1 Prototype Barrier Treatability Test Report*. 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 PNNL-14960, *200-BP-1 Prototype Hanford Barrier Annual Monitoring Report for Fiscal Year 2004*.

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

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 Modified RCRA C Barrier is considered an appropriate process option for soil waste sites not contaminated with significant concentrations of transuranic constituents. The Hanford Barrier is considered an appropriate process option for use at soil waste sites, or portions of such sites, contaminated with significant concentrations of plutonium (e.g., the Z-Ditches).

4.2.1.3.2 Vertical Barriers (Slurry Walls and Grout Walls)

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

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

While the need for horizontal control of contaminant migration has not been identified based on the RI Report, these options are retained for use in the development of remedial alternatives in Chapter 5.0. These options also are retained for potential use following the collection and evaluation of data to confirm that the appropriate remedial action has been specified for the analogous waste sites.

While use of slurry walls and grout walls would provide a means of limiting horizontal movement of contamination and water, in particular as part of a barrier alternatives, suitability of

this technology to limit vertical migration of contaminants is less certain. Because the Z-Ditches are long and narrow, installation of a horizontal grout barrier beneath this site would be difficult to construct. For these reasons, the use of slurry walls and grout walls as horizontal barriers to prevent vertical migration of contaminants is not retained in this FS.

4.2.1.4 Removal, Treatment, and Disposal

The Implementation Plan identified excavation of contaminated soils (with treatment as needed to meet disposal criteria), transportation, and disposal to the appropriate disposal facility as an applicable technology for the waste sites. Excavation of material generally is accomplished using standard earth-moving equipment, such as backhoes and front-end loaders. This technology is retained for use at sites as a standalone remedial alternative and in combination with other remedial technologies, such as barrier. As depths increase, there is more chance that the side slope requirements (generally a horizontal to vertical ratio of 1.5:1) will interfere with nearby buildings and facilities.

The levels of radiological contamination at 200-CW-5 OU waste sites may pose a significant dose threat to workers. Elevated levels of Am-241 and Pu-239/240 encountered during excavation and disposal activities may result in implementing remote-handled removal techniques. Whether remote or contact handled, special safety controls will be required to address the contaminant concentrations. These factors are discussed in further detail in Chapter 6.0. Shoring may be needed at cut intervals to reach these depths safely. Large excavations would significantly increase the time that workers are exposed to the highly contaminated zones, resulting in increased doses. In addition, large excavations to these depths would put a significant amount of contaminated material at risk for spread through airborne pathways. Costs would increase because of these augmented safety techniques.

Waste disposal is divided into two types. The first is onsite disposal of waste soils that would designate as mixed or low-level waste. The second is temporary onsite storage of waste containing plutonium at concentrations greater than 100 nCi/g, followed by offsite disposal.

(1) Onsite disposal of low-level and mixed low-level waste. The onsite disposal option for mixed or low-level waste is ERDF. The waste acceptance criteria for ERDF (WCH-191, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*) are based on regulatory requirements (e.g., RCRA land-disposal restrictions) and risk-based considerations for long-term protection of human health and the environment. If waste cannot be accepted at ERDF, then a suitable offsite disposal facility will be used; however, all contaminated soils from the 200-CW-5 OU without plutonium and americium at concentrations greater than 100 nCi/g are expected to be acceptable to ERDF.

(2) Disposal of waste containing plutonium at concentrations greater than 100 nCi/g. Some waste soil containing plutonium at concentrations greater than 100 nCi/g may be generated during the Z-Ditches remediation. Repackaged soil that is determined to contain transuranic radionuclides at concentrations greater than 100 nCi/g (100,000 pCi/g), would be transported to the Waste Receiving and Processing facility for waste certification and shipment to the Waste Isolation Pilot Plant (WIPP) in New Mexico.

The WIPP is exempt from RCRA land-disposal restrictions. Consequently, specific ex situ treatment for organic and inorganic contaminants of Z-Ditches mixed waste that would require disposal at WIPP will not be necessary. However, such treatment likely would not be necessary in any case because organic and inorganic contaminants have not been detected in Z-Ditches soils.

4.2.1.5 Ex Situ Treatment

Ex situ treatment processes retained in the Implementation Plan include thermal desorption, vapor extraction, mechanical separation, soil washing, ex situ vitrification, solidification/stabilization, and soil mixing.

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 the data contained in the RI Report and the results of the risk assessment, remediation for hydrocarbons or organics is not necessary. These ex situ technologies are ineffective for radionuclides and inorganic compounds and, therefore, were rejected for this FS.

The primary mechanical separation technique for solid media 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). The main disadvantage of this technology is that increased waste handling carries the potential of greater 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 proved clogging of the sieving device may be a problem. There is no apparent technical advantage to using mechanical separation for the waste sites in this FS, therefore, the technology is not retained in this FS.

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 the results of the RI, treatment is not required to meet the ERDF or WIPP waste acceptance criteria; therefore, soil washing is not retained in this FS.

Ex situ vitrification is costly and is deemed unnecessary to dispose of waste at ERDF or WIPP. An onsite ex situ vitrification facility (the Waste Vitrification Plant) is currently under construction; however, at the earliest it will not be available to treat waste until 2012. Also, the costs associated with treating waste at this facility are not yet available and authorization for this plant to process transuranic waste soil is not established. Therefore, ex situ vitrification is not retained in this FS.

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

Soil mixing or blending as an ex situ treatment to change waste classification (e.g., reduce classification from transuranic to low level to allow onsite disposal at ERDF) is not allowed under DOE orders. Therefore, soil mixing as a specified ex situ treatment is not retained in this FS. However, limited blending of soil with noncontaminated materials (e.g., kitty litter to absorb

liquids) may be required to meet worker health and safety standards or to achieve a proper waste form to meet disposal facility waste acceptance criteria. This action is incidental to remedial action activities and is not considered a stand-alone alternative requiring evaluation in this FS.

4.2.1.6 In Situ Treatment

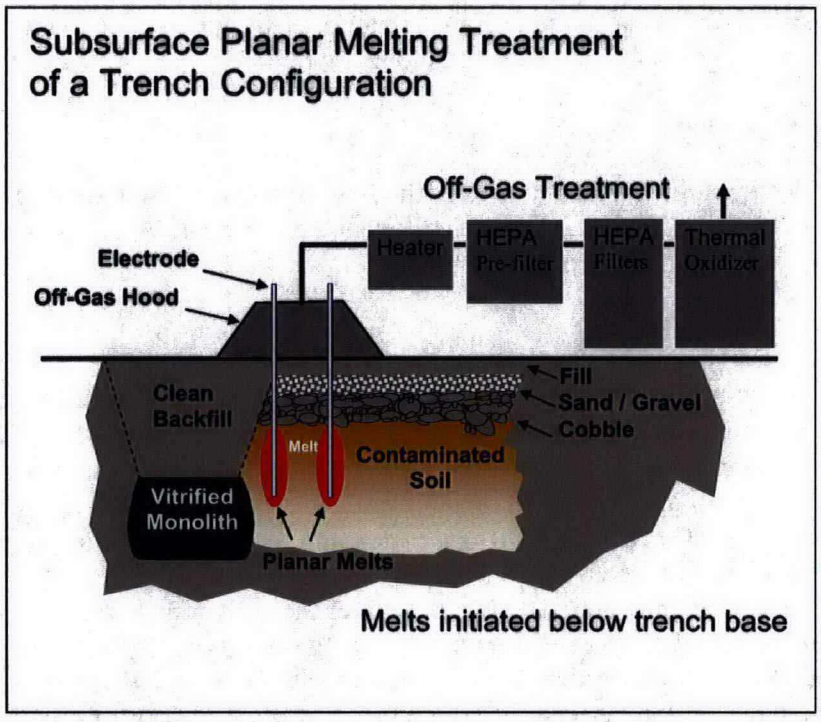
In situ treatment technologies were retained in the Implementation Plan to mitigate contaminant mobility or to treat organics in situ. The technologies are vitrification, grout injection, soil mixing, dynamic compaction, and natural attenuation.

4.2.1.6.1 In Situ Vitrification

The ISV process is a mobile, subsurface, in situ thermal-treatment process. ISV applies an electrical current through vertically placed electrodes to melt contaminated soil. As the soil melts, it becomes electrically conductive and continued application of power results in joule heating within the molten media between and around the electrodes. Melt temperatures attain between 1200 and 2000 °C (2200 to 3600 °F), depending on the composition of the mixture. To accommodate subsidence caused by soil densification and increase thermal efficiency and radionuclide retention, clean overburden is placed over the melt zone before initiating melting. Air emissions are collected and treated locally in an offgas treatment system before discharge to the environment. This process forms a stable, vitrified glass matrix. When cooled, the matrix is durable, non-leachable, and impermeable, which destroys, removes, or immobilizes contaminants. The glass monolith forms a substantial physical barrier that inhibits both human and biological intrusion into the residual contamination (PNL-4800 SUPP 1, *In Situ Vitrification of Transuranic Waste: An Updated Systems Evaluation and Applications Assessment*). Los Alamos National Laboratory reported that several diamond bits were required to perform sampling because of the hardness of the glass. Figure 4-4 shows a conceptual schematic of this ISV technology.

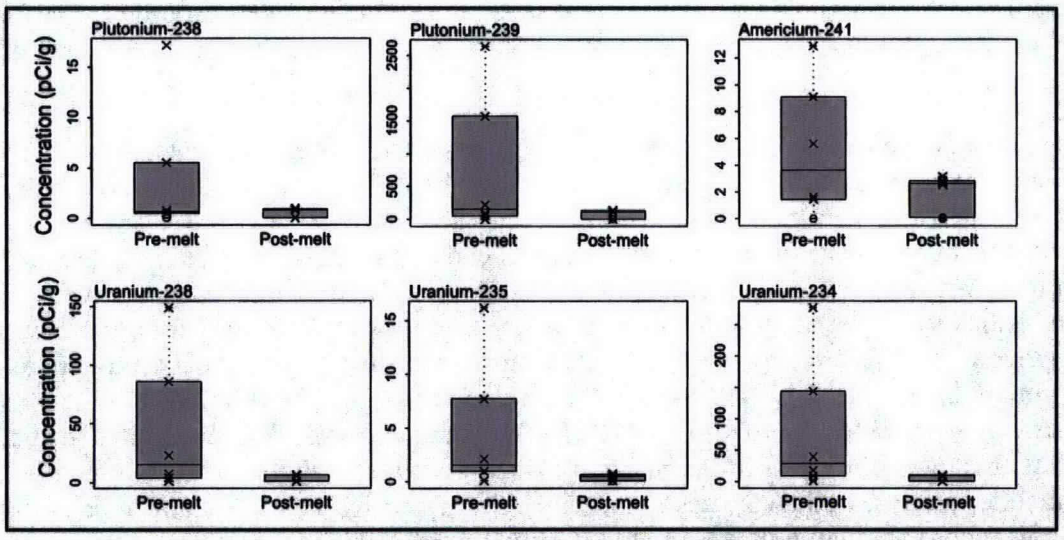
The stable mass chemically incorporates most inorganics (including heavy metals and radionuclides) homogeneously distributed throughout the melt because of the low viscosity of the molten glass and the convective flow that occurs. ISV destroys or removes organic contaminants by pyrolysis (which occurs as the temperature increases before the actual melting) and/or by chemical reactions (e.g., catalytic dechlorination reactions). The convective mixing reduces criticality potential by preventing necessary conditions, particularly for plutonium which is not reduced to its reactive metallic state and is uniformly dispersed (not concentrated) as an oxide within the glass (LA-UR-03-6494, *IM Completion Report for the NTISV Hot Demonstration at SWMU 21-018(a)-99 (MDA V)*). Analytical data identified both a general reduction in radionuclide concentrations in post-melt glass and a uniform distribution of radionuclides because of the convective mixing. Also, typically the melt retains greater than 99.99 percent of the plutonium (PNNL-11346, *Plutonium Dioxide Dissolution in Glass*). Pre- and post-melt radionuclide concentrations from the Los Alamos National Laboratory test (LA-UR-03-6494) are depicted in Figure 4-5. ISV encapsulates the highly contaminated soils and immobilizes alpha emitters, such as plutonium, so that any subsequent direct contact poses only moderate risks. Plutonium contamination immobilized in the glass was nonsmearable, was not detected in the air, and surface dose reduction is expected because of self-shielding of the vitrified mass (PNL-4800 SUPP 1).

Figure 4-4. Conceptual Schematic: In Situ Vitrification.



HEPA = high-efficiency particulate air (filter).

Figure 4-5. Comparison of Pre- and Post-In Situ Vitrification Radionuclide Concentrations.



Source: LA-UR-03-6494, *IM Completion Report for the NTISV Hot Demonstration at SWMU 21-018(a)-99 (MDA V).*

ISV is not considered effective at depths greater than about 6.1 m (20 ft) or where individual melts must be greater than 12.2 by 12.2 m (40 by 40 ft) at the surface. ISV is not a fully matured technology and presents some implementation and performance acceptance challenges in a field environment. Some of these challenges requiring acceptable resolutions are as follows:

- Effective depth
- Assurance of acceptable glass form at the bottom of the melt
- Proper mixing of the soil
- Performance of glass for 1,000 years
- Glass formula evaluation and addition of new material
- In-process sampling analysis accuracy
- Homogeneity of glass formed
- Exposure and radiation levels at the top of the melt.

A number of tests and demonstrations have been conducted to address these issues. As part of the development of the original ISV process by PNNL for DOE, a full-scale radioactive melt was completed at the 216-Z-12 Crib. The technology was demonstrated most recently by a "hot" demonstration at Los Alamos National Laboratory, reported in LA-UR-03-6494. Based on the results of in-process monitoring and sampling conducted during the hot demonstration, the technology processed the desired treatment volume, the resulting glass was both homogeneous and durable, and contaminants were not driven from the absorption bed into the surrounding tuff. Other tests (AMEC Earth & Environmental and Geomelt Richland Test Facility in 1996 and Parson's Chemical Works, Inc., site in Grand Ledge, Michigan [EPA/540/R-94/520, *Geosafe Corporation In Situ Vitrification, Innovative Technology Evaluation Report*]) showed that melting operations conducted close together would fuse without trapping unprocessed waste.

ISV may be applicable for the Z-Ditches containing high concentrations of transuranic isotopes (e.g., Pu-239/240 and Am-241) within 5.3 m (17.5 ft) of the surface. ISV has been selected at other DOE sites for processing soil contaminated with transuranic radionuclides as reported in EPA/541/R-02/100, *Record of Decision (ROD) for Waste Area Group 7, Trenches 5 and 7 in Melton Valley at Oak Ridge National Laboratory*. Based on the technology development to date, which shows that ISV is likely to meet requirements for long-term waste site contaminant control and stability, ISV is retained in this FS.

4.2.1.6.2 Grout Injection

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 implemented at several small-scale sites. However, in situ grouting has not been applied to large-scale sites with many radiological and chemical hazards such as the 200-CW-5 OU sites. Grout injection, as a standalone action, is rejected for this FS because of the size and depth of the waste sites. However, the technology is applicable as a sub-element to other remedial alternatives, such as barrier placement, to fill voids in pipelines, cribs, and tanks that would remain in place under the alternative. Of the 200-CW-5 OU waste sites, grout injection immobilization treatment is applicable only to the approximately 1,392 m (4,560 ft) of 6 in. diameter perforated waste distribution piping of the 216-Z-20 Tile Field, if the piping is not removed.

4.2.1.6.3 Dynamic Compaction

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. Compaction can reduce the hydraulic conductivity of subsurface soils and the mobility of contaminants. Because the compactive energy attenuates with depth, dynamic compaction is limited to shallow applications, typically less than 3 m (10 ft). Chemicals and radionuclides at the sites in this FS generally are deeper than 3 m (10 ft). For this reason, dynamic compaction is rejected in this FS as a standalone action and is not retained in the FS as a sub-element of any other alternative.

4.2.1.6.4 Soil Mixing

In situ 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. This technology is not suitable for use at the Z-Ditches because the contamination is shallow and does not contain chemicals that would require treatment to allow land disposal; the primary site contaminants are radionuclides (americium and plutonium) that are immobile in soils; and, because the size of the Z-Ditches Treatment area would make ensuring its effectiveness difficult. Consequently, soil mixing as in-situ treatment is rejected for this FS.

4.2.1.6.5 Natural Attenuation

Natural attenuation is retained for this FS 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, natural attenuation is a slow process at sites that have radionuclides with long half-lives (e.g., plutonium and americium) 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 and in situ treatment) are difficult to implement, ineffective, and potentially cost prohibitive.

4.2.2 Remedial Technologies and Process Options Retained for 200-CW-5 Operable Unit Alternative Development

Table 4-1 shows the remedial technologies and process options retained for development of remedial alternatives specific to the 200-CW-5 OU based on the technology screening identified in this chapter.

5.0 REMEDIAL ACTION ALTERNATIVES

The EPA guidance for conducting FSs under CERCLA recommends that a limited number of technologies be carried forward from the technology identification and screening activity; these technologies then are grouped into remedial alternatives to address the site-specific conditions. In Chapter 4.0, technologies were identified and screened based on site-specific characteristics and COCs. In this chapter, these technologies are grouped into remedial alternatives to address site contamination problems. Several remedial alternatives are developed and described in this chapter for the 200-CW-5 OU waste sites.

5.1 DEVELOPMENT OF ALTERNATIVES

Significant efforts and evaluations have contributed to defining applicable technologies and process options that address the 200-CW-5 OU waste sites. The Implementation Plan (DOE/RL-98-28), Appendix D, provides initial information on identification and screening of remedial technologies for the 200 Area waste sites. The Implementation Plan, in conjunction with the earlier (Chapter 4.0) technology screening, forms the basis for the development of remedial alternatives. The Implementation Plan preliminarily developed remedial alternatives based on the results of the technology screening for the waste sites. Remedial alternatives identified in the Implementation Plan for the 200-CW-5 OU included the following:

- No action
- Maintain existing soil cover/monitored natural attenuation/institutional controls (MESC/MNA/IC)
- RTD (onsite disposal and geologic repository)
- Containment using surface barriers (barrier)
- In situ grouting or stabilization
- ISV.

Evaluation of the no-action alternative is a requirement under CERCLA. The MESC/MNA/IC alternative is retained and further developed in this FS for sites where existing remedial actions are in place or where contamination is expected to reach RAOs within a reasonable institutional controls period. The RTD and capping (barrier) alternatives also are retained and further developed in this FS. This FS developed two alternatives combining RTD of the site and barrier placement components that were not identified in the Implementation Plan. The ISV technology alternative is retained for consideration at the Z-Ditches in two alternatives that use ISV in combination with RTD or barrier placement due to high plutonium concentrations and site configuration. The in situ grouting or stabilization alternative, as a standalone alternative, is screened out of this FS because of implementation problems associated with the size of the waste sites and unproven effectiveness on large-scale sites having radiological and chemical hazards.

However, in situ grouting or stabilization technologies are retained for inclusion as elements of other remedial actions. The following subsections further develop and describe the alternatives.

One important factor in the development of site-specific remedial alternatives is that radionuclides, heavy metals, and some inorganic compounds cannot be destroyed and therefore persist in the environment. As such, these compounds must be physically removed or treated (e.g., immobilized, contained, or chemically converted) to achieve a less mobile or less toxic form to meet the RAOs. However, because at the Z-Ditches heavy metals or inorganic compounds do not present unacceptable risk, it is the long-lived radionuclides that will drive the development of remedial alternatives that provide long-term protectiveness.

5.2 DESCRIPTION OF ALTERNATIVES

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

- Alternative 1 – No Action
- Alternative 2 – MESC/MNA/IC
- Alternative 3 – RTD
- Alternative 4 – Barrier
- Alternative 5A – RTD with Barrier
- Alternative 5B – RTD with Barriers
- Alternative 6A – ISV with Barrier and RTD
- Alternative 6B – ISV with Barrier.

Table 5-1 illustrates the process of identifying technology types, combining process options, and presenting the elements of each alternative.

5.2.1 Alternative 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 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 are instituted or continued. Selecting the no-action alternative would require that a waste site does not pose an unacceptable threat to human health or the environment.

Based on the waste-site evaluations and the results of the risk assessment, only one portion of the Z-Ditches will meet the RAOs using the no-action alternative. Characterization data show that no unacceptable threat to human health or the environment exists at the north end of the 216-Z-1D Ditch and so the no-action alternative is retained for this 200-CW-5 OU location only.

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

Technology Type	Process Option	Alternative 1 – No Action	Alternative 2 – MESC/ MNA/IC	Alternative 3 – RTD	Alternative 4 – Barrier	Alternatives 5A and 5B –RTD with Barrier (5A), and RTD with Barriers (5B) [a]	Alternatives 6A and 6B – ISV with Barrier and RTD (6A), and ISV with Barrier (6B)
No action	No action	X					
Land-use restrictions	Deed restrictions		X		X	X	X
Access controls	Signs/fences		X		X	X	X
	Entry control		X		X	X	X
Monitoring	Groundwater		X		X	X	X
	Vadose zone		X		X	X	X
	Air		X		X	X	X
Surface barriers	Existing soil cover		X				X
	Barrier				X	X	
In situ physical treatment	Grout injection [c]				X	X	X
In situ thermal treatment	ISV						X
Removal	Conventional excavation			X		X	X [b]
	Excavation in high concentration areas [f]			X		X	
Landfill disposal	Onsite landfill			X		X	X
Monitored natural attenuation	Offsite landfill/ repository			X [d]		X [d]	
	Monitored natural attenuation		X		X	X	X

[a] Alternatives 5A and 5B both have RTD and barrier components but at different site locations.
[b] A component of Alternative 6A (ISV and RTD) only.
[c] Grout injection is limited to stabilizing buried 216-Z-20 Tile Field waste distribution piping to prepare for barrier placement under Alternatives 4, 5B, and 6B.
[d] This applies to disposal at an offsite repository (i.e., WIPP) of excavated soil designated as TRU waste (potentially generated under Alternatives 3 and 5B).
ISV = in situ vitrification.
MESC/MNA/IC = maintain existing soil cover/monitored natural attenuation/institutional controls.
RTD = removal, treatment, and disposal.
WIPP = Waste Isolation Pilot Plant.

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

This alternative takes advantage of existing soil covers and the nature of the contaminants that have relatively short half-lives, in combination with institutional controls, to provide protection of human health and the environment. Monitoring also is an element of this alternative. For the waste sites in this OU, an existing soil cover exists that was placed during construction (i.e., clean backfill over the subsurface of the 216-Z-20 Tile Field) or after site retirement during backfilling or site stabilization activities. Under this alternative, these existing soil covers would be maintained to isolate the contamination and limit intrusion, thereby breaking the exposure pathway between human and ecological receptors and the contaminants. Institutional controls, including legal and physical barriers, also would be used to prevent human intrusion into the site.

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

Contaminants remaining beneath the clean soil cover would be allowed to attenuate naturally until RAOs are met. 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-99/009, *Use of Monitored Natural Attenuation at Superfund RCRA Corrective Action and Underground Storage Tank Sites November 1997*, OSWER 9200.4-17P), to verify that contaminants are attenuating as expected. Attenuation monitoring activities could include monitoring of the vadose zone using geophysical logging methods or groundwater monitoring to verify that natural attenuation processes are effective.

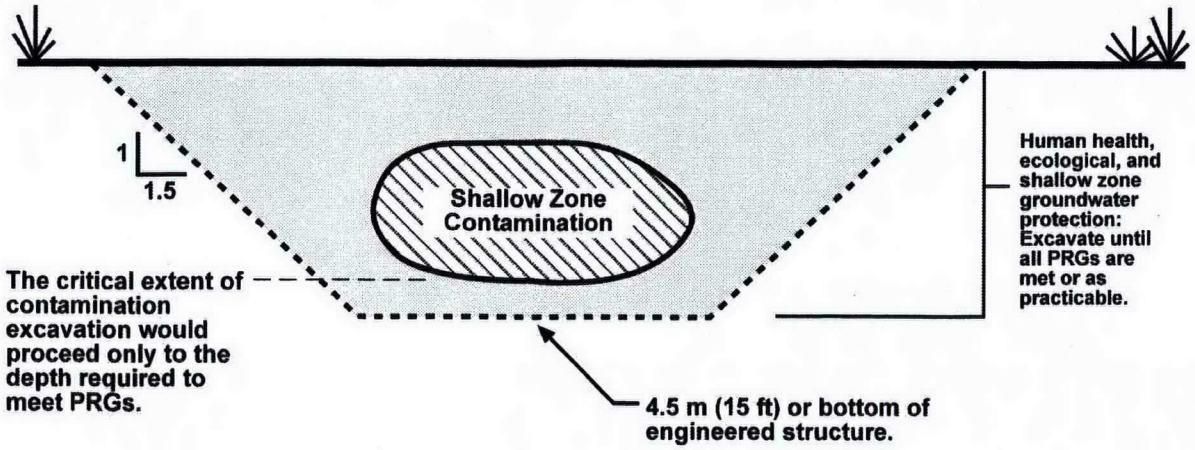
The existing network of groundwater monitoring wells in the Central Plateau is adequate for monitoring these sites, in coordination with the groundwater OUs (200-UP-1 and 200-ZP-1). Where the existing network is unsatisfactory, additional monitoring wells are planned. If remediation activities result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

5.2.3 Alternative 3 – Removal, Treatment, and Disposal

Under this alternative, contaminated soil would be removed, treated if required to meet receiving facility waste acceptance criteria, and disposed of at an approved facility. Some soil blending may be required to meet worker health and safety standards and to meet waste acceptance criteria with regard to waste form, but will not be performed solely to achieve waste

reclassification through dose reduction. A generalized cross section for this alternative is shown in Figure 5-1 showing only shallow zone contamination such as could be found at the Z-Ditches.

Figure 5-1. Generalized Removal, Treatment, and Disposal Alternative (Alternative 3).



PRG = preliminary remediation goal.

The disposal facility chosen depends on the type of waste to be disposed. The majority of the waste generated under this alternative would be low-level waste that can be disposed of at the ERDF. For waste with plutonium or americium above 100 nCi/g, disposal to a geologic repository is currently required. As reported in the RI Report (DOE/RL-2003-11), plutonium and americium levels in some portions of the Z-Ditches exceed 100 nCi/g.

5.2.3.1 Removal, Treatment, and Disposal of Low-Level Waste

Soil and associated structures (such as tile field piping) having contaminant concentrations above the PRGs would be removed as low-level waste under this alternative using conventional excavation techniques where appropriate, or specialized excavation techniques where contamination levels require added protection. Contaminated excavated materials would be disposed of at an approved disposal facility, currently envisioned as the ERDF. Whenever possible, noncontaminated excavated soil (e.g., clean overburden) would be stockpiled in an adjacent area as backfill material. Precautions would be used to minimize the generation of onsite fugitive dust. Depending on the configuration and depth of the excavation, shoring might be used to comply with safety requirements and to reduce the quantity of excavated soil.

The excavation depth and volume of soil removed largely depend on the PRGs that are exceeded. At the Z-Ditches, inadvertent intruder exposure goals and human-health direct-contact and ecological PRGs are exceeded. Consequently, removals generally would be conducted to a maximum of 4.6 m (15 ft) consistent with the points of compliance identified in WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties," and WAC 173-340-7490, "Terrestrial Ecological Evaluation Procedures." Based on characterization data (Chapter 2.0) and risk assessment results (Chapter 3.0), the Z-Ditches excavation depth considered protective of human-health, ecological, and intruder receptors could be limited to approximately 4 m (13 ft) bgs. Because groundwater protection PRGs were not exceeded at the Z-Ditches, deep zone soils need not be removed to protect groundwater. Risk

assessment results that support the depth of excavation are contained in Chapter 3.0. Below-grade structures deeper than 4.6 m (15 ft), including some 216-Z-20 Tile Field waste distribution piping that could be deeper than 4.6 m (15 ft) bgs, would be removed if practicable.

The remediation of soil and associated structures for this 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, field screening) collected during remediation to guide the direction and scope of the activity. Waste-site data are collected to assess the extent of contamination and to make "real-time" decisions in the field. Targeted (or hot-spot) removals could be considered under this alternative where contamination is localized.

Based on existing information, soil and/or debris removed from the waste sites do not require treatment to meet ERDF waste acceptance criteria (WCH-191, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*). However, additional activities are required to meet health and safety requirements during excavation, handling, transportation, and disposal. Highly contaminated soil will be blended with less contaminated soil to achieve as low as reasonably achievable (ALARA) goals and to reduce worker risks at all points in the removal and disposal process. Contaminated soil and structures will be containerized (e.g., containers, burrito wraps, bulk shipment) on site and transported to the ERDF, located in the 200 West Area.

After the PRGs 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 any remaining 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 that are consistent with industrial usage. Maintenance of the site is required until the revegetation species are sufficiently established.

5.2.3.2 Removal, Treatment, and Disposal of Transuranic Waste

As identified in Chapter 2.0, plutonium and americium exists in Z-Ditches soils at concentrations above 100 nCi/g. Therefore, some excavated soil could designate as TRU waste. The plutonium and americium contamination above 100 nCi/g is confined to a relatively thin layer originating at the bottom of the ditches and existing between the depths of approximately 2.1 and 3.35 m (7 and 11 ft) bgs. This layer is approximately 274 m (900 ft) long and 55 m (180 ft) wide and is located in the approximate center one-third of the Z-Ditches length.

Sites that received waste containing transuranic constituents are classified in accordance with DOE O 435.1 as pre- or post-1970s waste sites, based on the date of waste disposal. Waste containing transuranic isotopes at greater than 100 nCi/g that was generated after 1970, was designated as TRU waste, and was retrievably disposed onsite, could be subject to retrieval requirements. However, these requirements do not apply to concentrations of transuranic contaminants in soil, even where concentrations could exceed 100 nCi/g. The Z-Ditches soil is not waste until generated as waste by being removed for disposal and would not be a transuranic waste until packaged and designated. Consequently, the Z-Ditches in situ contaminated soil is not regulated under DOE O 435.1 and the DOE O 435.1 waste management standards would not

apply to the Z-Ditches CERCLA response action until the waste is generated and/or packaged for disposal.

Under this alternative, contaminated soil would be retrieved and verified as low-level waste or TRU waste by sampling and analysis and would be subject to treatment as necessary to meet disposal site waste acceptance criteria. TRU waste would be temporarily stored and disposed at the WIPP. Excavation of soil and waste containing plutonium at levels of concern has been performed at DOE sites, including the Hanford Site, Idaho National Laboratory (INEEL-01-00281, *Engineering Design File, Operable Unit 7-13/14 Evaluation of Soil and Buried Waste Retrieval Technologies*), Rocky Flats Site, and Savannah River Site. For soil sites, standard or modified excavation equipment would be used to retrieve the soil and waste until PRGs are met. Equipment for removal of plutonium contaminated soil and waste is proven and available. Any clean overburden soil removed would be stockpiled in an adjacent onsite area. Extensive 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.

Further characterization before excavation could be required to confirm that plutonium and/or americium levels exist at the waste site to help establish worker health and safety requirements. Soils and waste contaminated with plutonium and/or americium at greater than 100 nCi/g would be segregated during retrieval and would be further tested to minimize the amount of soil classified as TRU waste requiring disposal at WIPP. Wastes acceptable for disposal at the WIPP would be sent there, and treatment is not deemed necessary to meet waste acceptance criteria. Packaging of the soil and waste for disposal at the WIPP most likely would occur at the site during excavation, but also could be performed in a separate storage facility. Details would be determined during remedial design, once more precise information on the location, volume, and concentration of plutonium and/or americium contamination was determined.

Following retrieval of the waste, the site would be backfilled with clean soil and recontoured, resurfaced, and/or revegetated to establish site conditions consistent with industrial land use. Maintenance of the site is required until the revegetation species are sufficiently established.

5.2.4 Alternative 4 – Barrier

The barrier alternative consists of constructing a surface barrier over the contaminated waste site that is designed to break the exposure pathway preventing human and ecological exposure. Although groundwater has not been shown to be at risk from Z-Ditches contaminants, the barrier also will be an ET-type barrier designed to prevent infiltration. Additional elements to the barrier alternative include institutional controls, discussed earlier, and monitored natural attenuation, which is particularly important for the Z-Ditches that have elevated contamination levels that pose long-term human-health, ecological, and inadvertent intruder risks. Grout injection of the remaining 216-Z-20 Tile Field waste distribution piping could be a potential sub-element of this alternative. For the Z-Ditches where the contamination is shallow and long-lived, the barrier alternative would include institutional controls to prevent future human intrusion.

A Z-Ditches barrier would be designed to ensure contaminant isolation and control infiltration. The ET surface barriers rely on the water-holding capacity of a soil, evaporation from the near-surface, and plant transpiration to control water movement through the barrier. Monolithic and capillary ET barrier designs have been approved or planned for use in several western states (EPA, 2003, *Remediation Technology Descriptions*; DOE/RL-93-33, *Focused Feasibility Study of Engineered Barriers for Waste Management Units in the 200 Areas*) and have been shown to be equivalent to or to exceed the performance of the standard RCRA Subtitle C Barrier design.

Use of a barrier alternative would require an assessment of the lateral extent of contamination during the confirmatory and/or remedial design phases to properly size the cap to prevent exposure and infiltration. 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) could be necessary to deter lateral infiltration. The overlap is dependent on the barrier design used and the lateral extent of contamination. For the purposes of this FS, an overlap of 6.1 m (20 ft) is assumed based on the performance of an ET barrier. The type and availability of barrier construction materials also are design considerations. The results of the most recent investigation (BHI-01551, *Alternative Fine-Grained Soil Borrow Source Study Final Report*) will be considered during remedial design for selection of the barrier construction materials.

A surveillance and maintenance program will be necessary throughout the barrier life to maintain cap integrity and ensure continued protection. These surveillance and maintenance activities would be a portion of institutional controls to ensure that the cap is performing as designed. This includes performance monitoring through groundwater and vadose-zone soil monitoring, if practical. This FS assumes robust performance monitoring during the first 5 years after construction, followed by a more focused effort thereafter.

To consider this alternative as protective at the Z-Ditches, the institutional controls that perform barrier inspections and maintenance must be assumed to continue for the duration of unacceptable site risk. Given the long half-lives of the primary Z-Ditches contaminants (Am-241 and Pu-239/240), site contamination will not meet RAOs through natural attenuation for thousands of years.

If a barrier is the preferred alternative or a component of the preferred alternative, finalization of barrier design will occur as part of the remedial design process. The final design will be determined in the remedial design phase and will consider RAOs and ROD requirements, performance standards to ensure continued effective waste isolation and infiltration control, lateral extent of contamination, material availability, cost effectiveness, and current surface barrier technology information.

5.2.5 Alternatives 5A and 5B – Removal, Treatment, and Disposal with Barrier (5B) or Removal, Treatment, and Disposal with Barriers (5B)

Under Alternatives 5A and 5B, selected portions of the site would be excavated to the depths required to meet PRGs to a maximum of 15 feet, and a barrier would be installed at remaining

location(s) to prevent exposure by breaking the exposure pathway. These excavation activities would remove a significant fraction of this site's near-surface contamination load while the barrier breaks the exposure pathway to contaminants remaining at non-excavated locations. The RTD and barrier placement activities would be similar in nature and extent to those described in the preceding subsections. The RTD and barrier components could be coordinated differently, as described below in Alternatives 5A and 5B, depending on site-specific contaminant conditions and protectiveness requirements.

Alternative 5A would place a barrier over the area of plutonium concentrations above 100 nCi/g located at the central portion of the site to isolate the contamination and break the exposure pathway and then remove soil from remaining site locations to PRGs for disposal at ERDF. The barrier component would eliminate the higher worker risk and costs associated with soil removal and potential generation as TRU waste. The RTD component would significantly reduce overall site risk by removing contaminants from locations generally containing less than 100 nCi/g, which represents the majority of the site area. The barrier design would be determined during remedial design. Institutional controls for the duration of site risk to prevent intrusion would be an additional requirement for this alternative, because contamination above PRGs is left on site.

Alternative 5B would remove the high-risk soil containing plutonium above 100 nCi/g from the central portion of the site for disposal at WIPP and then place a barrier over the remainder of the site. The excavation would serve to remove the mass of long-lived, near-surface plutonium contamination associated with the bottom of the ditches at this portion of the site, which presents the greatest site risk. The barrier primarily would serve to mitigate the direct-exposure risk from contaminants remaining in shallow soil of the non-excavated locations. Although soil contaminated at levels above PRGs would remain in place at the site, the overall contamination levels and therefore the overall site risk would be significantly reduced through removal of the most contaminated soils and by the barrier over the remaining contamination. The actual design of the barrier would be determined through the detailed design activities. Grout injection of the remaining 216-Z-20 Tile Field waste distribution piping could be a potential sub-element of this alternative.

5.2.6 Alternatives 6A and 6B – In Situ Vitrification with Barrier and Removal, Treatment, and Disposal (6A), or In Situ Vitrification with Barrier (6B)

Under Alternatives 6A and 6B, Z-Ditches soil with plutonium contamination above 100 nCi/g would undergo ISV treatment, and risk from site contaminants at the remaining less contaminated Z-Ditch locations would be mitigated through removal or placement of a barrier. The ISV treatment would immobilize radionuclide contaminants in Z-Ditches soils above 100 nCi/g in an impermeable, durable, stable, and non-leachable glass matrix. The glass waste form would mitigate human-health direct-contact, ecological, and inadvertent intruder risk. ISV would significantly reduce radiation dose potential at the site because most of the radiological exposure at the Z-Ditches is from alpha-emitting radionuclides that are permanently bound in the glass matrix and which provide much less direct radiation dose than the gamma-emitting

radionuclides. Further, the ISV convective mixing and the final glass matrix have been demonstrated to reduce exposure from gamma-emitting radionuclides.

Although the waste is treated, exposure potential from the glass matrix will remain at reduced but unspecified concentrations. Consequently, a barrier will be placed over the ISV melts to prevent exposure to the treated glass matrix and to prevent infiltration. In addition, the ISV alternative would require continuing institutional controls and monitoring for the duration of site risk. Institutional controls would be used to ensure barrier integrity for waste isolation, prevent intrusion, and verify that the immobilization performance requirements are met.

The ISV treatment area would include the Z-Ditches zone of plutonium radionuclide concentration above 100 nCi/g that exists intermittently between the depths of 3.35 and 7 m (11 and 23 ft) bgs and for a length of about 274 m (900 ft), centered along the length of the ditches. Beneath some portions of this high contamination zone, fission products and TRU contamination below 100 nCi/g, continue to a depth of approximately 5.3 m (17.5 ft) bgs. Although individual ISV melts normally are constrained to an effective area of about 12.2 by 12.2 by 6.1 m deep [40 by 40 by 20 ft), testing has shown that multiple melts can be merged to allow effective ISV treatment of wider and longer areas. Consequently, the Z-Ditches contamination is within ISV's demonstrated area of effectiveness making ISV a potentially viable alternative. This alternative is particularly viable when compared to worker safety considerations and uncertainties associated with excavation and disposal at WIPP of this material.

Once ISV operations are concluded, the resulting matrix would be sampled to verify quality, leachability, and homogeneous mixing of contaminants, along with other performance parameters, especially between and underneath melts to verify complete melting of the contaminated soil. Sampling would be accomplished using techniques similar to those described in LA-UR-03-6494, *IM Completion Report for the NTISV Hot Demonstration at SWMU 21-018(a)-99 (MDA V)*, including use of a hollow-stem auger rig with a diamond-impregnated epoxy coring bit due to the hardness of the glass matrix. Sampling under the melt could be accomplished with conventional slant drilling. Analyses likely would be similar to the radionuclide analyses performed at Los Alamos that would address 200-CW-5 OU COCs.

As described below for Alternatives 6A and 6B, the ISV technology could be used in combination with other alternatives, such as RTD and barriers, to achieve RAOs. The ISV component of Alternatives 6A and 6B would be the same but the approach for combining alternatives to achieve RAOs and most effectively meet CERCLA criteria will depend on site-specific contaminant conditions and protectiveness requirements.

Alternative 6A would use ISV treatment, at areas of radionuclide contamination above 100 nCi/g with a barrier to prevent exposure and infiltration over the ISV melts, in conjunction with RTD of remaining contaminated soil for disposal at ERDF to meet PRGs. The ISV treatment would permanently immobilize the highest risk contaminants in an impermeable, durable, stable, and non-leachable glass matrix that would remain protective during an extended attenuation period. The ISV component would serve to eliminate the higher worker risk and costs associated with removal and disposal of the mass of long-lived, plutonium contamination associated with the bottom of the ditches. The RTD component would further reduce overall site risk by removing remaining contaminants above PRGs from the majority of the site. The RTD component of

Alternative 6A would be the same as the RTD component for Alternative 5A. Institutional controls would be required for this alternative because contamination above PRGs, although immobilized, is left on site requiring isolation and intrusion protection.

Alternative 6B includes the same ISV treatment component as Alternative 6A but in combination with a barrier over the entire site toprevent exposure and to limit infiltration. The ISV component of Alternative 6B treats the same areas of contamination above 100 nCi/g as Alternative 6A, and protects the site in the same manner and to the same extent as does the ISV portion of Alternative 6A. The barrier component of Alternative 6B would be similar to the barrier identified for use with other barrier alternatives and would provide the same level of protectiveness, through mitigation of the already reduced direct-exposure risk from contaminants remaining in shallow soil. The actual design of the barrier would be determined through the detailed design activities. Although untreated soil with contamination above PRGs would remain in place, the overall contamination levels and therefore the overall site risk would be significantly reduced. Institutional controls would be required for this alternative, because contamination remains onsite above PRGs, although immobilized and protectively capped, requiring isolation and intrusion protection.

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6.0 DETAILED ANALYSIS OF ALTERNATIVES

This chapter presents the detailed analysis of the 200-CW-5 OU remedial alternatives described in Chapter 5.0. The alternatives are evaluated against the first seven of the nine CERCLA evaluation criteria described in the following section to identify if they meet the criteria. As indicated later in this chapter, the last two CERCLA criteria are addressed outside the scope of this FS. The alternative evaluation is performed for the Z-Ditches and for the 216-Z-1D Ditch North Section as separate sites. The 216-Z-1D Ditch North Section is evaluated separately from the southern portion because it operated during a different time period and characterization data have shown that it is not contaminated above levels that would require remedial action to meet RAOs.

Initially, the term "Z-Ditches" referred to the portions of the 216-Z-1D, 216-Z-11, and 216-Z-19 Ditches that are approximately 838 m (2,749 ft) in length and are parallel, side by side, and that comprise one contiguous, similarly contaminated area for which characterization data, risk information, and alternative cost information exist. However, all of the 200-CW-5 OU sites including the analogous sites (216-Z-20 Tile Field and UPR-200-W-110) in their entirety will now be considered for remedial action as part of one Z-Ditches decision unit. This approach was arrived at during the evaluation of alternatives described later in this chapter. This evaluation indicated that Alternatives 1 (no action) and 2 (MESC/MNA/IC) would fail protectiveness requirements for the original Z-Ditches group, leaving only Alternatives 3, 4, 5A, 5B, 6A, and 6B as viable alternatives for all the Z-Ditches, including the analogous sites. Each of the viable alternatives has excavation or barrier as a primary component. However, because the Z-Ditches and analogous sites are in proximity to each other, any excavation or barrier action addressing the original three Z-Ditches likely would encroach on analogous site boundaries. This encroachment would include the analogous sites in the action and prevent a separate action. Substantial economies would be expected to be realized through implementation of a coordinated remedial action for all 200-CW-5 OU sites.

The analysis of the alternatives takes into account the nature and extent of the contaminants in the Z-Ditches and considers the assumed land use. Currently, the land use for the Z-Ditches is industrial as stated in the response to Hanford Advisory Board Advice Number 132 (Klein et al., 2002, "Consensus Advice #132: Exposure Scenarios Task Force on the 200 Area"). This land use can be reasonably predicted to be the same for the next 50 years, given the DOE's current commitment to vitrify waste in the tank farms, but is assumed to remain industrial for the foreseeable future and for the duration of site risk.

The detailed analysis is presented by alternative and the analysis shows how each alternative meets CERCLA criteria for the Z-Ditches. Table 6-1, presented later in this chapter, summarizes the detailed analysis of each criterion and its critical components for the 200-CW-5 OU waste sites. Initially, analogous waste sites were assigned to representative sites after establishment of an analogous relationship based primarily on similar or bound nature and extent of contamination with the representative site decision assumed to be appropriate for the analogous sites. However, because the Z-Ditches decision unit now includes all the 200-CW-5 OU sites, the analogous relationship is not an important factor in remedy selection.

6.1 DESCRIPTION OF EVALUATION CRITERIA

The 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 important for selecting remedial alternatives. These criteria serve as the basis for conducting detailed alternative analyses in this chapter and comparative analyses of alternatives later in this FS (Chapter 7.0) and for subsequent alternative recommendations.

The nine CERCLA evaluation criteria are as follows:

- Overall protection of human health and the environment
- Compliance with 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 those that do not comply with ARARs (or do not justify a waiver) would not meet statutory requirements and are eliminated from further consideration in this FS.

For alternatives that meet threshold criteria, 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 upon which the remedy selection is based. The CERCLA guidance for conducting an FS lists appropriate questions to be answered when evaluating an alternative against the balancing criteria (EPA/540/G-89/004). The detailed analysis process in this chapter addresses these questions, providing a consistent basis for the evaluation of each alternative.

The final two criteria, state and community acceptance, are modifying criteria that will be evaluated outside the scope of this FS. The criterion of state acceptance will be addressed in the Proposed Plan (DOE/RL-2004-26). The Proposed Plan will identify the preferred remedy (or remedies) accepted by the Tri-Parties. The criterion of community acceptance will be evaluated following the issuance of the Proposed Plan for public review and comment.

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

6.1.1 Overall Protection of Human Health and the Environment

This threshold 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 criterion is the primary objective of the remedial action program. As indicated in EPA guidance, this criterion, and the criteria for compliance with ARARs, long-term effectiveness and permanence, and short-term effectiveness, overlap (EPA/540/G-89/004). This FS used the CERCLA risk range of 1×10^{-4} to 1×10^{-6} ELCR for human health as the range of protectiveness. A maximum 15 mrem/yr dose for radionuclides was applied as an operational guideline that equates to an ELCR within the CERCLA risk range. An HQ of one or less was applied for nonradionuclides. Alternatives were measured against these standards to determine if the alternative is protective. Ecological compliance was judged using WAC 173-340-900, "Tables," and DOE/STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*.

Protection of groundwater was measured against groundwater protection standards derived from the maximum contaminant levels identified in 40 CFR 141, "National Primary Drinking Water Regulations," in fate and transport modeling reported in the RI Report (DOE/RL-2003-11), and Appendix C of this FS. Groundwater protection standards are provided for radionuclides as soil contaminant concentrations that will not result in a groundwater concentration that exceeds 4 mrem/yr and for nonradionuclides will not exceed concentrations calculated using the formulas of WAC 173-340-747. However, the analysis of Z-Ditches alternatives will reflect that the 200-CW-5 OU risk assessment showed that groundwater protection standards were not exceeded at any 200-CW-5 OU waste sites.

6.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

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

justifying the waiver. Several of these ARARs address the protection, restoration, or enhancement of fish and wildlife habitat and other natural, cultural, and historical resources.

6.1.3 Long-Term Effectiveness and Permanence

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

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

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

A related consideration is the restoration time required to reestablish sustainable environmental conditions, including 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. As long as contamination remains onsite above RAOs, an evaluation of alternative performance is required, at a minimum, every 5 years.

6.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

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

This criterion focuses on the following factors for each alternative:

- The treatment processes used and the materials treated

- Whether recycling, reuse, and/or waste minimization are used in the treatment process

- The type and quantity of treatment residuals that remain following treatment, and whether any special treatment actions will be needed

- Whether the alternative satisfies the statutory preference for treatment as a principal element.

6.1.5 Short-Term Effectiveness

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

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

- Physical, biological, and cultural impacts that might result from the construction and implementation of the remedial action, and whether the impacts can be controlled or mitigated.

- The amount of time for the RAOs to be met.

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

6.1.6 Implementability

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

The following factors are considered for each alternative:

- Technical feasibility
  - The likelihood of technical difficulties in constructing and operating the alternative
  - The likelihood of delays because of technical problems
  - Uncertainties related to innovative technologies that could cause 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 scarce resources, services, and materials
  - Availability of adequate onsite or offsite treatment storage capacity, and disposal services, if necessary
  - Availability of necessary equipment, specialists, and provisions to ensure obtaining any additional resources, if necessary.

6.1.7 Cost

This criterion considers the cost of implementing a remedial alternative, including capital costs, operations and maintenance costs, and monitoring costs for the duration of the 150-year period of active institutional controls. The cost evaluation also includes monitoring of any restoration or mitigation measures for natural, cultural, and historical resources. Details of the cost estimates are presented in Appendix D. The input parameters used in these estimates are the best available at this time, but in many cases the data on COCs, site locations, and site dimensions are somewhat limited leading to potential uncertainties for all the sites evaluated in this FS. Despite these uncertainties, the cost estimates are of sufficient quality to fulfill the primary objective, which is to aid in selecting preferred remedial alternatives. Appendix D calculated time to complete remediation for the Z-Ditches area in a manner that likely would overestimate the time to complete remediation. Remedial activity timeframes were calculated for each of the Z-Ditches consecutively when, in actuality, site remedial activities at the contiguous Z-Ditches could proceed concurrently.

The cost estimates for the purposes of this study are presented in either FY 2007 constant dollars or present-value terms. The cost estimates were prepared from information available at the time of this study. The actual cost of the project will depend on additional information gained during the remedial design phase, the final scope and design of the selected remedial action, the schedule of implementation, the competitive market conditions, and other variables. However, most of these factors are not expected to significantly affect the relative cost differences of alternatives.

6.1.8 State Acceptance

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

6.1.9 Community Acceptance

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

6.2 DETAILED ANALYSIS OF ALTERNATIVES

This section presents the detailed analysis of the alternatives evaluated under an industrial land-use scenario for the Z-Ditches decision unit representing all 200-CW-5 OU sites except the 216-Z-1D Ditch North Section. To the extent practicable and to avoid FS redundancy, where a primary component of an alternative (e.g., barrier or RTD) has undergone detailed analysis against the CERCLA criteria and will be used by another alternative in a substantially similar manner, the earlier detailed analysis will be referenced. Table 6-1, presented at the end of this section, summarizes the detailed analysis of the Z-Ditches alternatives presented in the following subsections.

6.2.1 Detailed Analysis of Alternative 1 – No Action

Alternative 1 is retained for detailed analysis of Z-Ditches alternatives as a baseline description of the effects of taking no action as required by CERCLA regulations. Although no action is taken under this alternative, it is recognized that natural attenuation, an EPA-recognized treatment process for radionuclides, will occur at all radioactively contaminated sites, regardless of the alternative selected.

As addressed in the following subsections (with the exception of the earlier excluded northern section of the 216-Z-1D Ditch), the no-action alternative fails the threshold criteria for ecological and human health (without a cover). It also is not protective of inadvertent intruders. Consequently for the Z-Ditches, no-action is screened out as a candidate 200-CW-5 OU alternative. As shown in the risk assessment (Chapter 3.0), the 216-Z-1D Ditch North Section does not represent a threat to human health or the environment and currently is not anticipated to require remedial action to meet RAOs. As such, the no-action alternative is recommended for this location. Because no action is required at this location, no other alternatives need be considered and evaluated for this site.

6.2.1.1 Overall Protection of Human Health and the Environment

For the Z-Ditches, the no-action alternative would fail to provide overall protection of human health and the environment under CERCLA because contaminants at concentrations above PRGs would remain onsite with no measures performed to prevent human or ecological exposure to the contaminants or to monitor their migration. Therefore, for the Z-Ditches, this alternative fails to meet this criterion under CERCLA but is protective for the 216-Z-1D Ditch North Section.

6.2.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

ARARs can be action-, chemical-, or location-specific. Because no remedial activities would take place under this alternative, action-specific ARARs would not be triggered. No location-specific ARARs have been identified for the waste sites. Chemical-specific ARARs for human-health direct-contact and ecological protection have been exceeded at the Z-Ditches. Because no action would be taken to control the exposure pathway, this alternative would not meet the ARARs for protection of human-health and ecological receptors at the Z-Ditches but would comply with ARARs for the 216-Z-1D Ditch North Section. ARARs include risk-based concentrations for soil cleanup that, if exceeded, would result in a radiological dose of

15 mrem/yr or greater under an industrial scenario. As shown in Table 3-1, the dose rate for the Z-Ditches exceeds 15 mrem/yr assuming that no credit is taken for protectiveness of the existing cover. The appropriateness of the 15 mrem/yr dose is discussed in EPA, 1997, *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination*, OSWER Directive 9200.4-18, and clarified in EPA/540/R-99/006, *Radiation Risk Assessment At CERCLA Sites: Q&A*, Directive 9200.4-31P.

6.2.1.3 Long-Term Effectiveness and Permanence

Long-Term Effectiveness and Permanence for Human Health. For the Z-Ditches, the no-action alternative fails to provide long-term effectiveness and permanence for human health under the industrial scenario, because contaminant concentrations are above the PRGs. For this reason, this alternative fails to meet this criterion under CERCLA.

Long-Term Effectiveness and Permanence for Groundwater. Contaminants are not predicted to reach the groundwater at the Z-Ditches. Therefore, Alternative 1 does provide long-term effectiveness for groundwater protection for the Z-Ditches.

Long-Term Effectiveness and Permanence for the Environment. The Z-Ditches sites do not meet the standard for protection of the environment in the 0 to 4.6 m (0 to 15-ft) bgs zone.

6.2.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Reduction of toxicity, mobility, or volume would occur at all the waste sites in the form of natural attenuation, which is 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, at the Z-Ditches the concentrations of radionuclides with long half-lives (e.g., Pu-239/240 with a half-life of 24.069 years and Am-241 with a half-life of 432 years) are high enough to require thousands of years for the radionuclides to decay to below PRG levels.

In EPA/540/R-99/009, *Use of Monitored Natural Attenuation at Superfund RCRA Corrective Action and Underground Storage Tank Sites November 1997*, OSWER 9200.4-17P, the EPA acknowledges that natural attenuation can be an appropriate treatment for contaminated soil. Because of uncertainties in the science of natural attenuation processes, the EPA considers source control and performance monitoring to be fundamental components of this remedy. However, the no-action alternative has no source control or monitoring components; therefore, because of the concentrations and the substantial length of time required for Z-Ditches radionuclides to meet PRGs through natural attenuation, this alternative fails to meet this criterion under CERCLA.

6.2.1.5 Short-Term Effectiveness

No short-term risks to humans would be associated with the no-action alternative because remedial activities would not be conducted. Risk to other workers in the vicinity of the site is minimal because of protective soil covers and appropriate safety measures for work activities. However, human-health risk for the industrial trench digger could exist at the Z-Ditches and this alternative takes no active measures to mitigate this risk beyond natural attenuation.

Consequently, the alternative fails to meet the criterion for short-term effectiveness with regard to timely achievement of RAOs.

6.2.1.6 Implementability

The no-action alternative could be implemented immediately and would not present any technical or administrative problems. Radionuclides at all of the waste sites addressed by this FS are currently undergoing natural attenuation.

6.2.1.7 Cost

The no-action alternative would involve no implementation costs.

6.2.2 Detailed Analysis of Alternative 2 – Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls

Under Alternative 2, existing soil covers and/or barriers would be maintained to prevent direct human and ecological exposure to contaminants remaining onsite and to provide protection from intrusion by human and/or biological receptors. This alternative generally is limited to sites where risk will attenuate to below RAOs in a reasonable length of time, usually associated with the 150-year period of active institutional controls, and where infiltration or intrusion controls are not required. Legal and physical barriers also would be used to prevent human access to the site. The existing soil covers and/or barriers break the exposure pathway between human and ecological receptors and the contaminants. Although the risk assessment has not identified unacceptable risk to groundwater at the Z-Ditches, because significant contamination inventory will remain in-place onsite, groundwater monitoring is included in this alternative.

The following sections present a detailed analysis of Alternative 2 against the evaluation criteria.

6.2.2.1 Overall Protection of Human Health and the Environment

Current protective measures and existing soil cover would provide overall protection of human health and the environment. However, contamination in shallow-zone soils will remain that present risk to ecological receptors and to inadvertent intruders.

The Z-Ditches exceed human-health direct-contact and ecological PRGs in the 0 to 4.6 m (0 to 15-ft) bgs zone. In addition, an inadvertent intruder analysis performed separately for the three proximate Z-Ditches (216-Z-1D, 216-Z-11, and 216-Z-19) showed that each ditch to varying degrees posed a threat to inadvertent intruders (Appendix E). However, as discussed earlier, the proximity of the Z-Ditches, shared flow paths, and surface stabilization activities have obscured site boundaries (RI Report), and it is now conservatively assumed that the collective Z-Ditches area poses a threat to inadvertent intruders that is equivalent to the risk posed by the most contaminated of the three ditches. Because of the threat posed to human and ecological receptors, this alternative is not protective of human health and the environment. However, institutional controls would be in place to prevent intruder access and potential exposure.

6.2.2.2 Compliance with Applicable or Relevant and Appropriate Requirements

Under Alternative 2, ARARs would not be met at the Z-Ditches. At the Z-Ditches, human-health direct-contract PRGs will be exceeded past the 150-year active institutional control period. Thus, each site fails to comply with ARARs in at least one category.

6.2.2.3 Long-Term Effectiveness and Permanence

6.2.2.3.1 Human Health

Alternative 2 would rely on natural attenuation (e.g., radioactive decay) to decrease contaminants until concentrations reached levels that would be protective of human health and the environment. However, under Alternative 2, radionuclides would remain in Z-Ditches soil in the 0 to 4.6 m (0 to 15-ft) bgs zone at concentrations that would exceed the human-health guidelines of 15 mrem/yr and an ELCR of greater than 1×10^{-4} for direct contact under an industrial land-use scenario for a time period greater than 150 years. In addition, radionuclides would remain in the soil at concentrations that would result in potential risk to inadvertent human intruders. This alternative would rely on continuing institutional controls to maintain the existing soil cover and prevent unauthorized worker or intruder access. Such institutional controls are presumed to remain viable for the duration of site risk. However, if institutional controls fail to prevent access, if some of the existing soil cover erodes, or if under an industrial-use scenario a worker digs at the site, humans could be exposed to these contaminants and this alternative would not be protective of human health in the long term.

6.2.2.3.2 Protection of Groundwater

Analysis shows no risk to groundwater from the southern Z-Ditch area. Therefore, Alternative 2 would be protective of groundwater at this site.

6.2.2.3.3 The Environment

The Z-Ditches have contaminants located in the shallow soils (0 to 4.6 m [0 to 15-ft] bgs) that present potential risks to burrowing animals; therefore, this alternative does not provide long-term protection to the environment for these sites.

6.2.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 2 does not provide treatment to reduce toxicity, mobility, or volume. The Z-Ditches COCs are not mobile and therefore do not require treatment to reduce contaminant movement in vadose-zone soil. However, the Z-Ditches contain a large volume of soil contaminated with high concentrations of radionuclides that under the industrial land-use scenario would exceed acceptable dose and risk guidelines well beyond a reasonable attenuation period.

6.2.2.5 Short-Term Effectiveness

6.2.2.5.1 Remediation Worker Risk

For Alternative 2, only minimal short-term worker risks are expected, and these risks are associated with monitoring and maintenance activities. Experienced workers using appropriate safety precautions would conduct these activities. Risks would decrease over time as the radionuclides decay. As such, the risk to workers is qualitatively identified as low. Additionally, DOE control of the Central Plateau is assumed for the next 50 years given DOE's commitment to vitrify the waste in the tank farms. Therefore, failure of this alternative in the short term is considered unlikely.

6.2.2.5.2 Impact to Environment During Remediation

Minimal remedial actions would occur under Alternative 2 that have a potential to adversely impact the environment in any significant manner. Alternative 2 reduces the risk to human and ecological receptors through maintenance of existing soil covers and the implementation of institutional controls during the effective institutional control period. The Z-Ditches have contamination in the shallow soils 0 to 4.6 m (0 to 15 ft) bgs, and short-term impacts to vegetation and wildlife could occur at these sites during the implementation of alternative monitoring and during repair (if needed) of existing covers. However, because the waste sites have been highly disturbed and the existing soil cover provides protection for all but the deep-burrowing animals, the short-term impacts to the environment are expected to be low.

6.2.2.5.3 Time to Achieve the Remedial Action Objectives

Alternative 2 would take approximately 60 days to implement the required program of monitoring and surveillances. However, this alternative takes no measures beyond the 150-year active institutional controls period to ensure that the site remains protective until RAOs are met through natural radiological decay of contaminants, which at the Z-Ditches would take thousands of years.

6.2.2.5.4 Implementability

Alternative 2 could be readily implemented and would not present technical problems. This alternative currently is being implemented through Hanford Site access controls, surface stabilization actions, subsurface radiation area work and access controls, and waste-site radiation area surveillance and maintenance programs.

6.2.2.6 Cost

The present-worth cost to implement Alternative 2 is summarized in Table 6-1 and is estimated to be approximately $9,950,100 ($42,501,600 nondiscounted). Cost estimates for Alternative 2 were developed based on existing costs for similar activities currently conducted on the Hanford Site. These activities involve periodic surveillance of the waste sites for evidence of contamination and biologic intrusion; emplacement of vegetation, herbicide application, or other activities to control deep-rooted plants; control of deep-burrowing animals; maintenance of signs and/or fencing; maintenance of the existing soil cover (including an assumed periodic addition of

soil); administrative controls; and site reviews. The present-worth costs assume a 3.2 percent discount rate (based on 2007 Office of Management and Budget information) and assume an operations and maintenance period equal to 150 years. Long-term monitoring costs associated with groundwater are not included in this cost estimate, because contaminated groundwater in the 200 West Area will be addressed by the 200-UP-1 and 200-ZP-1 Groundwater OUs. Details of the cost estimates are presented in Appendix D.

6.2.3 Detailed Analysis of Alternative 3 – Removal, Treatment, and Disposal

Under Alternative 3, contaminated soil and debris (e.g., buried concrete headwall structure) would be removed to PRGs from the Z-Ditches Work Areas 1, 2, and 3 as shown in Figure 6-1; treated as necessary to meet disposal facility waste acceptance criteria; and transported for disposal at an approved waste disposal facility. Contaminated waste and soil are expected to require removal at all three work areas as shown in Figure 6-2 and would not be removed to depths greater than 4.6 m (15 ft) bgs.

Alternative 3 has two disposal paths for radiologically contaminated soil. Soils that are not contaminated with plutonium or americium above 100 nCi/g would be disposed onsite at ERDF. Soils contaminated above 100 nCi/g are currently required to be handled, packaged, stored, and ultimately disposed in accordance with WIPP waste acceptance criteria. Figures 6-1 and 6-2 show the lateral and vertical extent of concentrations of Pu-239/240 potentially above 100 nCi/g. The amount of plutonium that the site received during its operation is unknown. Soils from all other Z-Ditches locations are anticipated to be low-level waste. Based on the Z-Ditches characterization data, soils are not anticipated to require treatment before disposal at ERDF or WIPP.

This alternative generally provides a high degree of overall protection of human health and the environment, because contaminants are removed to meet PRGs and no unacceptable risks would remain at the Z-Ditches. Because contaminants above PRGs would be removed from a waste site and placed in an approved disposal facility, failure of this alternative is not likely. Verification sampling would be conducted to determine that PRGs are met by the removal activities. Risks associated with the failure of the disposal facilities (ERDF and WIPP) are not evaluated here, but are instead evaluated in the disposal facility documents, including ERDF authorization basis documents.

The following subsections present a detailed analysis of Alternative 3 against CERCLA evaluation criteria.

Figure 6-1. Generalized Site Configuration under Alternative 3.

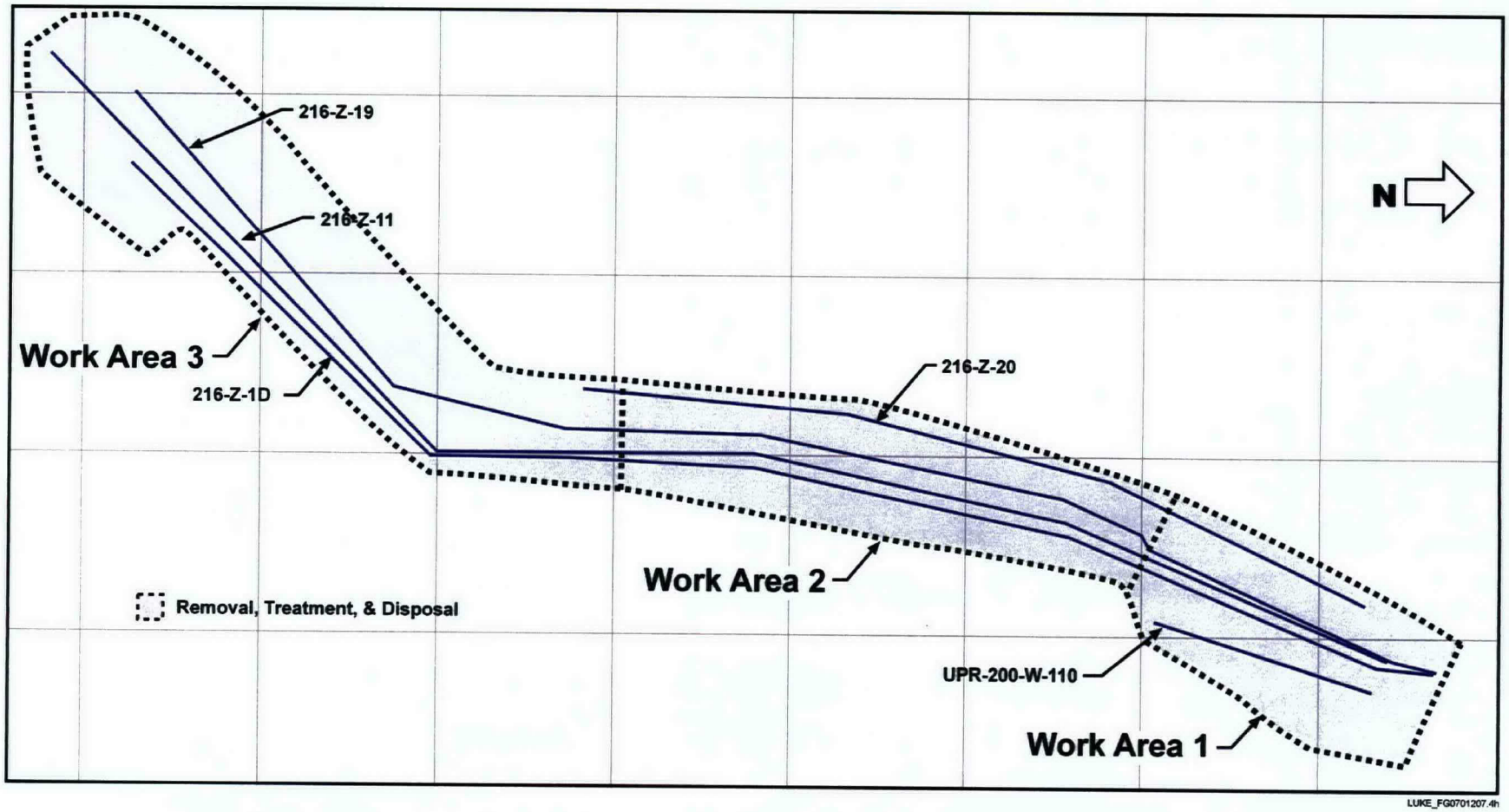
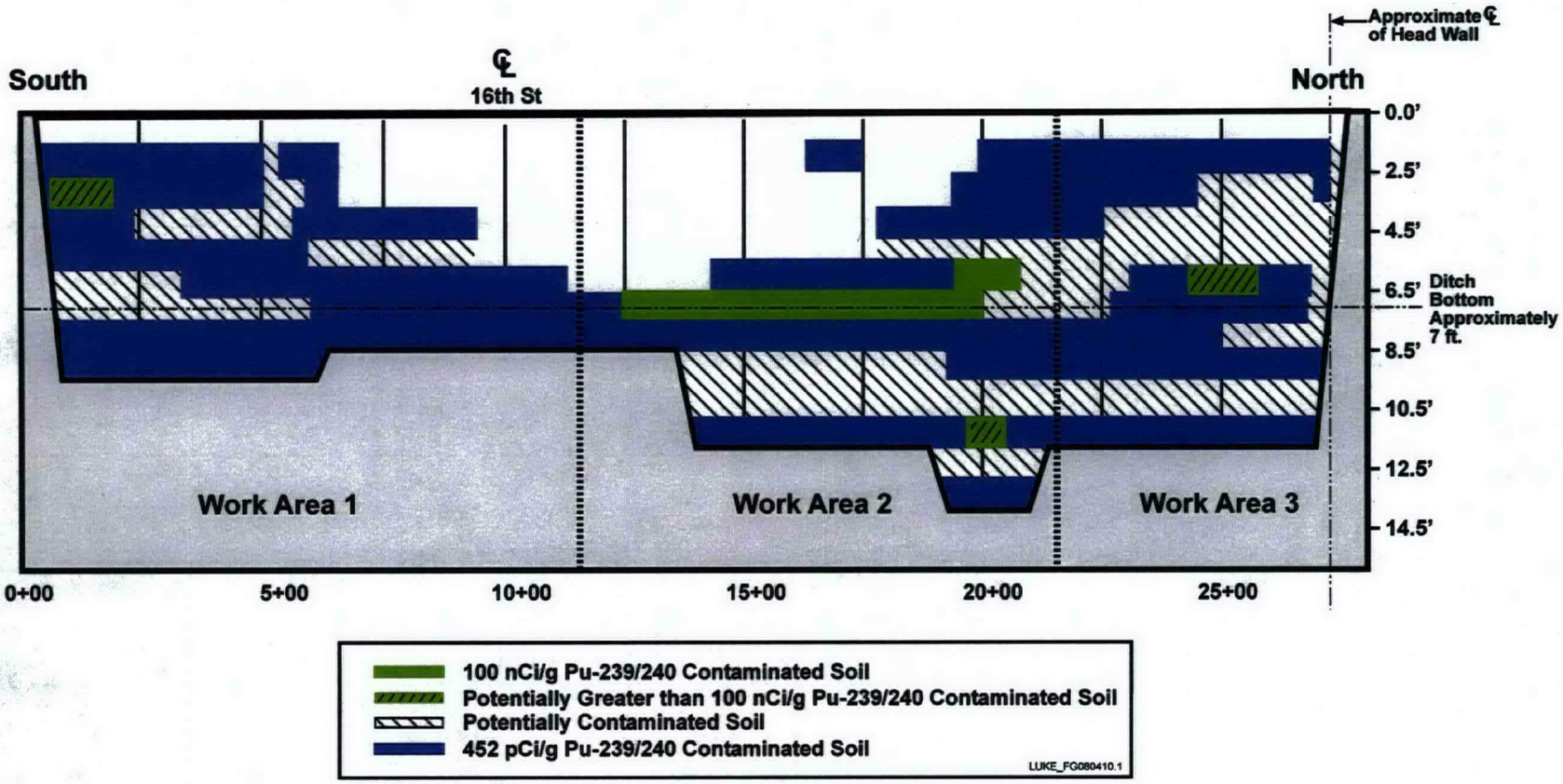


Figure 6-2. Cross Section of Z-Ditches Soil Contamination and Work Areas.



6.2.3.1 Overall Protection of Human Health and the Environment

Because this alternative removes contaminants that are above PRGs, it provides overall protection of human health and the environment in all cases. Risk analysis of the Z-Ditches area showed that contamination above PRGs occurs only in the shallow zone (0 to 4.6 m [0 to 15 ft] bgs). At the deepest point, contaminants would require removal to a depth of approximately 4 m (13 ft) bgs to eliminate potential risk to human and ecological receptors and to potential inadvertent intruders. Because, as described earlier, the Z-Ditches are physically close and similarly contaminated, the entire Z-Ditches area would be excavated to ensure overall protection of human health and the environment.

6.2.3.2 Long-Term Effectiveness and Permanence

6.2.3.2.1 Human Health

With regard to human health, Alternative 3 would be effective and permanent in the long term for all sites because excavation activities would remove contaminants to meet human-health RAOs. EPA cleanups prescribe remedies that use permanent solutions to the maximum extent practicable and where cost-effective. Removal of contaminants would be a permanent solution at the Z-Ditches and no controls would be required that potentially could fail. The waste would remain onsite at ERDF or would be disposed offsite at WIPP. This action would transfer the long-term impact of the waste from the Z-Ditches to these disposal facilities, which are designed for long-term management of buried waste.

6.2.3.2.2 Protection of Groundwater

Because no risks to groundwater have been identified from the 200-CW-5 OU waste sites, evaluation of Alternative 3 for groundwater protectiveness is not required.

6.2.3.2.3 The Environment

Alternative 3 removes all contaminated Z-Ditches soil in the 0 to 4.6 m (0 to 15-ft) bgs zone to PRGs and therefore would be effective and permanent with respect to the environment and ecological receptors. Excavation and transportation of waste and structures would disturb areas beyond the waste-site boundaries during the implementation period. These areas would be revegetated after disturbance, which would include control of intrusion by non-native, noxious plants until the new vegetation is established. Clean excavation material would be stockpiled for use in backfilling excavations. Additional backfill material would be obtained from existing soil borrow areas. However, any impact to the environment from borrow pit operations would be minimal.

6.2.3.3 Reduction of Toxicity, Mobility, or Volume Through Treatment

The RTD alternative generally only would include treatment of the removed waste to the extent necessary to meet disposal facility waste acceptance criteria, which is not anticipated to be required.

6.2.3.4 Short-Term Effectiveness

6.2.3.4.1 Remediation Worker Risk

During Alternative 3 implementation, contamination at the Z-Ditches could pose a significant dose threat to workers. Qualified workers using appropriate safety precautions would conduct Alternative 5A excavation activities. Short-term effects of this alternative would be associated primarily with worker safety during waste excavation (soil and structures), transportation, and disposal. Unprotected workers present a potential unacceptable risk because of the high concentrations at the Z-Ditches of long-lived americium and plutonium isotopes, although they are not expected at concentrations above 100 nCi/g at Work Areas 1 and 3.

Worker dose calculations are contained in engineering files, and total Pu-239/240 and Am-241 cumulative radiation dose to all workers from implementing this alternative is estimated to be 5.8 person-rem. Potential exposure to high levels of Am-241 and Pu-239/240 in the Z-Ditches could result in excavation and disposal activities requiring remote-handled removal techniques. Whether remote handled or contact handled, special safety controls could be required to address the contaminant concentrations. Shielded excavation equipment for these wastes may be required to reduce worker dose. Worker protection also could include providing filtered breathing air and use of water spray for dust suppression. Other controls also have been proven to handle potential problems with excavating large soil sites.

Additional measures are needed to limit the quantity of exposed soil during excavation, such as a rolling excavation, where only a small portion of the waste site is excavated at a time and the excavation is backfilled before the next small section of the waste site is exposed. Stringent work control measures are especially important at the portions of the site contaminated at greater than 100 nCi/g, where radiological risks to workers and the environmental are potentially the highest and ALARA is a primary consideration in planning work activities. These activities limit the worker risk but also have a direct impact on schedule and cost. Based on the effectiveness of such controls, construction of a containment structure to further limit airborne releases may be needed. Nonetheless, excavation with dust suppression, and health and safety controls, have proved effective in excavating large soil sites.

6.2.3.4.2 Impact to Environment During Remediation

Physical disruption of the waste sites during Alternative 3 excavation, increased human activity, and noise, in addition to the generation of fugitive dust, affect local biological resources. However, the waste sites are located in historically disturbed industrial areas. Potential animal intrusion and biological uptake also are issues that will require control of open excavations and exposed contaminated soils at the end of each day. This control could be accomplished through placement of covers or fixatives. Not only are digging animals a concern, but in open trenches where cellulose was used to control dust and other airborne releases, insects such as fruit flies represent a further pathway to spread contamination. These are documented pathways at the Hanford Site. The surface area disturbed during excavation of the Z-Ditches will be 3 ha (7 acres). It is assumed that an additional 0.6 ha (2 acres) will be disturbed from activities such as staging construction activities and stockpiling clean soil, for a total disturbed area of 4 ha

(8 acres). Currently there are no obstructions surrounding the Z-Ditches hindering this alternative.

Transportation activities on the Central Plateau would increase as a result of bringing construction equipment to the site, transporting contaminated soils to ERDF and WIPP, and bringing clean fill to the excavated sites. Because the Z-Ditches and ERDF are located onsite, minimal potential risk is associated with the transport of waste. However, excavated waste soils contaminated with plutonium and/or americium above 100 nCi/g would be transported to WIPP. Currently approximately 2,962 m^3 (3,875 yd^3) of soil from Work Area 2 would be placed in containers, certified, and transported to WIPP. These actions would cause short-term impacts. Air monitoring around the waste sites would be used to monitor potential air releases (e.g., waste or fill-material particulates) that could affect the public and the environment.

6.2.3.4.3 Time to Achieve the Remedial Action Objectives

Alternative 3 prevents risk to human and ecological receptors by moving the source to an engineered disposal facility. Construction and waste excavation activities for the Z-Ditches would be expected to require approximately 1,040 work days to complete. The timeframe used is shown in Appendix D and assumes two hydraulic excavators are used, operations are conducted 40 hours per week, and ERDF would be accepting approximately 336 m^3 (440 yd^3) of waste per day from the 200-CW-5 OU remedial action. Once completed, all long-term RAOs will be met (e.g., reducing risk to human health and ecological receptors and reduction of exposure to industrial workers). Short-term concerns, which include preventing or reducing occupational health risks and minimizing the general disruption of wildlife habitat, will be addressed during the remedial action. Worker risk will be mitigated by implementation of stringent worker safety requirements and site contamination controls. Disruption of wildlife habitat is mitigated due to current and future land use as an industrial setting providing little habitation for vegetation and wildlife.

6.2.3.5 Implementability

Excavation is a proven and implementable technology used to remove wastes. Equipment and qualified operators to perform this relatively shallow excavation are readily available. Excavations deeper than 4.6 m (15 ft) bgs are not required to meet human and ecological RAOs. Because of high radiological contamination levels, significant pre-job safety analysis would be required before implementation. Any above- or below-ground structures (e.g., vent pipes and concrete structures) would be removed along with the waste site soil covers and contaminated soils. Every 0.3 m (1 ft) of excavation would require 0.46 m (1.5 ft) of side slope for a 1:1.5 vertical to horizontal ratio. This safety measure significantly increases the amount of material excavated, but is considered implementable.

To remove soils contaminated above the PRGs, the Z-Ditches excavation at some locations would be advanced up to a depth of up to 4.6 m (15 ft) bgs. To remove the COCs at this group, 63,913 m^3 (83,595 yd^3) of soil would have to be removed and sent to ERDF and/or WIPP. The remaining capacity of ERDF as of February 6, 2004, was 7.65 million m^3. Because only approximately 60,950 m^3 (79,720 yd^3) of soils would be sent to ERDF, this is considered implementable. The volume that would go to WIPP would be determined by onsite sampling

during the excavation and packaging process and could be up to 2,962 m^3 (3,875 yd^3) based on the Z-Ditch study results (Appendix A of this document). Disposal at WIPP could impact alternative implementability given that WIPP acceptance of this quantity of DOE complex TRU waste would require WIPP facility confirmation.

This alternative is administratively feasible because as a CERCLA action, coordination with other offices is minimal. Although CERCLA actions must meet substantive ARAR requirements, such actions are not required to obtain the permits sometimes required under other environmental regulations. Further, cultural resources or endangered species are not present at the Z-Ditches that could present regulatory restraints or delays during the activities.

6.2.3.6 Cost

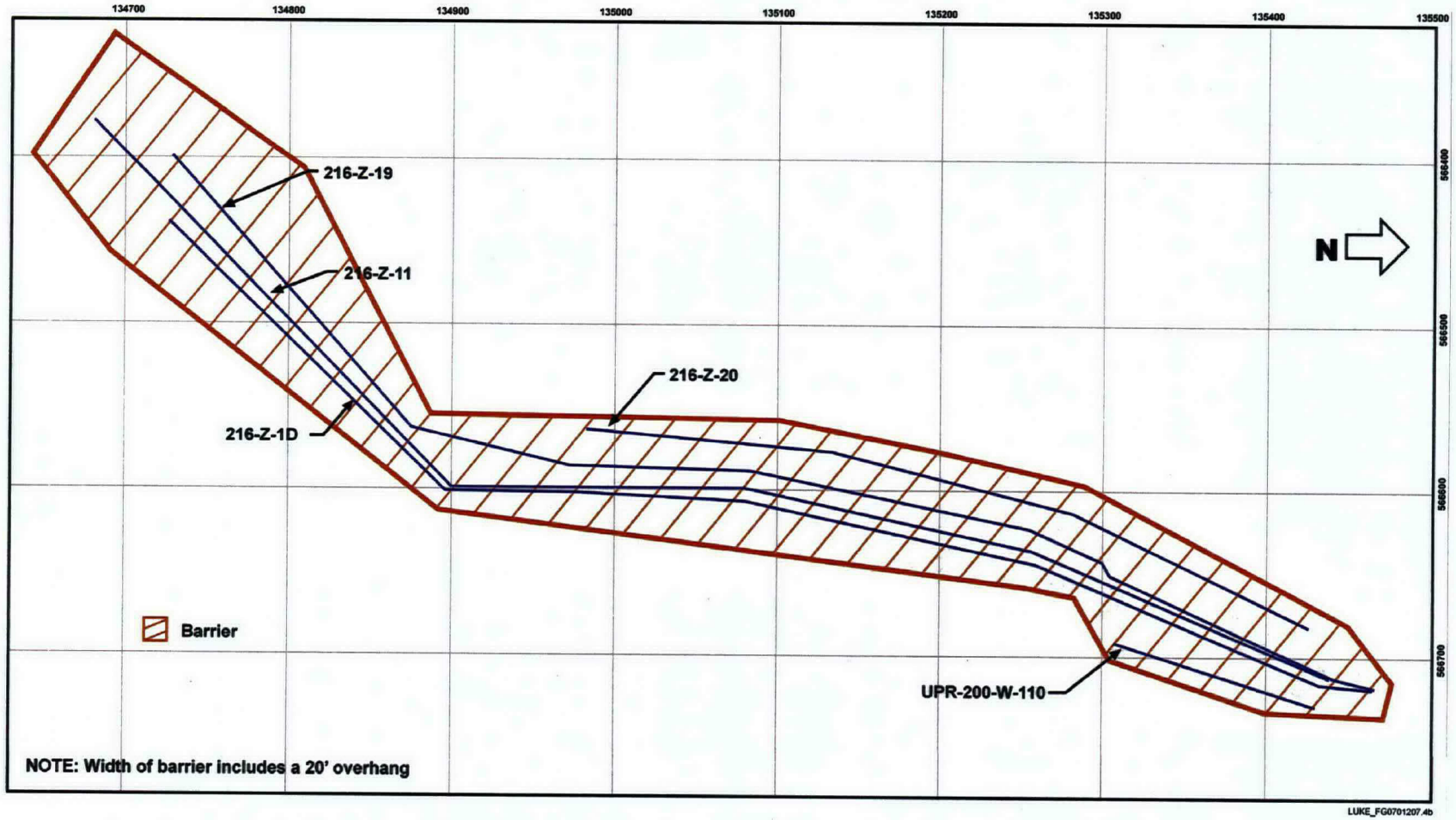
The cost to implement Alternative 3 for the Z-Ditches is summarized in Table 6-1 and detailed in Appendix D. For the Z-Ditches, the present-worth cost is $145,742,900 ($153,899,600 nondiscounted). Costs include mobilizing personnel and equipment; monitoring, sampling, and analysis; excavating; disposing of the waste at ERDF; backfilling with onsite resources and additional backfilling from a local stockpile; revegetating; and performing prime contractor oversight. Costs are based on the use of standard excavation equipment (e.g., hydraulic excavators, front-end loaders, tractor trailers). The costs are based on the assumption that a subcontractor would do the work, with oversight performed by prime contractor personnel. Details of the cost estimates are presented in Appendix D. The average programmatic disposal cost assigned to the Hanford Site for FYs 2006 and 2007 average $31,366 per m^3/yr ($23,980 per yd^3/yr). If this cost were added to the project disposal cost, the total disposal cost for Alternative 3 disposal at ERDF would be $77,501,000, up from an estimated $70,109,262.

The costs for excavation of waste containing plutonium and/or americium at greater than 100 nCi/g that would require offsite disposal at WIPP are significantly higher than excavation costs for low-level waste. Hanford Site programs bear the cost of excavation, packaging, and waste certification for WIPP disposal. The cost of waste transportation to WIPP and WIPP disposal are programmatically borne by WIPP.

6.2.4 Detailed Analysis of Alternative 4 – Barrier

Alternative 4 would place a barrier on the Z-Ditches as depicted in Figure 6-3 to limit industrial worker and ecological direct-contact exposure. The Z-Ditches COCs are immobile and groundwater risk was not identified. However, because of the long half-life of plutonium, infiltration prevention will be a barrier design consideration. Plutonium above 100 nCi/g is present at the central portion of the site (Work Area 2), and remaining site locations (Work Areas 1 and 3) also contain concentrations of long-lived radionuclides above PRGs. The barrier design primarily would be used to prevent human and ecological direct-contact exposure. This barrier would not render site contamination inaccessible for future remedial action as technologies evolve that could alter remedial decision making.

Figure 6-3. Generalized Site Configuration under Alternative 4.



The ARARs and technical guidance do not provide specific performance or technical standards for the design life of a barrier over material having plutonium or americium at greater than 100 nCi/g. However, 10 CFR 61.52, "Land Disposal Facility Operation and Disposal Site Closure," suggests the top of the Class C low-level waste should be approximately 5 m (16 ft) below the surface, or that intrusion barriers should be designed to protect against inadvertent intrusion for at least 500 years (WAC 173-340-7490(4)(b), "Standard Point of Compliance"). The barrier is planned to ensure that contamination above cleanup levels is at least 4.6 m (15 ft) below the barrier surface. The noncontaminated soil covers over the waste sites would be incorporated into the barrier design to maximize use of existing clean cover and minimize the cost of materials and impact to visual aesthetics. The institutional controls will protect against inadvertent human intrusion for the duration of site risk.

The overlying ET layer will retain moisture in the upper level and inhibit moisture infiltration into the contamination zone. This lack of moisture should effectively discourage root penetration past the layer.

Institutional controls, including land use and site access restrictions to prevent intrusion, would be instituted at barrier sites until the RAOs are achieved through natural attenuation. Operations and maintenance planning would provide vadose-zone monitoring for remedy performance and a means of identifying potential impacts to groundwater, which currently are not expected. Groundwater monitoring would be coordinated with monitoring at the appropriate groundwater OU.

The following sections present a detailed analysis of Alternative 4 against the evaluation criteria.

6.2.4.1 Overall Protection of Human Health and the Environment

This alternative would be protective of human health and the environment because the barrier system would isolate contaminants and reduce direct contact and inhalation of soil particulate risk to less than 1×10^{-6}. A barrier system would provide additional distance between potential human and ecological receptors, above and beyond the existing soil covers over the waste sites. The barrier alternative would include institutional controls to ensure barrier integrity, limit access to prevent intrusion into the contamination zone, and monitor performance to ensure continued protectiveness.

6.2.4.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 4 would comply with all ARARs for the waste sites by reducing the risk to less than 10^{-6} for exposure to contaminants remaining onsite by emplacing a protective barrier. In addition to the barrier, institutional controls such as additional land-use restrictions and groundwater monitoring are elements of this alternative to ensure continued protectiveness.

6.2.4.3 Long-Term Effectiveness and Permanence

6.2.4.3.1 Human Health

The barrier alternative would be protective of human health and the environment by breaking the direct-contact-exposure pathways. Chemicals and radionuclides left in place at the waste sites

would be physically isolated from receptors by the existing soil covers and the barrier. Contaminants at the Z-Ditches waste site have no impact to groundwater. However, the barrier would be designed to limit infiltration.

The 5-year reviews required for sites with contaminants above PRGs would serve to monitor the effectiveness and reliability of the barriers, and adjustments and maintenance activities could be instituted to help prevent failure. Continued site management in the form of institutional controls (e.g., deed restrictions, fencing, signage, monitoring of groundwater) as a required component of this alternative would ensure continued protectiveness.

6.2.4.3.2 Protection of Groundwater

Alternative 4 is protective of the groundwater because no impact to groundwater from the Z-Ditches was identified.

6.2.4.3.3 The Environment

This alternative would provide protection to the environment by placing a barrier between the waste and the surface flora and fauna as mentioned above. The barrier is protective of ecological receptors by eliminating the direct-exposure pathway. However, the barrier and institutional controls would be designed to prevent the intrusion of deep-rooted plants and burrowing animals.

6.2.4.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 4 has no engineered treatment component to reduce toxicity, mobility, or volume through treatment. The barrier alternative would prevent direct-contact exposure while natural attenuation through radioactive decay reduces radioactivity levels. Natural attenuation would greatly reduce the concentrations and therefore the toxicity and volume of the shorter-lived cesium and strontium during the design life of the barrier. Over a much longer time period, the barrier also would keep the site protective as the toxicity and volume of the longer-lived plutonium and americium are reduced through natural attenuation.

6.2.4.5 Short-Term Effectiveness

6.2.4.5.1 Remediation Worker Risk

For Alternative 4, only minimal short-term risks are expected and primarily would be associated with general construction activities at the borrow sites and placement of the barrier. Workers that are qualified (i.e., have the appropriate training and experience) and use appropriate safety precautions would conduct these activities. Risks to workers for this alternative were compared to the baseline no-action alternative. The barrier alternative would not require excavation of contaminated soils, and buried structures (e.g., buried concrete headwall structures) are not expected that would require removal to prevent subsidence and so would minimize worker risk from exposure to contaminated material. Worker risk would be controlled through adherence to site health and safety procedures. Air monitoring would address potential air releases (e.g., barrier-material particulates) that could affect the public during construction of the surface barriers.

6.2.4.5.2 Impact to Environment During Remediation

Physical disruption of the waste sites during barrier construction, increased human activity and noise, and the generation of fugitive dust affect local biological resources and could disrupt wildlife. However, the waste sites are located in historically disturbed industrial areas already disturbed by earlier facility operations and in areas adjacent to ongoing facility operations. As such, short-term impacts to vegetation and animals at these sites would be low because these sites currently have poor wildlife habitats.

6.2.4.5.3 Time to Achieve the Remedial Action Objectives

The time to complete design, construction, and support activities under Alternative 4 is shown in Appendix D. These activities could require approximately 394 field work days to complete.

6.2.4.6 Implementability

Alternative 4 is administratively implementable because it would require little or no coordination between regulatory agencies that could cause constraints or delays. Further, no cultural resources or endangered species exist at the site that invoke regulations that could cause accommodation delays.

Construction of the barrier at Work Area 2 would follow standard procedures that have been thoroughly field tested at the Hanford Site. The barriers likely would require repair and possibly replacement sometime during the operational timeframe. Monitoring the continued integrity of the barriers would be accomplished through visual inspection and would be supplemented with groundwater sampling. Implementation of the barrier alternative would require additional design data (e.g., ground-penetrating radar) and possibly confirmatory sampling, if required to supplement existing data in determining the lateral extent (overhang) of the barrier.

Barrier construction requires only standard construction materials that are readily available. Gravel, sand, and silt/loam soil used for the barriers would be transported from borrow areas located on or near the Hanford Site. Construction workers primarily would be associated with operating heavy earth-moving equipment and truck drivers and qualified workers would be readily available. Anticipated volumes of these materials are identified in Appendix D. Area C currently is being evaluated as a silt borrow location; the area has a large volume of fine-grained material. Other locations have not yet been determined. Soil most likely would come from near the waste sites or from Pit 30, which is located between the 200 East and 200 West Areas.

Analyses of an appropriate borrow area for silt/loam soil would be the subject of a future NEPA evaluation to determine a location with the least impacts to natural and cultural resources. Borrow material occurs in environmentally sensitive areas and obtaining sufficient barrier material, especially for a multilayered barrier, could affect areas of ecological significance and is a consideration in evaluating the relative risk reduction gained by installing the barrier. Analyses of an appropriate borrow area for silt/loam soil would be the subject of a future NEPA evaluation to determine a location with the least impacts to natural and cultural resources.

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.

6.2.4.7 Cost

The present-worth cost to implement the Alternative 4 barrier for the Z-Ditches is $37,218,700 ($113,525,100 nondiscounted). Costs include stabilization of the existing site; excavation or import, transportation, and placement of barrier material; compaction of the barrier; prime contractor oversight; and confirmatory sampling. Costs are based on the use of standard equipment (e.g., hydraulic excavators, front-end loaders, dozers) and assume that a subcontractor would do the work, with oversight performed by the prime contractor. The present-worth costs assume a 3.2 percent discount rate (based on 2007 Office of Management and Budget information) and assume operations and maintenance for 150 years. The operations and maintenance costs include site inspection/surveillance, periodic radiation site surveys of surface soil, monitoring of site vadose-zone soils, biotic control, maintenance of signs and markers, cover maintenance, and site reviews. Long-term monitoring costs associated with groundwater are not included in this cost estimate because contaminated groundwater in the 200 West Area will be addressed by the 200-UP-1 and 200-ZP-1 Groundwater OUs.

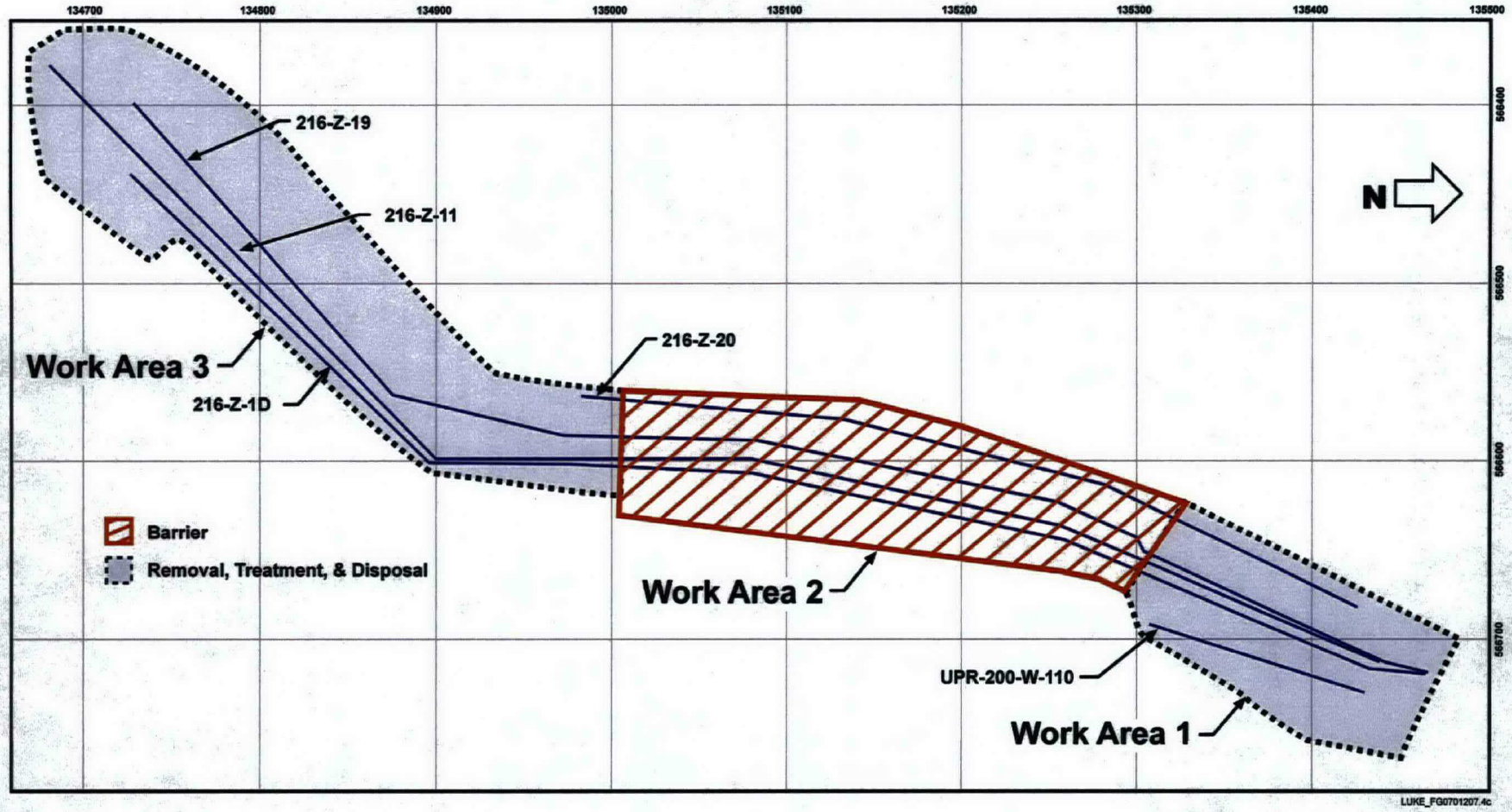
6.2.5 Detailed Analysis of Alternative 5A – Removal, Treatment, and Disposal with Barrier

Alternative 5A removes the soil to meet PRGs in Work Areas 1 and 3 and places a barrier over Work Area 2 similar to that described for Alternative 4. Site configuration under Alternative 5A is depicted in Figure 6-4. Work Area 2 represents the area where plutonium is expected to exist in soil at greater than 100 nCi/g.

This alternative removes COCs in soil of Work Areas 1 and 3 to a depth of approximately 3.5 m (11.5 ft) (Figure 6-1), to a maximum depth of 4.6 m (15 ft) bgs. At Work Areas 1 and 3, waste soil would be low-level waste. The excavation at Work Areas 1 and 3 would be filled with borrow material obtained on the Hanford Site. When the backfilling operation is finished, contamination at Work Area 2 would be isolated with a barrier as described for Alternative 4. Institutional controls as described for Alternative 4 would be established to ensure barrier integrity and limit unauthorized site access to prevent intrusion into the contamination zone.

The following sections present a detailed analysis of Alternative 5A against the evaluation criteria.

Figure 6-4. Generalized Site Configuration under Alternative 5A.



6.2.5.1 Overall Protection of Human Health and the Environment

Under Alternative 5A, RAOs will be met at Work Areas 1 and 3 by RTD to cleanup levels and at Work Area 2 by placement of a barrier that breaks the direct-contact-exposure pathway. To ensure RAOs are met, Work Areas 1 and 3 potentially could require excavation to a depth of approximately 4 m (13 ft) (which is the maximum identified depth of contamination above PRGs at the Z-Ditches), but no greater than 4.6 m (15 ft) bgs.

This alternative generally provides an elevated degree of overall protection of human health and the environment. Removal of shallow-zone contaminants above the PRGs from Work Areas 1 and 3 permanently removes risk from these locations. At Work Area 2 where plutonium contamination is greater than 100 nCi/g, the barrier will break the potential direct-contact-exposure pathway to potential human and ecological receptors, which eliminates site risk at this location until RAOs are met through natural attenuation.

6.2.5.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 5A would comply with ARARs for the waste sites by removing soil contaminated above the PRGs at Work Areas 1 and 3 and by placement of a barrier that breaks the direct-contact-exposure pathway at Work Area 2, which has plutonium at greater than 100 nCi/g. The Alternative 5A RTD component would comply with the same ARARs in the same manner as Alternative 3, RTD, for the Z-Ditches as addressed earlier. The barrier component will break the pathway for human and ecological receptors and prevent direct-contact exposure during the period of natural attenuation thereby complying with ARARS in the same manner as Alternative 4 discussed earlier. Institutional controls such as additional land-use restrictions that prevent intrusion and groundwater monitoring are elements of the barrier component of this alternative that help ensure long-term protectiveness and meeting ARARs.

6.2.5.3 Long-Term Effectiveness and Permanence

6.2.5.3.1 Human Health

The Alternative 5A barrier at Work Area 2 uses the same barrier as Alternative 4, and would be protective of human health and the environment by breaking the direct-contact-exposure pathways. Human and ecological receptors would be physically isolated from chemicals and radionuclides left in place at the site by the barrier. Intrusion would be prevented to the same degree as Alternative 4 by use of a similar barrier with similar institutional controls. Continued site management in the form of institutional control would ensure barrier integrity and performance. Because contaminants at the Z-Ditches waste sites have no potential to impact groundwater, the barrier would be designed to limit infiltration. The Alternative 5A RTD component, which excavates soil to a maximum 4.6 m (15 ft) depth, would permanently protect human health in the same manner and to the same degree at excavated Work Areas 1 and 3 as previously discussed for Alternative 3.

6.2.5.3.2 Protection of Groundwater

Alternative 5A is protective of the groundwater because no impact to groundwater from the Z-Ditches was identified.

6.2.5.3.3 The Environment

The Alternative 5A barrier at Work Area 2 would protect the environment by placing a barrier (between the contamination and environmental receptors at Work Area 2) that breaks the direct-contact-exposure pathway in the same manner and to the same degree as described earlier for Alternative 4. The Alternative 5A RTD component at Work Areas 1 and 3 would protect the environment by permanently removing contamination to below cleanup levels, which eliminates the exposure pathway to environment and ecological receptors in the same manner and to the same degree as described earlier for Alternative 3.

6.2.5.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 5A has similar RTD and barrier components as Alternatives 3 and 4, respectively, and includes no treatment to reduce toxicity, mobility, or volume of contaminants. The barrier, although not providing treatment, will accommodate natural attenuation treatment by preventing direct-contact exposure while radionuclide concentrations attenuate to below PRGs.

6.2.5.5 Short-Term Effectiveness

6.2.5.5.1 Remediation Worker Risk

Short-term effects of Alternative 5A would be associated primarily with worker safety during waste excavation (soil and structures), transportation, and disposal. Unprotected workers present a potential for unacceptable risk because of the high concentrations at the Z-Ditches of long-lived americium and plutonium isotopes, although not expected at concentrations above 100 nCi/g at Work Areas 1 and 3. Worker radiation doses for this alternative are similar to Alternative 3, because most of the radioactivity is in the upper layers of soil.

Qualified workers using appropriate safety precautions would conduct barrier activities. Similar to Alternative 4, only minimal short-term risks are expected. The barrier portion of this alternative would not require excavation of contaminated soils; therefore, potential risks to workers primarily would be associated with general construction activities at the borrow sites and placement of the barrier. Worker risk would be controlled through adherence to site health and safety procedures, including air monitoring to address potential air releases (e.g., barrier-material particulates) that could affect the public during construction of the surface barriers.

6.2.5.5.2 Impact to Environment During Remediation

Most of the short-term impacts to the environment from Alternative 5A will be from the excavation phase of the work. These impacts were analyzed earlier for Alternative 3 and would be mitigated by similar site contamination controls and air monitoring around the waste site for potential air releases that could affect the public and the environment. Physical disruption of the

waste sites during excavation, increased human activity and noise, and generation of fugitive dust all affect local biological resources. Barrier placement activities would disturb site surfaces during barrier construction. However, this site is located in a historically disturbed industrial area.

Transportation activities on the Central Plateau would increase as a result of bringing construction equipment to the site, transporting contaminated soils to ERDF, and bringing clean fill to the excavated sites and barrier material. Approximately 50,081 m^3 (65,504 yd^3) of radionuclide-contaminated soil excavated from the Z-Ditches Work Areas 1 and 3 would be transported to ERDF. WIPP disposal is not anticipated to be required at the less contaminated Work Areas 1 and 3. Because ERDF is located onsite, minimal environmental disturbance would be associated with the transport of waste.

6.2.5.5.3 Time to Achieve the Remedial Action Objectives

The following estimates of time to complete Z-Ditches excavation and barrier placement remediation activities under Alternative 5A are from Appendix D. The appendix calculated time to complete remediation of the Z-Ditches and to meet the RAOs for this alternative as 676 work days.

6.2.5.6 Implementability

The implementability of Alternative 5A is greater than Alternatives 3 and 4, which underwent detailed analysis for technical and administrative feasibility earlier in this chapter. The excavation and disposal of the less contaminated Work Area 1 and 3 soils is technically more implementable than Alternative 3, which excavates soil containing plutonium concentrations greater than 100 nCi/g. However, even at Work Areas 1 and 3, the use of more sophisticated excavation equipment and techniques could be required if areas of plutonium and/or americium above 100 nCi/g are encountered. The Alternative 5A barrier component would be more easily implemented than Alternative 5 because it requires barrier placement over a smaller area.

6.2.5.7 Cost

The present-worth cost to implement Alternative 5A excavation of Work Areas 1 and 3 and barrier emplacement over Work Area 2 is $55,558,800 ($90,641,600 nondiscounted). Barrier costs include stabilization of the existing site; excavation or import, transportation, and placement of material; compaction of the barrier; prime contractor oversight; and confirmatory sampling as described for Alternative 4. The operations and maintenance costs include site inspection/surveillance, periodic radiation site surveys of surface soil, monitoring of site vadose-zone soils, biotic control, maintenance of signs and markers, cover maintenance, and site reviews. Costs for the RTD component include mobilization, sampling, excavation, onsite disposal at ERDF, and site restoration activities as described for Alternative 3. Long-term groundwater-monitoring costs are not included in this cost estimate because contaminated groundwater in the 200 West Area will be addressed by the 200-UP-1 and 200-ZP-1 Groundwater OUs, outside the scope of the 200-CW-5 OU RI/FS process.

6.2.6 Detailed Analysis of Alternative 5B – Removal, Treatment, and Disposal with Barriers

Alternative 5B includes the removal of plutonium at concentrations greater than PRGs from soil of Work Area 2 and placement of barriers over Work Areas 1 and 3. The Z-Ditches site configuration under Alternative 5B is depicted in Figure 6-5. The excavation would remove soil at Work Area 2 to a depth of approximately 4 m (13 ft) bgs, to a maximum of 15 ft bgs. This excavation would remove the bulk of the radionuclide inventory above 100 nCi/g at the Z-Ditches. This action would significantly reduce overall site risk. The excavation would be filled with staged clean backfill and/or clean borrow material obtained on the Hanford Site.

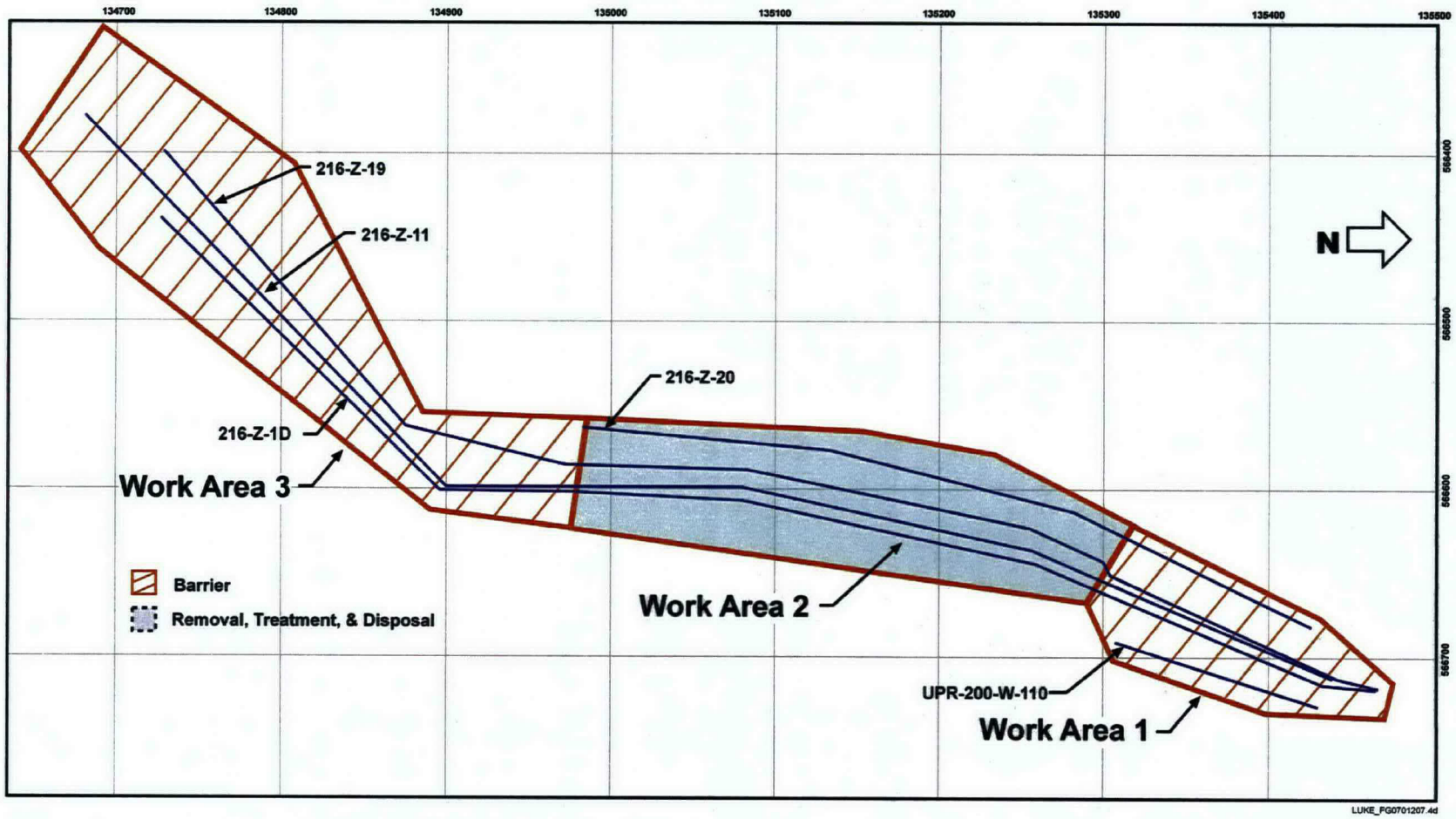
Because contamination would remain at Work Areas 1 and 3 above PRGs after the Work Area 2 excavation, this alternative provides for barriers over Work Areas 1 and 3 similar to that used for Alternative 4. The barriers break the direct-contact-exposure pathway to protect human and ecological receptors. Soil covers over the waste sites would be incorporated to the extent practicable using existing covers to minimize the cost of materials and the impact to visual aesthetics. The RTD activities at Work Area 2 generally would be the same as those described earlier for Alternative 3 but more limited in scope. This activity removes a significant portion of the near-surface contaminant inventory. Institutional controls, including maintenance of the barrier, land-use restrictions, and monitoring, would be instituted at Work Areas 1 and 3 to ensure barrier integrity, intrusion prevention, and protectiveness until the RAOs are achieved through natural attenuation.

6.2.6.1 Overall Protection of Human Health and the Environment

The RTD at Work Area 2 to a depth of approximately 4 m (13 ft) bgs would remove significant overall site risk by removing the zone of highest site contamination, leaving only the less contaminated material. Removal of the contamination at Work Area 2 would eliminate human-health, ecological, and inadvertent intruder risk at this portion of the site. In the long term, this alternative is protective of human health and the environment but the radiological risk to workers during the excavation essentially is the same as for Alternative 3, because the material being removed under Alternative 5B is the same material that causes most of the dose for the full-excavation alternative. The excavation would provide overall protection of human health and the environment in the same manner as Alternative 3, but to a lesser degree because not all contamination is removed.

The Alternative 5B barriers would break the direct-contact-exposure pathway at Work Areas 1 and 3 during the period of natural attenuation of the remaining, long-lived but significantly lower concentration radionuclides. Institutional controls including land-use restrictions, would be instituted at the site to prevent intrusion until the RAOs are achieved through natural attenuation. The Alternative 5B barriers would provide overall protection of human health and the environment in the same manner and to the same degree as Alternative 4.

Figure 6-5. Generalized Site Configuration under Alternative 5B.



6.2.6.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 5B would comply with ARARs by removing exposure risk at Work Area 2 through removal of all contamination above PRGs (including the high risk plutonium greater than 100 nCi/g) and at Work Areas 1 and 3 by placement of barriers that break the direct-contact pathway for the remaining, lower risk contaminants. In conjunction with the barriers, institutional controls such as additional land-use restrictions and groundwater monitoring are elements of this alternative.

6.2.6.3 Long-Term Effectiveness and Permanence

6.2.6.3.1 Human Health

The Alternative 5B barrier component using a similar barrier as Alternative 4 would break the direct-contact-exposure pathway at Work Areas 1 and 3 by physically isolating the contamination and would control infiltration into the contamination zone. Continued site management in the form of institutional control would ensure barrier integrity and performance and prevent intrusion by inadvertent human intruders. Because contaminants at the Z-Ditches waste sites have no potential to impact groundwater, the barrier would be designed primarily for prevention of intrusion by burrowing animals, deep-rooted plants.

The Alternative 5B RTD component, which removes all Work Area 2 contamination above PRGs from soil of Work Area 2, including plutonium, would permanently reduce overall site human-health risk in the same manner, but to a slightly lesser degree than previously discussed for Alternative 3, which removes all contamination above PRGs.

6.2.6.3.2 Protection of Groundwater

Alternative 5B is protective of the groundwater because no impact to groundwater from the Z-Ditches was identified.

6.2.6.3.3 The Environment

The Alternative 5B RTD at Work Area 2 would protect the environment by permanently removing contamination above PRGs at Work Area 2, including the high-risk contamination. This significantly reduces potential overall site exposure risk in the same manner but to a slightly lesser degree than as previously discussed for Alternative 3, which removes all site contamination above PRGs. The Alternative 5B barriers at Work Areas 1 and 3 would protect the environment by breaking the direct-contact-exposure pathway and preventing infiltration into the contamination zone in the same manner and to the same degree as described earlier for Alternative 4. The institutional controls associated with this alternative would prevent intrusion.

6.2.6.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 5B has RTD and barrier components as do Alternatives 3 and 4. Consequently, Alternative 5B detailed analysis for reduction of toxicity, mobility, or volume of contaminant through treatment is similar to the earlier detailed analyses for these alternatives. Alternative 5B barrier actions do not reduce the toxicity, mobility, or volume through treatment. Although not

providing treatment, the barriers will accommodate natural attenuation by preventing direct-contact exposure while radioactivity naturally attenuates to below PRGs.

6.2.6.5 Short-Term Effectiveness

6.2.6.5.1 Remediation Worker Risk

Short-term effects of Alternative 5B would be associated primarily with worker safety during contaminated soil excavation at Work Area 2and waste transportation and disposal. Unprotected workers present a potential for unacceptable risk because of the high concentrations at the Z-Ditches of long-lived americium and plutonium isotopes at Work Area 2. Worker radiation doses for this alternative are similar to Alternative 3, because much of the site dose is from Work Area 2 soil that contains the Z-Ditches plutonium at concentrations greater than 100 nCi/g. Qualified workers would conduct Alternative 5B excavation activities using appropriate safety precautions, including equipment shielding, high-efficiency particulate air filtration for breathing air, and equipment modification to provide additional shielding as detailed earlier for Alternative 3. However, this alternative presents increased potential for risk over Alternative 5A, which places a barrier over Work Area 2 and limits excavation activities to the less contaminated Work Areas 1 and 3. Excavation workers, truck drivers, and waste management workers would be exposed to dose rates from contaminated soil and debris that could require special protections. These protections would significantly increase costs but have been proven to mitigate potential exposure associated with excavating large soil sites.

For the Alternative 5B barrier component, only moderate short-term risks are expected. Because the barrier portion of this alternative would not require excavation of contaminated soils, the risks to workers primarily would be associated with general construction activities at the borrow sites and placement of the barriers. Worker risk would be controlled through adherence to site health and safety procedures, including air monitoring to address potential air releases (e.g., barrier-material particulates) that could affect the public during construction of the surface barriers.

6.2.6.5.2 Impact to Environment During Remediation

Most of the short-term impacts to the environment from Alternative 5B will be from the excavation phase of the work, are as analyzed earlier for Alternative 3, and would be mitigated by similar site contamination controls and air monitoring around the waste site for potential air releases that could affect the public and the environment. Overall, the potential environmental impacts from Alternative 5B RTD would be greater than Alternative 5A, which does not excavate soil contaminated with plutonium at greater than 100 nCi/g, but would be less than Alternative 3, which excavates all site contaminants. Impacts from the barrier activity are as analyzed for Alternative 4.

Physical disruption of the waste sites affects local biological resources and could disrupt wildlife. These disruptions include excavation; transport of waste, backfill and barrier waste, and material; increased human activity and noise; and the generation of fugitive dust. However, the waste site is located in historically disturbed industrial areas adjacent to ongoing facility operations. Although short-term impacts to vegetation and animals at these sites would be low because these sites currently have poor wildlife habitats, controls will be in place to reasonably limit access and reduce

exposure to acceptable levels during remedial actions. The RTD component potentially could impact the environment in the same manner but to a lesser degree than Alternative 3, which excavates the entire site. Up to approximately 332.7 m^3 (11,750 yd^3) of radionuclide-contaminated soil excavated from the Z-Ditches Work Area 2 would be transported to ERDF or WIPP. Because ERDF is located onsite, minimal environmental disturbance would be associated with the transport of waste.

6.2.6.5.3 Time to Meet Remedial Action Objectives

The following estimates of time to complete remediation activities under Alternative 5B are from Appendix D. As shown in Appendix D, the time to complete excavation and the barrier for the Z-Ditches under Alternative 5B is approximately 337 work days.

6.2.6.6 Implementability

The implementability of Alternative 5B RTD of Work Area 2 is as previously analyzed for Alternative 3, which considered the implementability of sophisticated worker safety measures for removal of potentially up to 332.7 m^3 (11,750 yd^3) of waste containing plutonium at greater than 100 nCi/g and uncertainties associated with disposal of the waste at WIPP.

Given technical and administrative feasibility considerations, the Alternative 5B barriers at Work Areas 1 and 3 would be equally as implementable as Alternative 4, which requires barrier placement over the entire site and that underwent detailed analysis earlier in this chapter.

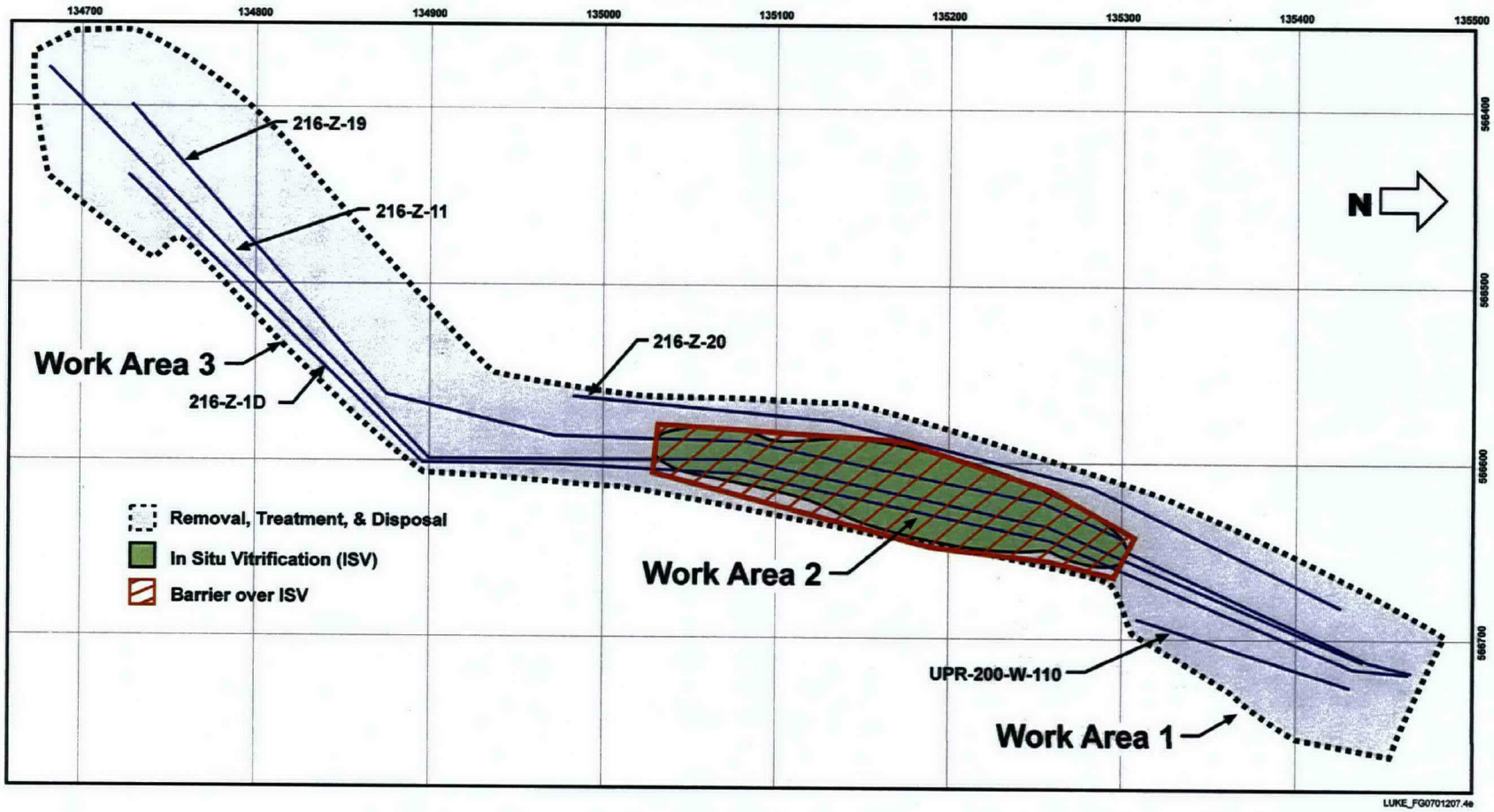
6.2.6.7 Cost

The present-worth cost to implement Alternative 5B RTD and placement of barriers is approximately $137,508,700 ($197,162,300 nondiscounted). Barrier costs include stabilization of the existing site; excavation or import, transportation, and placement of material; compaction of the barriers; prime contractor oversight; and confirmatory sampling as described for Alternative 4. The operations and maintenance costs include site inspection/surveillance, periodic radiation site surveys of surface soil, monitoring of site vadose-zone soils, biotic control, maintenance of signs and markers, cover maintenance, and site reviews. Costs for the RTD component include mobilization, sampling, excavation, waste disposal, and site restoration activities as described for Alternative 3. Long-term monitoring costs associated with groundwater are not included in this cost estimate because contaminated groundwater in the 200 West Area will be addressed by the 200-UP-1 and 200-ZP-1 Groundwater OUs.

6.2.7 Detailed Analysis of Alternative 6A – In Situ Vitrification with Barrier and Removal, Treatment, and Disposal

Alternative 6A includes the removal of contaminated soil in Work Areas 1 and 3 to below PRGs and treatment of the soil contaminated with plutonium above 100 nCi/g at Work Area 2 with an ISV process. Site configuration under Alternative 6A is depicted in Figure 6-6.

Figure 6-6. Generalized Site Configuration under Alternative 6A.



The analysis for the RTD component of this alternative is the same as the analysis for Alternative 5A, which also would remove soil with contaminants above PRGs from Work Areas 1 and 3. The excavation would be filled with borrow material obtained on the Hanford Site. This alternative is applicable to the Z-Ditches because of the high concentration of plutonium and americium and because the Z-Ditches configuration is shallow and narrow, which suits the ISV treatment process.

As described in Chapter 4.0, ISV applies an electrical current to melt contaminated soil and forms a vitrified mass that is stable and impermeable with low contaminant leachability when cooled. Tests and natural analogs have shown vitrified waste to have the long-term stability required for sites having long-lived radionuclide contamination. The stable mass chemically incorporates most inorganics (including heavy metals and radionuclides) and destroys or removes all organic contaminants. Convective mixing that occurs during the molten phase of vitrification will cause contaminant homogeneity throughout the melt matrix. Although ISV primarily is an immobilization treatment process, it also can reduce contaminant volume accounting for from 20 to 50 percent soil mass reduction. Subsidence would occur and be filled with clean material.

To prevent human and ecological direct contact, a barrier similar to the barrier used in Alternative 4 over the ISV melt area would be a component of this alternative. Alternative 6A would include continuing institutional controls and monitoring to ensure barrier integrity and performance and to prevent intrusion.

The following sections present a detailed analysis of Alternative 6A against the evaluation criteria.

6.2.7.1 Overall Protection of Human Health and the Environment

Alternative 6A is considered protective of human health and the environment and will meet RAOs for the Z-Ditches because it permanently treats the most contaminated Z-Ditch soils in-place and removes contaminants to below PRGs from the remaining areas of the site. An ISV process will be used to immobilize the highest concentration alpha-emitting contaminants at Work Area 2 by binding them in a non-leachable glass matrix that also will prevent any unanticipated migration. Sampling would be performed to verify that the final waste form meets design specifications. Because the waste remains onsite, although protectively treated, a barrier similar to that used for Alternative 4 will be placed over the ISV melts that permanently breaks the direct-contact-exposure pathway and prevents infiltration until RAOs are reached in the glass matrix through natural attenuation. Institutional controls at the ISV melt location could be required, and would include maintenance of a protective cover, land-use restrictions to prevent intrusion, and monitoring. The RTD component removes the contaminants to below PRGs at Work Areas 1 and 3.

Alternative 6A generally provides an elevated degree of overall protection of human health and the environment, because shallow-zone contaminant concentrations above the PRGs are removed and plutonium at greater than 100 nCi/g is permanently immobilized. In addition, the barrier breaks the potential direct-contact-exposure pathways to human and ecological receptors and prevents infiltration into the contamination zone. However, of the alternatives considered in this

FS, ISV is considered an innovative technology and is not technically proven for large-scale application and therefore has the greatest level of technical uncertainty.

The detailed analysis of human health and environmental protectiveness for the Alternative 6A RTD component is the same analysis as for Alternative 5A, which provides for RTD of the same locations to the same lateral and vertical extent.

6.2.7.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 6A complies with ARARs by significantly reducing site risk through ISV treatment of soil contaminated with plutonium above 100 nCi/g at Work Area 2 (which immobilizes the contaminants). Placement of a barrier over the ISV melts breaks the potential direct-contact-exposure pathway to immobilized but remaining contaminants. RTD at Work Areas 1 and 3 permanently removes the exposure pathway to the lower risk contaminants. Institutional controls associated with this alternative include land-use restrictions will be instituted to prevent access by inadvertent intruders for the duration of site risk and will provide for continued groundwater monitoring. The Alternative 6A RTD component would comply with ARARs by removing contaminants to below cleanup levels at Work Areas 1 and 3 in the same manner as described for Alternative 5A.

6.2.7.3 Long-Term Effectiveness and Permanence

6.2.7.3.1 Human Health

With regard to human health, Alternative 6A would be effective and permanent in the long term because ISV treatment permanently immobilizes contaminants in the glass matrix, thereby meeting direct-contact-exposure human and ecological RAOs. To be effective in the long term, a barrier is assumed necessary after implementation of the alternative to break the direct-contact-exposure pathway to the treated glass matrix until and to prevent infiltration until radionuclide PRGs are met through natural attenuation.

The Alternative 6A RTD component would provide long-term effective and permanent protection of human health by permanently removing contamination to below cleanup levels, thereby eliminating the exposure pathway to human receptors at Work Areas 1 and 3 to the same extent as described earlier for Alternative 5A.

6.2.7.3.2 Groundwater Protection

Alternative 6A is protective of the groundwater because no impact to groundwater from the Z-Ditches was identified.

6.2.7.3.3 The Environment

Alternative 6A would protect the environment at Work Area 2 because ISV would permanently immobilize the contamination into a stable and impermeable glass matrix having low contaminant leaching potential. Because of the hardness of the glass matrix, penetration by burrowing animals is not anticipated. Furthermore, the risk analysis (Chapter 3.0) shows that potential ecological risks at the Z-Ditches are negligible because of the minimal habitat and

forage offered at the Z-Ditches and because burrowing animals are not likely to be present. Alternative 6A would further protect the environment by placing a barrier between the glass waste matrix and the surface flora and fauna to prevent direct-contact exposure. Institutional controls would be instituted to prevent the intrusion of deep-rooted plants and burrowing animals.

The Alternative 6A RTD component would provide long-term permanence and protection of the environment in the same manner and to the same degree as Alternative 5A, which also provides for RTD of Work Areas 1 and 3 and which underwent detailed analysis for this criterion earlier in this chapter.

6.2.7.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 6A ISV is a treatment that permanently reduces contaminant mobility but to a limited degree can also reduce contaminant volume and toxicity. ISV meets the statutory preference for treatment over other less permanent waste management approaches. This alternative will immobilize contaminants in a stable and impermeable glass matrix with low contaminant leaching potential until RAOs are met through natural attenuation. ISV reduces contaminated soil volume during the vitrification process by approximately 20 to 50 percent (EPA/540/R-94/520, *Geosafe Corporation In Situ Vitrification, Innovative Technology Evaluation Report*). The barrier over the glass matrix will accommodate natural attenuation by breaking human and ecological direct-contact-exposure pathways during the extended natural attenuation period.

The Alternative 6A RTD component does not provide for reduction of toxicity, mobility, or volume through treatment but addresses toxicity, mobility, and volume of contaminants at the site through contaminant removal.

6.2.7.5 Short-Term Effectiveness

6.2.7.5.1 Remediation Worker Risk

Qualified workers using appropriate safety precautions would conduct Alternative 6A RTD and ISV (with barrier placement) activities. For Alternative 6A, short-term risks from the ISV component are expected to be moderate. The potential risks to workers from the ISV component primarily would be associated with ISV construction activities. These activities include installation and operations of high-voltage electrical lines and equipment; installation and operations of the thermally and electrically hot ISV melt probes; installation and operation of offgas collection hoods over the melts; and transportation of make-up soil from borrow sites and soil placement over the melt locations to address subsidence and volume reduction. Worker risk would be controlled through adherence to site health and safety procedures. An offgas treatment system would be in continuous operation during ISV operations to collect, treat, and analyze airborne contaminants having a potential to impact workers before release to the environment. Air monitoring around the gas hood and treated air release points also would mitigate potential air releases that could affect workers or the public during ISV operations. Short-term risks from Alternative 6A barrier placement are associated with general construction activities such as soil addition or barrier construction. These potential risks are considered minimal and would be further minimized by the use of qualified workers using appropriate safety precautions.

The Alternative 6A RTD component would present the same short-term worker risk as described earlier for Alternative 5A, which provides for RTD of the same areas (Work Areas 1 and 3) to the same extent.

6.2.7.5.2 Impact to Environment During Remediation

Local biological resources would be affected by physical disruption of the waste sites during equipment mobilization, excavation, ISV operations, additions of clean fill to excavations and subsidence areas, barrier placement over the ISV melt, and demobilization. The increased human activity and noise and the generation of fugitive dust affect local biological resources that readily can be controlled through standard mitigation operations such as water sprays. However, the waste sites are located in historically disturbed industrial areas. Approximately 5 ha (12 acres) of surface area will be disturbed during ISV implementation.

The Alternative 6A RTD component would present the same short-term environmental impacts during remediation as Alternative 5A, which provides for RTD of the same areas (Work Areas 1 and 3) and to the same extent.

6.2.7.5.3 Time to Achieve the Remedial Action Objectives

Based on calculations performed in Appendix D, ISV with barrier and RTD activities would be expected to require 1,439 work days to complete and to meet the RAO for preventing unacceptable risk to human and ecological receptors. This extended period of implementation is based on the assumption that ISV and associated site activities generally will be performed consecutively, not concurrently.

6.2.7.6 Implementability

Of the Z-Ditches remedial alternatives analyzed in this FS, the Alternative 6A ISV component is the least used and least proven in routine field operations. ISV has been proven effective on smaller test sites, and major concerns have been satisfactorily resolved in these tests. However, ISV is not used routinely for large-scale operations and should be considered a less proven technology. For this reason, cost estimates, schedules, and overall technical feasibility and effectiveness have a higher degree of uncertainty than is the case for other, more proven, alternatives. This alternative likely would require a pilot test project to resolve technical uncertainties.

The implementability of the Alternative 6A RTD component is the same as for Alternative 5A, which underwent detailed analysis earlier in this chapter and provides for RTD of the same locations (Work Areas 1 and 3) and to the same extent.

6.2.7.7 Cost

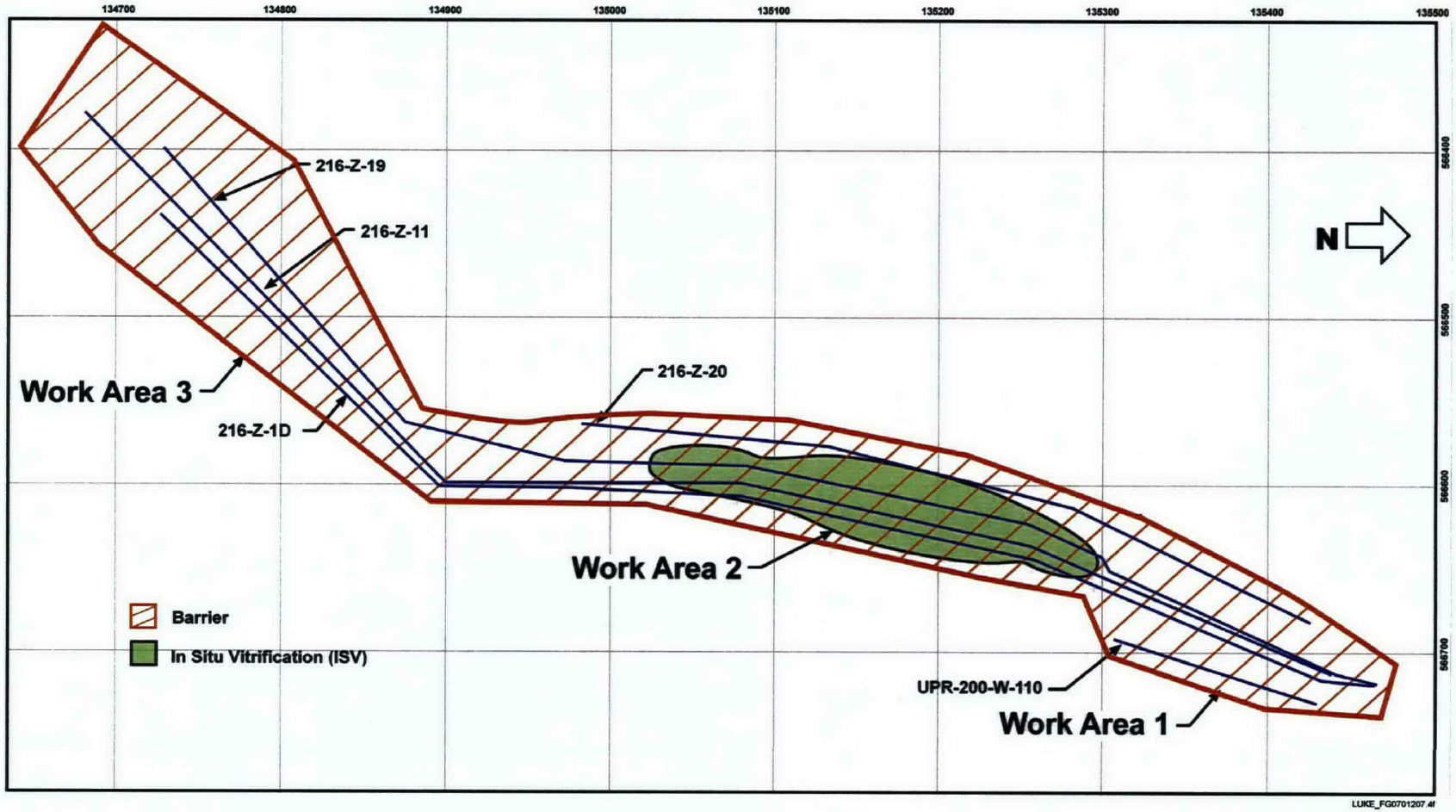
Alternative 6A includes RTD of contaminants in Work Areas 1 and 3 and ISV treatment of soil at Work Area 2 that contains plutonium above 100 nCi/g with placement of a barrier over the ISV melt site. The present-worth cost of Alternative 6A is $268,655,000 ($298,557,000 nondiscounted). ISV costs include mobilizing personnel and equipment; monitoring, sampling, and analysis; ISV operations; disposal of secondary waste (e.g., scrub liquid and high-efficiency particulate air filters); backfilling with onsite resources; procuring additional backfill from a local stockpile; compacting the barrier (if a barrier is required); revegetating and stabilizing the site; and prime contractor oversight. 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 cost estimate assumes that the subcontractor personnel are wearing Level D personal protective equipment (e.g., coveralls, no respirators) during ISV operations. The operations and maintenance costs include site inspection/surveillance, periodic radiation site surveys of surface soil, monitoring of site vadose-zone soils, biotic control, maintenance of signs and markers, cover maintenance, and site reviews. Long-term monitoring costs associated with groundwater are not included in this cost estimate because contaminated groundwater in the 200 West Area will be addressed by the 200-UP-1 and 200-ZP-1 Groundwater OUs.

The cost of the Alternative 6A RTD component would include the same cost factors identified for the Alternative 5A RTD component, which provides for RTD of Work Areas 1 and 3 for which cost was evaluated earlier in this chapter. Details of the cost estimates are presented in Appendix D.

6.2.8 Detailed Analysis of Alternative 6B – In Situ Vitrification with Barrier

Alternative 6B includes the ISV treatment of soil at Work Area 2 containing plutonium above 100 nCi/g, and placement of a barrier over the entire site, including over the ISV melt location. Grout injection of the remaining 216-Z-20 Tile Field waste distribution piping after barrier placement would be a potential sub-element of this alternative. The Alternative 6B ISV treatment is the same activity as performed under Alternative 6A, which underwent detailed analysis earlier in this chapter and this alternative is considered applicable to the Z-Ditches for the same reasons. The Alternative 6B barrier is similar to the full site barrier presented for Alternative 4. Site configuration under Alternative 6B is depicted in Figure 6-7. As with Alternative 6A, because significant contamination inventory will remain in place under this alternative, institutional controls and monitoring would be required throughout the period of natural attenuation to ensure the barrier is maintained and remains protective and to prevent access by inadvertent intruders. The following sections present a detailed analysis of Alternative 6B against the evaluation criteria.

Figure 6-7. Generalized Site Configuration under Alternative 6B.



6.2.8.1 Overall Protection of Human Health and the Environment

Alternative 6B is considered protective of human health and the environment for the Z-Ditches. The ISV component permanently immobilizes the highest concentration alpha- and gamma-emitting contaminants at Work Area 2 in the glass matrix. The ISV has the potential to provide a high degree of overall protection of human health and the environment because contaminants are converted to a stable form with low leachability. However, of the alternatives considered in this FS, ISV is considered an innovative technology and is not technically proven for routine, large-scale application and therefore has a high level of technical uncertainty. The Alternative 6B barrier component places a protective isolation barrier over the entire site, including the ISV melts, that breaks the human and ecological direct-contact-exposure pathway until RAOs are met through natural attenuation. The Alternative 6B barrier component provides overall protection of human health and the environment in the same manner and to the same degree as Alternative 4, which also provides for a barrier over the entire site and which underwent detailed analysis earlier in this chapter.

6.2.8.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 6B provides for ISV at the same location (Work Area 2) and to the same degree as Alternative 6A, which underwent detailed analysis earlier in this chapter. The detailed analysis of the CERCLA criteria for compliance with ARARs for the Alternative 6B ISV component would be the same analysis as that for the Alternative 6A ISV component.

Alternative 6B provides for a barrier at the same location (Work Areas 1 and 3) using a similar barrier to Alternative 4, which underwent detailed analysis earlier in this chapter. The detailed analysis of the CERCLA criteria for compliance with ARARs for the Alternative 6B barrier component would be the same analysis as that for the Alternative 4 barrier component.

6.2.8.3 Long-Term Effectiveness and Permanence

The CERCLA long-term effectiveness and permanence criteria pertain to analysis of the alternative for protectiveness of human health, groundwater, and the environment. The Alterative 6B ISV is the same activity at the same location (Work Area 2) and to the same degree as the previously analyzed Alternative 6A. Consequently, the detailed analysis of the CERCLA criteria for the long-term effectiveness and permanence criteria as they pertain to protectiveness of human health, groundwater, and the environment for the Alternative 6B ISV component would be the same analysis as performed earlier in this chapter for the Alternative 6A ISV component.

The Alternative 6B barrier also provides for a barrier over the entire site as previously analyzed for Alternative 4. The detailed analysis of the CERCLA criteria for the long-term effectiveness and permanence criteria as they pertain to protectiveness of human health, groundwater, and the environment for the Alternative 6B barrier component would be the same analysis as that performed for Alternative 4 earlier in this chapter.

6.2.8.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 6B permanently reduces toxicity and mobility through engineered ISV treatment that immobilizes contaminants and binds them into a stable, impermeable, and durable glass-like matrix that has low contaminant leaching potential until RAOs are met through natural attenuation. Alternative 6B provides for ISV at the same location (Work Area 2) and to the same degree as Alternative 6A, which underwent detailed analysis earlier in this chapter. Consequently, the detailed analysis of the CERCLA criteria for toxicity, mobility, and volume thorough treatment for the Alternative 6B ISV component would be the same analysis as that for the Alternative 6A ISV component.

Alternative 6B provides for a barrier over the entire site using a similar barrier as Alternative 4, which underwent detailed analysis earlier in this chapter. That analysis indicated that the Alternative 6B barrier component does not reduce contaminant toxicity, mobility, or volume through treatment.

6.2.8.5 Short-Term Effectiveness

The CERCLA short-term effectiveness criteria pertain to analysis of the alternative for remediation worker risk, impacts to the environment during remediation, and time to achieve RAOs. Alternative 6B has both ISV and barrier components, which essentially are identical to activities associated with alternatives that have undergone detailed analysis for these CERCLA criteria earlier in this chapter. Analysis for remediation worker risk considered worker training, experience, relative risk from ISV and barrier activities, and risk mitigation actions. For the impacts to the environment, earlier analysis considered impacts to the local biological resources, the area of disturbance from the various remedial activities, and mitigating factors. The earlier analyses also identified the time to achieve RAOs by ISV treatment and placement of a barrier that is protective until RAOs are met.

The Alterative 6B ISV component is the same activity at the same location (Work Area 2) and to the same degree as the previously analyzed Alternative 6A. The detailed analysis of the CERCLA criteria for the short-term effectiveness for the Alternative 6B ISV component would be the same analysis as that performed earlier for the Alternative 6A ISV component.

Alternative 6B also provides for a full site barrier using a similar barrier as previously analyzed for Alternative 4. The detailed analysis of the CERCLA criteria for the short-term effectiveness for the Alternative 6B barrier component would be the same analysis as that performed earlier for the Alternative 4 barrier component.

The time to implement Alternative 6B would be approximately 1,439 work days.

6.2.8.6 Implementability

The CERCLA short-term implementability criteria pertain to analysis of the alternative's technical and administrative feasibility and the availability of essential materials and services to implement the alternative. Alternative 6B has both ISV and barrier components, which are essentially identical to activities associated with alternatives that have undergone detailed analysis for these CERCLA criteria earlier in this chapter. Alterative 6B ISV is the same activity

at the same location (Work Area 2) and to the same degree as the previously analyzed Alternative 6A. The Alternative 6B barrier also provides for a full site barrier as previously analyzed for Alternative 4. The prior analyses considered technical feasibility with regard to the potential for delays or failure due to technical uncertainties, including the availability of essential materials and services and administrative feasibility with regard to coordination of agencies and potential regulatory constraints that could arise if cultural (archeological sites) or biological resources (endangered species) are encountered.

The detailed analysis of the CERCLA implementability criteria for the Alternative 6B ISV component would be the same as that for the Alternative 6A ISV component performed earlier. The detailed analysis of the CERCLA implementability criteria for the Alternative 6B barrier component would be the same as that performed earlier for the Alternative 4 barrier.

6.2.8.7 Cost

Alternative 6B includes ISV treatment of soil at Work Area 2 containing plutonium above 100 nCi/g and placement of a full site barrier. The Alternative 6B present-worth cost would be $256,033,900 ($348,501,700 nondiscounted). Alternative 6B has both the ISV and barrier components that are essentially identical to activities associated with alternatives that have undergone detailed cost analysis earlier in this chapter. Alterative 6B ISV is the same activity at the same location (Work Area 2) and to the same degree as the previously analyzed Alternative 6A. The cost considerations for ISV included the costs of mobilizing personnel and equipment; monitoring, sampling, and analysis; ISV operations; disposal of secondary waste (e.g., scrub liquid and high-efficiency particulate air filters); backfilling with onsite resources; procuring additional backfilling from a local stockpile; and prime contractor oversight.

The Alternative 6B barrier also provides for the same barrier over the entire site as previously analyzed for Alternative 4. The cost considerations for barrier placement included stabilization of the existing site; excavation or import, transportation, and placement of barrier material; compaction of the barrier; prime contractor oversight; and confirmatory sampling. The operations and maintenance costs include site inspection/surveillance, periodic radiation site surveys of surface soil, monitoring of site vadose-zone soils, biotic control, maintenance of signs and markers, cover maintenance, and site reviews. Long-term monitoring costs associated with groundwater are not included in this cost estimate because contaminated groundwater in the 200 West Area will be addressed by the 200-UP-1 and 200-ZP-1 Groundwater OUs.

Details of the cost estimates are presented in Appendix D.

Table 6-1. Summary of 200-CW-5 Operable Unit Alternatives. (9 Pages)

Criteria	Alternative 1 No Action	Alternative 2 MESC/MNA /ICs	Alternative 3 RTD	Alternative 4 Barrier (Full Site)	Alternative 5A RTD (Work Areas 1 and 3) with Barrier (Work Area 2)	Alternative 5B RTD (Work Area 2) with Barriers (Work Areas 1 and 3)	Alternative 6A ISV (Work Area 2) with Barrier and RTD (Work Areas 1 and 3)	Alternative 6B ISV (Work Area 2) with Barrier (Full Site)
Threshold Criteria 1. OVERALL PROTECTIVENESS								
Human health direct contact/ soil ingestion under industrial exposure	Existing cover reduces risk to below 1×10^{-6}. Not protective for human health (no cover) and inadvertent intruder.	Existing cover reduces risk to less than 1×10^{-6}.	Protective. Removes risk.	Reduces risk while barrier is maintained to below 1×10^{6}.	RTD removes risk in Work Areas 1 and 3 and barrier, while maintained, breaks the exposure pathway at Work Area 2.	Reduces overall site risk by RTD of the bulk of plutonium above 100 nCi/g at Work Area 2 and barrier over entire site, while maintained, breaks the exposure pathway at all work areas.	ISV reduces risk in Work Area 2 to less than 1×10^{-6} and RTD removes risk at Work Areas 1 and 3.	ISV reduces risk in Work Area 2 to less than 1×10^{-6} and barrier, while maintained, breaks the exposure pathway at all work areas.
Groundwater	No impact to groundwater identified.	No groundwater risk identified.	No groundwater risk identified.	No groundwater risk identified, and barrier provides infiltration control.	No groundwater risk identified, and barrier provides infiltration control.	No groundwater risk identified, and barrier provides infiltration control.	No groundwater risk identified, and barrier provides infiltration control.	No groundwater risk identified, and barrier provides infiltration control.
Environmental protection	Not protective for ecological receptors because contamination present in the 0 to 4.6 m (0 to 15-ft) bgs zone.	Not protective for ecological receptors because contamination is present in the 0 to 4.6 m (0 to 15-ft) bgs zone.	Removes risk.	Barrier eliminates ecological risk,	Ecological risk eliminated in Work Areas 1 and 3. Barrier breaks the ecological exposure pathway in Work Area 2.	RTD reduces ecological risk in Work Area 2, and barrier breaks the exposure pathway at all work areas.	ISV reduces ecological risk to below 1×10^{-6} in Work Area 2 and RTD eliminates risk in Work Areas 1 and 3.	ISV reduces ecological risk to below 1×10^{-6} in Work Area 2 and full site barrier, while maintained, breaks the exposure pathway at all work areas.
Threshold Criteria 2. COMPLIANCE WITH ARARs								
Chemical-specific ARAR	Does not comply. Site exceeds ecological protection requirements.	Does not comply. Exceeds ecological polychlorinated biphenyl cleanup requirements.	Meets criteria.	Meets criteria.	Meets criteria.	Meets criteria.	Meets criteria.	Meets criteria.
Location-specific ARARs	None	None	None	None	None	None	None	None

Table 6-1. Summary of 200-CW-5 Operable Unit Alternatives. (9 Pages)

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Action-specific ARARs	No action; therefore, no action-specific ARARs.	No action; therefore, no action-specific ARARs.	Meets criteria.	Meets criteria.	Meets criteria.	Meets criteria.	Meets criteria.	Meets criteria.
Other criteria and guidance	None	None	None	None	None	None	None	None
Balancing Criteria 3. LONG-TERM EFFECTIVENESS AND PERMANENCE								
Magnitude of Residual Risk								
Human health direct contact/ soil ingestion under industrial exposure	Source not removed so residual risk remains.	Source not removed so residual risk remains.	Permanently removes all site risk.	Waste remains onsite but barrier protective.	RTD permanently removes risk from Work Areas 1 and 3. Contamination remains at Work Area 2 but barrier breaks the exposure pathway.	RTD permanently reduces overall site risk by removal of the bulk of plutonium above 100 nCi/g at Work Area 2. Lower concentration waste remains onsite, but barrier over entire site breaks the exposure pathway.	ISV immobilizes contaminants, and barrier over ISV melts isolates contamination and prevents intrusion. RTD removes risk in Work Areas 1 and 3.	ISV immobilizes contaminants, and the barrier over the entire site breaks the exposure pathway.
Groundwater – ingestion	No groundwater risk identified.	No groundwater risk identified.	No groundwater risk identified.	No groundwater risk identified.	No groundwater risk identified.	No groundwater risk identified.	No groundwater risk identified.	No groundwater risk identified.
Ecological risk	Not effective because contamination remains in place above ecological risk levels with no action.	Not effective because contamination remains in place above ecological risk levels with no action.	Permanently removes ecological risk.	Barrier deters intrusion of deep-rooted plants or deep-burrowing animals.	RTD permanently removes risk at Work Areas 1 and 3. At Work Area 2, barrier ICs deter intrusion of deep-rooted plants or deep-burrowing animals.	RTD significantly reduces ecological risk at Work Area 2. Full site barrier breaks the ecological direct-contact-exposure pathway and ICs deter biological and ecological intrusion.	Work Area 2 ISV glass matrix impermeable to wildlife. Barrier over ISV melts breaks the ecological direct-contact-exposure pathway to glass matrix and ICs deter intrusion. RTD permanently removes risk from Work Areas 1 and 3.	Work Area 2 ISV glass matrix impermeable to wildlife. Full site barrier breaks the ecological direct-contact-exposure pathway to glass matrix at Work Area 2 and prevents biological and ecological intrusion at the entire.

Table 6-1. Summary of 200-CW-5 Operable Unit Alternatives. (9 Pages)

Criteria	Alternative 1 No Action	Alternative 2 MESC/MNA /ICs	Alternative 3 RTD	Alternative 4 Barrier (Full Site)	Alternative 5A RTD (Work Areas 1 and 3) with Barrier (Work Area 2)	Alternative 5B RTD (Work Area 2) with Barriers (Work Areas 1 and 3)	Alternative 6A ISV (Work Area 2) with Barrier and RTD (Work Areas 1 and 3)	Alternative 6B ISV (Work Area 2) with Barrier (Full Site)
Adequacy and reliability of alternative and controls.	Not adequate because no controls over remaining contamination.	Existing cover only adequate for human health (with cover). Reliability limited by IC viability. ICs presumed viable for the duration of site risk. Not effective for ecological or intruder risk.	RTD requires no controls after contaminant removal.	Barrier effective while maintained. ICs for continued maintenance presumed to be viable for the duration of site risk.	RTD requires no controls at Work Areas 1 and 3 after contaminant removal. Barrier effective while maintained. ICs for continued maintenance presumed to be viable for the duration of site risk.	RTD of plutonium above 100 nCi/g at Work Area 2 reliably reduces overall site risk but leaves residual contamination. Barrier over the entire site effective while maintained. ICs for barrier maintenance presumed to be viable for the duration of site risk.	RTD requires no controls at Work Areas 1 and 3 after contaminant removal. ISV reliability at Work Area 2 uncertain because ISV not proven on a large scale. Pilot demonstration necessary. Barrier over ISV melts is effective and reliable while maintained. ICs for barrier maintenance presumed viable for the duration of site risk.	ISV reliability at Work Area 2 less certain because ISV not proven on a large scale. Pilot demonstration necessary. Barrier over ISV melts and the entire site is reliable while maintained. ICs for continued maintenance presumed to be viable for the duration of site risk.
Need for 5-year review	Review required because contamination left onsite.	Required because contamination would remain onsite.	Not required because no contamination remains onsite.	Required because contamination remains onsite.	Required because contamination would remain onsite.	Required because contamination would remain onsite.	Required because contamination would remain onsite.	Required because contamination would remain onsite.
Balancing Criteria 4. REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT								
Treatment process used	None. Only radionuclide natural attenuation.	None. Only radionuclide natural attenuation.	None required because waste removed.	None. Only radionuclide natural attenuation.	None required for removed waste. Only natural attenuation at barrier.	None required for removed waste. Only radionuclide natural attenuation at barrier area.	ISV of plutonium above 100 nCi/g. None required for removed waste.	ISV of plutonium above 100 nCi/g and radionuclide natural attenuation at barrier.
Amount of soil treated	None	None	None	None	None	None	29,685 m^3 (38,826 yd^3) treated	29,685 m^3 (38,826 yd^3) treated
Reduction of toxicity, mobility, or volume of soil	None	None	None	None	None	None	ISV is an immobilization technology.	ISV is an immobilization technology.

Table 6-1. Summary of 200-CW-5 Operable Unit Alternatives. (9 Pages)

Criteria	Alternative 1 No Action	Alternative 2 MESC/MNA /ICs	Alternative 3 RTD	Alternative 4 Barrier (Full Site)	Alternative 5A RTD (Work Areas 1 and 3) with Barrier (Work Area 2)	Alternative 5B RTD (Work Area 2) with Barriers (Work Areas 1 and 3)	Alternative 6A ISV (Work Area 2) with Barrier and RTD (Work Areas 1 and 3)	Alternative 6B ISV (Work Area 2) with Barrier (Full Site)
Irreversible treatment	None	None	None	None	None	None	ISV not reversible.	ISV not reversible.
Type and quantity of residuals remaining after treatment	N/A	N/A	N/A	N/A	N/A	N/A	Approximately 29,685 m^3 (38,826 yd^3) of vitrified material requiring isolation and intrusion prevention.	Approximately 29,685 m^3 (38,826 yd^3) of vitrified material requiring isolation and intrusion prevention.
Statutory preference for treatment	Does not satisfy.	Does not satisfy.	Does not satisfy.	Does not satisfy.	Does not satisfy.	Does not satisfy.	Satisfies.	Satisfies.
Balancing Criteria 5. SHORT-TERM EFFECTIVENESS								
Community protection	No action presents no remedy implementation risk.	Minimal impact from risks from monitoring and cover repairs that can be closely controlled.	Increased potential for accidental contamination releases during RTD minimized by distance to potential receptors and extensive mitigation measures.	No potential for contamination release, and general barrier industrial impacts minimized by distance to potential receptors and extensive mitigation measures.	Potential for accidental contamination releases during RTD or general construction impacts during barrier placement minimized by distance to potential receptors and extensive mitigation measures.	Potential for accidental contamination releases during RTD or general construction impacts during barrier placement minimized by distance to potential receptors and extensive mitigation measures.	Community protection good because ISV process occurs under hoods with offgas monitoring and control systems to prevent releases. Increased potential for accidental contamination releases during RTD minimized by distance to potential receptors and extensive mitigation measures.	Community protection good because ISV process occurs under hoods with offgas monitoring and control systems to prevent releases. No potential for contamination release, and general barrier industrial impacts minimized by distance to potential receptors and extensive mitigation measures.

Table 6-1. Summary of 200-CW-5 Operable Unit Alternatives. (9 Pages)

Criteria	Alternative 1 No Action	Alternative 2 MESC/MNA /ICs	Alternative 3 RTD	Alternative 4 Barrier (Full Site)	Alternative 5A RTD (Work Areas 1 and 3) with Barrier (Work Area 2)	Alternative 5B RTD (Work Area 2) with Barriers (Work Areas 1 and 3)	Alternative 6A ISV (Work Area 2) with Barrier and RTD (Work Areas 1 and 3)	Alternative 6B ISV (Work Area 2) with Barrier (Full Site)
Worker protection.	No action; therefore, no risk to workers.	Minimal risk to workers from monitoring or cover repairs that can readily be controlled.	Highest short-term risk of radiological direct-contact and airborne exposure would be mitigated by stringent worker safety and site contamination controls.	Worker risk limited to industrial risks from barrier construction activities that are readily controllable.	High worker risk at RTD area would be mitigated by stringent worker safety controls and site contamination controls. General industrial risk to workers from barrier placement is reliably controllable.	High worker risk at RTD of plutonium above 100 nCi/g would be mitigated by stringent worker safety controls and site contamination controls. General industrial risk to workers from barrier placement is low and reliably controllable.	ISV risk moderate for electrical and construction hazards but increases with multiple mobilizations and a long implementation period. High worker risk at RTD Work Areas 1 and 3 would be mitigated by stringent worker safety controls and site contamination controls.	ISV risk moderate for electrical and construction hazards but increases with multiple mobilizations over a long implementation period. Worker risk from barrier construction activities low and is reliably controllable.
Environmental impacts.	No action; therefore, no impact.	Minimal risk from monitoring or cover repairs controllable.	Moderate environmental risk from accidental releases during RTD. Already disturbed industrial area with minimal habitat and no sensitive species.	Minimal environmental impact. Barrier construction traffic disturbs surrounding areas but little potential for contaminant releases.	Moderate environmental risk from accidental releases during RTD. Already disturbed industrial area with minimal habitat and no sensitive species. No contaminant releases from barrier construction.	Only moderate environmental risk from accidental releases during RTD because already disturbed industrial area with minimal habitat and absence of sensitive species. Minimal potential for environmental impact from barrier construction.	Low potential for releases due to extensive ISV process controls and equipment. Only moderate environmental risk from accidental releases during RTD because already disturbed industrial area with minimal habitat and absence of sensitive species.	Low potential for releases due to ISV process controls and equipment. Minimal environmental impact from barrier construction that will not disturb contaminated soils or from traffic disturbances of surrounding areas.

Table 6-1. Summary of 200-CW-5 Operable Unit Alternatives. (9 Pages)

Criteria	Alternative 1 No Action	Alternative 2 MESC/MNA /ICs	Alternative 3 RTD	Alternative 4 Barrier (Full Site)	Alternative 5A RTD (Work Areas 1 and 3) with Barrier (Work Area 2)	Alternative 5B RTD (Work Area 2) with Barriers (Work Areas 1 and 3)	Alternative 6A ISV (Work Area 2) with Barrier and RTD (Work Areas 1 and 3)	Alternative 6B ISV (Work Area 2) with Barrier (Full Site)
Time until action is complete.	No time required to implement.	60 days to establish ICs that would continue for the foreseeable future	Excavation and disposal of contaminated material would take 2 years	Barrier construction would take 1 year with ICs to continue for the foreseeable future.	RTD activities and barrier construction would take 2 years and 9 months with ICs for the foreseeable future.	RTD at Work Area 2 would take 2 years with barrier construction taking 1 year to begin after RTD completion and with ICs for the foreseeable future.	ISV of Work Area 2 and RTD of Work Areas 1 and 3 would occur consecutively and take a total of 3 years and 3 months with IC for the foreseeable future.	ISV of Work Area 2 with barrier placement over Work Areas 1 and 3 would occur consecutively and require approximately 4 years with ICs for the foreseeable future.
Balancing Criteria 6. IMPLEMENTABILITY								
Ability to construct and operate.	Technically implementable because no action.	Implementable. No construction, and continuation of current operations and maintenance and surveillance program implementable.	RTD of low-level waste common and implementable with little uncertainty. RTD of plutonium and americium above 100 nCi/g complicated by need to segregate suspect TRU waste and provide adequate worker safety.	Barrier construction and operation readily implementable and technically feasible.	RTD of Work Areas 1 and 3 low-level waste implementable with little uncertainty. Barrier construction readily implementable.	RTD of Work Area 2 complicated by need to segregate waste containing plutonium above 100 nCi/g and provide adequate worker safety. Barrier over entire site readily implementable.	ISV large-scale implementability uncertain without a pilot project. RTD of low-level waste at Work Areas 1 and 3 is implementable.	ISV large-scale implementability uncertain without a pilot project. Barrier construction and operation readily implementable.

Table 6-1. Summary of 200-CW-5 Operable Unit Alternatives. (9 Pages)

Criteria	Alternative 1 No Action	Alternative 2 MESC/MNA /ICs	Alternative 3 RTD	Alternative 4 Barrier (Full Site)	Alternative 5A RTD (Work Areas 1 and 3) with Barrier (Work Area 2)	Alternative 5B RTD (Work Area 2) with Barriers (Work Areas 1 and 3)	Alternative 6A ISV (Work Area 2) with Barrier and RTD (Work Areas 1 and 3)	Alternative 6B ISV (Work Area 2) with Barrier (Full Site)
Ease of doing more action if needed.	Not applicable – no action.	No monitoring or cover repair actions would physically impede further action.	Additional excavation laterally or to a maximum depth of 4.6 m (15 ft) bgs implementable.	Implementable to expand barrier size during construction.	Additional Work Area 2 excavation laterally or to a maximum depth of 4.6 m (15 ft) bgs implementable. Implementable to expand barrier size during construction.	Additional Work Areas 1 and 3 excavation laterally or to a maximum depth of 4.6 m (15 ft) bgs implementable. Implementable to expand barrier size during construction.	Technologically feasible to extend the melts laterally. Not implementable to change the monolithic mass once cooled. Additional excavation of Work Areas 1 and 3 to a maximum depth of 4.6 m (15 ft) bgs is implementable.	Technologically feasible to extend the melts laterally. Not implementable to change the monolithic mass once cooled. Implementable to expand barrier size during construction.
Ability to monitor effectiveness	Not applicable because no monitoring.	Site monitoring implementable and effective in early detection of cover failure.	No monitoring required.	Barrier monitoring implementable and effective in early detection of barrier failure.	No monitoring required at RTD areas. Barrier monitoring implementable and effective in early detection of barrier failure.	Monitoring of the barrier over the entire site after RTD of plutonium above 100 nCi/g at Work Area 2 would be implementable and effective in early detection of barrier failure.	Monitoring of soil around the ISV matrix readily implementable and monitoring of the glass matrix likely implementable but uncertain due to newness of ISV. Monitoring of RTD area not required.	Monitoring of soil around the ISV matrix readily implementable and monitoring of the glass matrix likely implementable but uncertain due to newness of ISV. Barrier monitoring implementable and effective in early detection of barrier failures.
Ability to obtain approvals and coordinate with other agencies	No approvals necessary.	No approvals necessary.	Meeting disposal facility (ERDF or WIPP) waste acceptance criteria implementable. Other agency or facility approvals not required.	No approvals necessary.	For RTD meeting disposal facility (ERDF) waste acceptance criteria, implementable. No barrier approvals necessary.	For RTD meeting disposal facility (ERDF or WIPP) waste acceptance criteria, implementable. No barrier approvals necessary.	No special approvals necessary for ISV. For RTD meeting disposal facility (ERDF or WIPP) waste acceptance criteria, implementable.	No special approvals necessary for ISV. No barrier approvals are necessary.

Table 6-1. Summary of 200-CW-5 Operable Unit Alternatives. (9 Pages)

Criteria	Alternative 1 No Action	Alternative 2 MESC/MNA /ICs	Alternative 3 RTD	Alternative 4 Barrier (Full Site)	Alternative 5A RTD (Work Areas 1 and 3) with Barrier (Work Area 2)	Alternative 5B RTD (Work Area 2) with Barriers (Work Areas 1 and 3)	Alternative 6A ISV (Work Area 2) with Barrier and RTD (Work Areas 1 and 3)	Alternative 6B ISV (Work Area 2) with Barrier (Full Site)
Availability of services and capacities.	No services or capacities required.	Contractor services readily available. No disposal facility capacity required.	Contractor services readily available. ERDF disposal capacity sufficient but WIPP waste acceptance less certain.	Contractor services readily available.	Contractor services readily available and ERDF capacity sufficient.	Contractor services readily available. ERDF disposal capacity sufficient but WIPP waste acceptance less certain.	Availability of ISV construction and operations personnel uncertain. Contractors for RTD and ERDF capacity sufficient.	Availability of ISV construction and operations personnel uncertain. Contractor services readily available.
Availability of equipment, specialists, and materials.	None required.	Site monitoring equipment and personnel and barrier repair material, equipment, and personnel readily available.	Standard excavation and material-handling equipment and containers available. Limited quantity of some waste boxes and special TRU waste containers.	Barrier placement equipment, materials, and personnel readily available.	For RTD at Work Areas 1 and 3, standard excavation and material-handling equipment and containers available. Barrier placement equipment, materials, and personnel readily available.	For RTD at Work Area 2, standard excavation and material-handling equipment and containers available but with limited quantity of some waste boxes and special WIPP waste containers. Barrier placement equipment, materials, and personnel readily available.	Availability of special ISV treatment and monitoring equipment (possibly multiple sets of probes and hoods), a robust power source, and probe operators uncertain. For RTD of low-level waste at Work Areas 1 and 3, standard excavation and material-handling equipment available.	Availability of special ISV treatment and monitoring equipment (possibly multiple sets of probes and hoods), a robust power source, and probe operators uncertain. Barrier placement equipment, materials, and personnel readily available.

Table 6-1. Summary of 200-CW-5 Operable Unit Alternatives. (9 Pages)

Criteria	Alternative 1 No Action	Alternative 2 MESC/MNA /ICs	Alternative 3 RTD	Alternative 4 Barrier (Full Site)	Alternative 5A RTD (Work Areas 1 and 3) with Barrier (Work Area 2)	Alternative 5B RTD (Work Area 2) with Barriers (Work Areas 1 and 3)	Alternative 6A ISV (Work Area 2) with Barrier and RTD (Work Areas 1 and 3)	Alternative 6B ISV (Work Area 2) with Barrier (Full Site)
Availability of technologies.	None required.	Monitoring and cover repair technology readily available.	Excavation technology readily available.	Barrier technology readily available.	Excavation and barrier technologies readily available.	Excavation and barrier technologies readily available.	Sufficient quantity and effectiveness of ISV technology shown for test-scale operations only. Technology will require pilot-scale demonstration. RTD technology for Work Areas 1 and 3 readily available.	Sufficient quantity and effectiveness of ISV technology shown for test-scale operations only. Technology will require pilot-scale demonstration. Barrier technology readily available.
Balancing Criteria 7. COST								
Capital cost	$0	$24.7	$153,899.6	$14,787.1	$47,058.6	$121,924.1	$284,355.3	$252,379.8
Nondiscounted costs	$0	$42,501.6	$153,899.6	$113,525.1	$90,641.6	$197,162.3	$298,557.0	$348,501.7
Total present-worth cost	$0	$9,950.1	$145,742.9	$37,218.7	$55,558.8	$137,508.7	$268,655.0	$256,033.9

ARAR = applicable or relevant and appropriate requirement.
bgs = below ground surface.
ERDF = Environmental Restoration Disposal Facility.
IC = institutional control.
ISV = in situ vitrification.
MESC/MNA/IC = maintain existing soil cover/monitored natural attenuation/institutional control.
N/A = not applicable.
RTD = removal, treatment, and disposal.
TRU = Radioactive waste as defined in DOE G 435.1-1, *Implementation Guide for Use with DOE M 435.1-1*.
WIPP = Waste Isolation Pilot Plant.

6.3 NEPA VALUES EVALUATION

The NEPA process is intended to help Federal agencies make decisions that are based on understanding environmental consequences, then to take actions that protect, restore, and enhance the environment. Secretarial policies (DOE, 1994) and DOE O 451.1B 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.

6.3.1 Description of NEPA Values

Several of the CERCLA evaluation criteria involve consideration of environmental resources, but the emphasis frequently is directed at the potential effects of chemical contaminants on living organisms. The NEPA regulations (40 CFR 1502.16, "Environmental Impact Statement," "Environmental Consequences") specify evaluation of the environmental consequences of proposed alternatives. These include potential effects on transportation resources; air quality; natural, cultural, and historical resources; noise, visual, and aesthetic effects; socioeconomic aspects of implementation; and environmental justice. The NEPA process also involves consideration of several issues such as cumulative impacts (direct and indirect), mitigation of adversely impacted resources, and the irreversible and irretrievable commitment of resources.

The NEPA-related resources and values that the DOE has considered in this evaluation include the following.

- Transportation impacts. This value considers impacts of the proposed remedial action on local traffic (e.g., traffic at the Hanford Site) and traffic in the surrounding region. Transportation impacts are considered in part under the CERCLA criteria of short-term effectiveness or implementability.

- Air quality. This value considers potential air quality concerns associated with emissions generated during the proposed remedial actions.

- Natural, cultural, and historical resources. This value considers impacts of the proposed remedial actions on wildlife, wildlife habitat, archeological sites and artifacts, and historically significant properties on the Central Plateau.

- Noise, visual, and aesthetic effects. This value considers increases in noise levels or impaired visual or aesthetic values during or after the proposed remedial actions.

- Socioeconomic impacts. This value considers impacts pertaining to employment, income, other services (e.g., water and power utilities), and the effect of implementation of the proposed remedial actions on the availability of services and materials.

- Environmental justice. Environmental justice, as mandated by Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, refers to fair treatment of humans of all races, cultures, and income levels with respect to laws, policies, and government actions. This value

considers whether the proposed remedial actions would have inappropriately or disproportionately high and adverse human health or environmental effects on minority or low-income populations.

- Cumulative impacts (direct and indirect). This value considers whether the proposed remedial actions could have cumulative impacts on human health or the environment when considered together with other activities on the Central Plateau, at the Hanford Site, or in the region.

- Mitigation. If adverse impacts cannot be avoided, remedial action planning should minimize them to the extent practicable. This value identifies required mitigation activities.

- Irreversible and irretrievable commitment of resources. This value evaluates the use of nonrenewable resources for the proposed remedial actions and the effects that resource consumption would have on future generations. When a resource (e.g., energy, minerals, water, wetland) is used or destroyed and cannot be replaced in a reasonable amount of time, its use is considered irreversible.

6.3.2 Detailed Evaluation of NEPA

6.3.2.1 Transportation Impacts

Implementation of remedial action at the waste sites likely would have some short-term impacts on local traffic and traffic in the surrounding region. For Alternatives 4, 5A, 5B, 6A, and 6B, impacts would result from hauling cover material to the waste site areas. For Alternatives 3, 5A, 5B, and 6A, impacts would result from hauling waste to ERDF and/or WIPP. For these alternatives, impacts could be expected from increased traffic bringing supplies, equipment, and workers to the sites. Alternative 6 also would include hauling ISV equipment to and from the ISV location. To mitigate these potential impacts, a transportation safety analysis would be performed before any transport activities began. The analysis would identify the need for specific precautions (e.g., road closures, preferred hauling times, staggered work shifts) to be taken as necessary. Increases in the workforce traffic related to waste treatment would be expected to be minor. The impacts of transportation of TRU waste to WIPP and disposal of TRU waste at WIPP were analyzed in DOE/EIS-0026-S-2, *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement*.

For Alternatives 3 and 5B, there may be a need to ship about 2,962 m^3 (3,875 yd^3) of soil contaminated with plutonium and/or americium above 100 nCi/g in special waste containers to WIPP. This would occur if a thin layer of soil beneath the Z-Ditches, generally expected to be limited to Work Area 2, is determined to have concentrations of plutonium or americium greater than 100 nCi/g.

6.3.2.2 Air Quality

No current air quality impacts are associated with Alternative 1; however, potential impacts to air quality could be associated with plant or animal uptake of contaminants and wind dispersion.

This also is true for Alternative 2. Potential near-term impacts to air quality associated with Alternatives 3, 4, and 5 are expected to be minor and could be mitigated through appropriate engineering controls. Alternative 6 includes an offgas treatment system, in operation during vitrification operations. Releases from the offgas treatment system would be subject to restrictions contained in a state air permit.

Potential air quality impacts primarily would be associated with fugitive dust during site preparation, structure demolition, excavation, placement of backfill or barriers, and revegetation activities. Dust suppression (using water and water treated with soil fixatives) would be used to control visible fugitive dust, so neither local nor regional air quality is expected to be affected. Routine emissions from vehicles would occur.

6.3.2.3 Natural, Cultural, and Historical Resources

In all cases, remediation will be performed on sites that have been disturbed by industrial activities. Therefore, although cultural resources could be encountered with Alternatives 3, 4, 5A, 5B, 6A, and 6B during the excavation and construction of staging areas, the probability is low. A cultural resource mitigation plan would be established before remediation was begun. 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.

6.3.2.4 Noise, Visual, and Aesthetic Effects

Alternatives 1 and 2 would have little to no impact on current noise, visual, or aesthetic site characteristics. Alternatives 3, 5A, and 6A 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 site materials. Likewise, Alternative 4 would increase noise levels and impair visual values in the short-term during construction of the barrier. These alternatives also could have some long-term visual and aesthetic impacts, both positive and negative. Positive impacts would result from the removal of aboveground site structures. Negative impacts would be associated with the visibility and aesthetics of the barriers over large distances if they are not contoured to blend in with the surrounding area. Alternatives 6A and 6B ISV would increase noise levels and impair visual values, but the impacts would be short-term during remedial actions. Aesthetically, given the past disturbance in the 200 Areas and on the Central Plateau, no impacts would be expected from the alternatives.

6.3.2.5 Socioeconomic Impacts

Alternative 1 would have no socioeconomic impacts. The other five alternatives would have some positive socioeconomic impacts related to the employment opportunities that would occur during the life of the remedial action project. The labor force required to implement remedial

action would be drawn from current Hanford Site contractors and the local labor force, so the socioeconomic impacts would be expected to be minimal.

6.3.2.6 Environmental Justice

Under Alternative 3, environmental justice issues would not be a concern because future surface uses on the Central Plateau would not be restricted beyond the Central Plateau-wide restrictions. Under Alternatives 1, 2, 4, 5A, 5B, 6A, and 6B, environmental justice impacts would be minimal because future-use restrictions would pertain to only a small percentage of the Central Plateau, and the Central Plateau still would be under active waste management industrial land use.

6.3.2.7 Irreversible and Irretrievable Commitment of Resources

All alternatives, except 1 and 2, would require some irreversible or irretrievable commitment of natural resources. All of the alternatives with the exception of Alternative 1 would result in some land-use loss. Alternatives 3, 4, 5A, 5B, 6A, and 6B would require additional soils, including 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 waste site areas 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 for the necessary attenuation period to meet RAOs. Alternative 3 generally would allow land use from the ground surface to a depth of 4.6 m (15 ft) bgs or greater following the completion and regulatory acceptance of remedial activities. Alternatives 4, 5A, 5B, 6A, and 6B 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 Alternatives 3, 5A, 5B, and 6A, ERDF would need to be expanded to accommodate the additional waste. Implementation of the alternative also would require waste disposal to WIPP. The waste volumes from the aboveground structure demolition in Alternatives 3, 4, 5A, 5B, 6A, and 6B are relatively small and are not anticipated to specifically require additional ERDF capacity.

Alternatives 3, 4, 5A, 5B, 6A, and 6B would require an irretrievable and irreversible commitment of resources in the form of geologic materials and petroleum products (e.g., diesel fuel, gasoline). With Alternatives 3, 5A, 5B, and 6A, 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 offsite. Rip-rap or other armoring materials needed to provide intrusion protection likely would come from offsite. With Alternatives 6A and 6B, some fill material would be needed to compensate for the volume reduction inherent in the vitrification process.

6.3.2.8 Cumulative Impacts

The proposed RAOs could have impacts when considered together with impacts from past and foreseeable future actions at and near the Hanford Site. Authorized current and future activities

include soil and groundwater remediation; waste management and treatment (e.g., tank farms, the Waste Treatment Plant); and surveillance, maintenance, decontamination, and decommissioning of facilities. Other Hanford Site activities that might be ongoing during remedial action at the Central Plateau waste sites include deactivation and decontamination of reprocessing facilities and operation of the Energy Northwest reactor. Activities near the Hanford Site include a privately owned radioactive and mixed waste treatment facility, a commercial fuel manufacturer, a commercial low-level radioactive waste disposal site, and a titanium reprocessing plant.

The proposed remediation alternatives would have minimal impacts on transportation, air quality, and natural, cultural, and historical resources. Noise, visual, and aesthetic effects, and socioeconomic impacts also would be minimal. Therefore, cumulative impacts with respect to these values are expected to be insignificant. The most notable area for cumulative impacts is with respect to the irretrievable and irreversible commitment of resources. All of the proposed alternatives except Alternative 1 would require long-term land-use restrictions.

To varying levels, Alternatives 2, 3, 4, 5A, 5B, 6A, and 6B would result in the loss of some land uses on the Central Plateau, but the cumulative impacts with respect to loss of land use are not expected to be significant. Alternatives 3, 5A, and 6A also would require a commitment of land use as a result of the ERDF expansion on the Central Plateau. This would be in addition to numerous other Hanford Site projects that would commit land use on the Central Plateau.

Under Alternatives 3, 4, 5A, 5B, 6A, and 6B, cumulative impacts also would occur with respect to the irretrievable and irreversible commitment of geologic resources. The Central Plateau waste sites constitute only a portion of the total actions requiring material for barriers and backfill at the Hanford Site. The total quantity of geologic materials required for other Hanford Site actions currently is being identified (BHI-01551, *Alternative Fine-Grained Soil Borrow Source Study Final Report*) and may be subject to a separate NEPA evaluation.

6.3.2.9 Mitigation

Alternative 1 would not include mitigation. Mitigation measures under Alternatives 2, 4, 5A, 5B, 6A, and 6B would include surveillance, physical controls, and potential interim remedies. Mitigation measures taken under Alternatives 3, 4, 5A, and 5B would include dust suppression, stockpiling clean topsoil for reuse, minimizing the size of construction areas, and planning activities to avoid nesting and breeding cycles of birds and mammals.

6.3.2.10 Summary of NEPA Evaluation

Remedial actions at the Central Plateau waste sites would result in some impacts to public health and the environment. However, the overall environmental impacts under normal operating conditions would not be large, nor would they vary greatly among the remedial alternatives.

7.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

This chapter presents the comparative analysis of the eight remedial alternatives analyzed for the Z-Ditches of the 200-CW-5 OU. This analysis will identify the relative advantages and disadvantages based on the detailed analysis of each alternative against the seven CERCLA evaluation criteria as presented in Chapter 6.0. The results of this analysis provide a basis for selecting a remedial alternative for the Z-Ditches. The remedial alternatives compared are as follows:

- Alternative 1 – No Action
- Alternative 2 – MESC/MNA/IC
- Alternative 3 – RTD
- Alternative 4 – Barrier
- Alternative 5A – RTD with Barrier
- Alternative 5B – RTD with Barrier
- Alternative 6A – ISV with Barrier and RTD
- Alternative 6B – ISV with Barrier.

This chapter compares the alternatives so that their relative advantages and disadvantages are evaluated succinctly within the framework of the seven CERCLA criteria. The CERCLA criteria and considerations for ranking each alternative are shown in Table 7-1.

Table 7-1. Alternative Ranking Considerations for CERCLA Criteria.

CERCLA Criteria	Alternative Evaluation
Overall protection of human health and the environment	Alternatives were ranked using residual risk and uncertainty as guiding standards.
Compliance with applicable or relevant and appropriate requirements	Alternatives were ranked using the standard that if all applicable or relevant and appropriate requirements are met then alternatives are equal.
Long-term effectiveness and permanence	Alternatives were ranked with useful life of alternative and danger to public and environment as guiding standards.
Reduction in toxicity, mobility, and volume through treatment	If treatment is applied, the alternative is ranked higher than if no treatment is applied. Otherwise, alternatives are ranked equally.
Short-term effectiveness	Alternatives were ranked primarily for the ability to prevent exposure to workers and the environment, with secondary ranking for time to meet remedial action objectives.
Implementability	Alternatives with proven technology ranked higher than unproven technologies. Secondary consideration is availability of resources to support remedial action.
Cost	Alternatives were ranked from lowest to highest cost.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*

7.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Alternative 3 provides the greatest protection of human health and environment because it removes all contaminants from the site to below the cleanup levels. Alternative 6A provides

greater protection to human health and the environment than the remaining alternatives, but less than Alternative 3 because it leaves waste in the ground. Alternative 5B provides the next best degree of overall protection to human health and the environment because it removes the material with concentrations greater than 100 nCi/g and places barriers that reduce the residual risk of the remaining contamination. Alternative 6B provides a slight improvement over Alternatives 4 and 5A because of the encapsulation and immobilization of the contaminants with concentrations greater than 100 nCi/g at the site; however, it leaves the residual risk left in place. Alternatives 4 and 5A are ranked equally because of the isolation of the waste at the site. Alternative 2 is ranked second to last because it provides for monitoring of the site, but leaves the contamination untouched. Alternative 1 fails to protect human health and the environment and presents the greatest uncertainty at the site. However, characterization data confirm no contamination at the 216-Z-1D Ditch North Section above PRGs, so Alternative 1 meets the evaluation criteria for this location.

7.2 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Alternatives 3, 4, 5A, 5B, 6A, and 6B meet the ARARS identified and are ranked equally. Alternatives 1 and 2 do not comply with ARARs for the Z-Ditches and are ranked last. However, characterization data confirm no contamination at the 216-Z-1D Ditch North Section above PRGs, so Alternative 1 will comply with ARARs for this location only.

7.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

Alternative 3 provides the greatest long-term effectiveness and permanence because it removes all contaminants at concentrations above PRGs from the site. Alternative 5B is the next best alternative for long-term effectiveness and permanence because it removes the high risk contamination having concentrations greater than 100 nCi/g and reduces the residual risk of remaining contamination with barriers. Alternative 6A provides greater long-term effectiveness and permanence than the remaining alternatives; however, it leaves waste in the ground. Alternative 6B provides slightly better protection than Alternatives 4 and 5A because of the encapsulation of contaminants with concentrations greater than 100 nCi/g at the site, but leaves the residual risk in place. Alternatives 5A is ranked next because it removes lower risk contamination from the majority of the site and leaves the remaining, higher risk contamination isolated with a barrier. Alternatives 4 is ranked next because all contamination remains on site but isolated with a barrier. Alternative 2 is ranked second to last because it provides for monitoring of the site, but leaves the contamination untouched. Alternative 1 fails to protect human health and the environment and presents the largest danger to the public at the site. However, characterization data confirm no contamination at the 216-Z-1D Ditch North Section above PRGs, so this alternative meets the evaluation criteria for this location.

7.4 REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

Alternative 6A ranks highest because it treats contaminated material and removes the remaining contamination to meet cleanup levels. Alternative 6B ranks second because it meets the criteria for treatment but leaves waste in place. The remaining alternatives are ranked equally because no reduction in toxicity, mobility, or volume is achieved through treatment.

7.5 SHORT-TERM EFFECTIVENESS

Alternatives 1 and 2 rank equally high with regard to controlling potential exposure to workers and the environment during remedial actions. Alternative 4 ranks next because it provides much lower potential for worker and environmental exposure to contaminants and lower overall risk than alternatives that excavate contaminated material. Alternative 6B is ranked next because contaminated material is not excavated but moderate worker risk is associated with the long ISV implementation timeframe and working with thermally and electrically hot equipment. Alternatives 5A and 6A have similar potential worker and environmental short-term risks associated with excavation of low-level waste from Work Areas 1 and 3 and are ranked equally. Alternative 5B ranks next because excavation of highly contaminated material poses potentially high worker risk. Alternative 3 ranks last because full site excavation poses the highest potential short-term worker risk.

7.6 IMPLEMENTABILITY

Alternatives 1 and 2 are ranked equally in implementing the remedial actions. Alternative 2 is currently in use at the Z-Ditches for the surveillance and monitoring program and the area is currently posted with signs and/or is fenced. Access to the site also is controlled through Hanford Site access requirements, an excavation permit program, and a radiation work permit program. However, except for 216-Z-1D North Section, Alternatives 1 and 2 are not considered viable stand alone alternatives. Alternative 4 is the most implementable viable alternative because the barrier has low potential for delays arising from technical or administrative difficulties or from regulatory interactions associated with cultural or ecological resources. All of the material, equipment, and personnel necessary to implement an Alternative 4 barrier are readily available. Alternative 5A ranks next because it consumes less limited resources (e.g., WIPP disposal capacity) than Alternatives 3 or 5B. Alternatives 3 and 5B rank equally because both alternatives consume limited disposal space at WIPP. Alternatives 6A and 6B rank last because of the unproven nature of ISV at a large-scale site, such as the Z-Ditches. ISV has been proven effective on smaller test sites and major concerns have been satisfactorily resolved in these tests, but ISV is not used routinely for large-scale operations and should be considered a less proven technology. For this reason, cost estimates, schedules, and overall technical feasibility and effectiveness have a higher degree of uncertainty than is the case for other, more proven alternatives. Alternatives relying on ISV likely would require a pilot test project to resolve technical uncertainties.

7.7 COST

The detailed information regarding implementation cost for each alternative is presented in Chapter 6.0, Chapter 8.0, and Appendix D. Although Alternatives 3, 4, 5A, 5B, 6A, and 6B meet threshold criteria, the relative costs of all alternatives is presented below (in thousands).

- Alternative 1 has no cost but does not address current risks, meet RAOs, or meet threshold criteria and is not a remedial alternative candidate for the Z-Ditches.

- Alternative 2, at $9,950.1 ($42,501.6 nondiscounted), has the lowest cost because it is minimally invasive and does not include labor-intensive activities.

- Alternative 4, at $37,218.7 ($113,525.1 non-discounted), can meet overall protectiveness goals by installing a barrier over the entire site. The barrier would have less implementation cost uncertainty than any other viable alternative. This alternative mitigates site risk by breaking the exposure pathway at the entire site, while minimizing worker risk and potential spread of contaminants associated with excavation of greater than 100 nCi/g contaminated soils. Because waste is left in place at concentrations above PRGs, long-term controls are required until PRGs are met, the cost of which can be uncertain. Engineered barriers would operate in conjunction with long-term institutional controls to help ensure barrier performance and integrity and to prevent intrusion until RAOs are met through natural attenuation.

- Alternative 5A, at $55,558.8 ($90,641.6 nondiscounted), meets protectiveness requirements by placing a barrier over soil contaminated at greater than 100 nCi/g and removing the less contaminated soils above PRGs from the majority of the site. This alternative meets the overall protectiveness goal, but has greater cost and uncertainty than Alternative 4, which avoids the cost and uncertainties associated with excavating contaminated soils. Because waste is left in place above cleanup levels, long-term controls are required until RAOs are met, the costs of which can be uncertain.

- Alternative 5B, at $137,508.7 ($197,162.3 nondiscounted), removes, treats, and disposes of soil greater than the preliminary remediation goals, places a barrier over the remaining site, and is more costly than Alternative 5A. Because waste is left in place above cleanup levels, long-term controls are required until RAOs are met, the long-term costs of which can be uncertain. The RTD component carries high costs and uncertainties associated with excavation and management of soil with concentrations greater than 100 nCi/g.

- Alternative 3, at $145,742.9 ($153,899.6 nondiscounted), provides full site excavation and initially is more expensive than Alternative 5B. However, costs associated with barrier maintenance make long-term costs for Alternative 5B higher. Although excavations would be relatively shallow (i.e., less than 5 m [15 ft] bgs), high contamination levels potentially throughout the site present difficult worker safety requirements and special site contamination controls. This alternative has cost uncertainties associated with the potential for disposal of waste at WIPP. Because contamination is not left onsite above PRGs, uncertainties associated with costs of long-term site monitoring are not incurred.

- Alternative 6B, at $256,033.9 ($348,501.7 nondiscounted), with ISV treatment and engineered barrier components, is the second-most costly alternative. Both the ISV and barrier components leave waste onsite, although in a protective manner, until RAOs are met through natural attenuation. The Alternative 6B ISV cost estimate carries uncertainties associated with implementation of this innovative and relatively untried technology, making accurate cost predictions and determination of overall effectiveness less certain. The barrier component leaves contaminated soil in place, which avoids much of the cost and uncertainty associated with excavation of soil with concentrations greater than 100 nCi/g, but incurs the uncertainties associated with the cost of long-term site monitoring.

- Alternative 6A, at $268,655.0 ($298,557.0 nondiscounted), with ISV treatment and RTD components, is the most costly alternative. The ISV component of this alternative has the same cost and uncertainties as the ISV component of Alternative 6B. The RTD component carries the same costs and uncertainties as Alternative 5B.

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8.0 CONCLUSIONS AND PATH FORWARD

This chapter summarizes the FS results, presents the path forward for the 200-CW-5 OU waste sites, and identifies recommended alternatives for remediation of these waste sites.

8.1 FEASIBILITY STUDY SUMMARY

This section summarizes the CERCLA remedial alternatives evaluation process and presents a relative ranking of preferred alternatives for the 200-CW-5 OU waste sites based on evaluation results.

8.1.1 CERCLA Evaluation Process

The following eight remedial alternatives were evaluated for the 200-CW-5 OU waste sites:

- Alternative 1 – No Action
- Alternative 2 – MESC/MNA/IC
- Alternative 3 – RTD
- Alternative 4 – Barrier
- Alternative 5A – RTD with Barrier
- Alternative 5B – RTD with Barrier
- Alternative 6A – ISV with Barrier and RTD
- Alternative 6B – ISV with Barrier.

These alternatives were evaluated against the CERCLA criteria in Chapter 6.0 and then were evaluated against each other in Chapter 7.0 for relative effectiveness in meeting the criteria. Table 8-1 shows the relative ranking of remedial alternatives for the Z-Ditches group as a single decision unit for all 200-CW-5 OU waste sites based on the detailed and comparative analyses presented in Chapters 6.0 and 7.0, respectively. The Z-Ditches currently exceed human-health direct-contact exposure PRGs under an industrial-use-exposure scenario (if no credit is taken for the existing cover), ecological PRGs, and inadvertent intruder dose goals. The evaluation considered alternative effectiveness in reducing human direct-contact, ecological, and inadvertent intruder risks in an industrial land-use scenario. Groundwater protection PRGs were not exceeded and groundwater protection was not a primary considerations in the FS. A preferred alternative for 200-CW-5 OU waste sites is presented later in this chapter and in the Proposed Plan (DOE/RL-2004-26).

Table 8-1. Comparison of Alternatives for the Z-Ditches. (2 Pages)

CERCLA Alternative Evaluation Criteria	Alternatives							
					RTD/Barrier		ISV with RTD or Barrier	
	Alt 1 No Action [a]	Alt 2 MESC/ MNA/IC [b]	Alt 3 RTD [c]	Alt 4 Barrier [d]	Alt 5A [e] RTD Work Areas 1&3 Barrier Work Area 2	Alt 5B [f] RTD Work Area 2 Barriers Work Areas 1 & 3	Alt 6A [g] ISV Work Area 2 & Barrier RTD Work Areas 1&3	Alt 6B [h] ISV Work Area 2 Barrier (Full Site)
Recommended Z-Ditches Alternative					☑			
Threshold Criteria								
Overall protection	☐	☐	☑	☑	☑	☑	☑	☑
Compliance with ARARs	☐	☐	☑	☑	☑	☑	☑	☑
Balancing Criteria								
Long-term effectiveness	N/A	Low	High	Low	High	Moderate	High	Moderate
Short-term effectiveness	N/A	High	Low	High	Moderate	Moderate	Moderate	Moderate
Reduction in TMV [i]	N/A	Low	Low	Low	Low	Low	High	High
Implementability	N/A	High	Low	High	High	Low	Low	Low
Cost comparison (costs shown in thousands of $)								
Capital costs	N/A	$24.7	$153,899.6	$14,787.1	$47,058.6	$121,924.1	$284,355.3	$252,379.8
Nondiscounted costs	N/A	$42,501.6	$153,899.6	$113,525.1	$90,641.6	$197,162.3	$298,557.0	$348,501.7
Total present worth	N/A	$9,950.1	$145,742.9 [j]	$37,218.7	$55,558.8	$137,508.7	$268,655.0	$256,033.9

NOTE: The ranking of alternatives is based on information available at the writing of this feasibility study and may be revised based on future 200-CW-5 Operable Unit waste-site characterization information.

[a] As described earlier in this feasibility study, the no-action alternative meets CERCLA threshold criteria only at the 216-Z-1D North Section that is not part of the Z-Ditches decision unit. For the Z-Ditches decision unit that represents all remaining 200-CW-5 Operable Unit sites, the no-action alternative does not meet CERCLA threshold criteria and is not a candidate alternative. Therefore, evaluation of this alternative against CERCLA balancing criteria is not applicable.

[b] Alternative 2: Maintain existing soil cover/monitored natural attenuation/institutional controls.

[c] Alternative 3: Removal, treatment, and disposal.

[d] Alternative 4: Barrier.

[e] Alternative 5A (Figure 6-4) involves removal, treatment, and disposal of low-level contamination at Work Areas 1 and 3 and placement of a barrier over plutonium greater than 100 nCi/g at Work Area 2.

[f] Alternative 5B (Figure 6-5) involves removal, treatment, and disposal of plutonium greater than the preliminary remediation goal from Work Area 2 with a site barrier over Work Areas 1 and 3.

[g] Alternative 6A (Figure 6-6) involves ISV of plutonium greater than 100 nCi/g at Work Area 2 with barrier over ISV melts and with RTD of low-level radiological contamination at Work Areas 1 and 3.

[h] Alternative 6B (Figure 6-7) involves ISV of plutonium greater than 100 nCi/g at Work Area 2 with full site barrier.

[i] Toxicity, mobility, or volume through treatment.

[j] This cost does not reflect the programmatic disposal cost at the Waste Isolation Pilot Plant.

☑ = Recommended alternative.
☑ = Yes, meets criterion.
☐ = No, does not meet criterion.
High: best satisfies evaluation guidelines.
Moderate: partially satisfies evaluation guidelines.
Low: least satisfies evaluation guidelines.

Table 8-1. Comparison of Alternatives for the Z-Ditches. (2 Pages)

CERCLA Alternative Evaluation Criteria	Alternatives							
					RTD/Barrier		ISV with RTD or Barrier	
	Alt 1 No Action [a]	Alt 2 MESC/ MNA/IC [b]	Alt 3 RTD [c]	Alt 4 Barrier [d]	Alt 5A [e] RTD Work Areas 1&3 Barrier Work Area 2	Alt 5B [f] RTD Work Area 2 Barriers Work Areas 1 & 3	Alt 6A [g] ISV Work Area 2 & Barrier RTD Work Areas 1&3	Alt 6B [h] ISV Work Area 2 Barrier (Full Site)

ARAR = applicable or relevant and appropriate requirement.
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*
IC = institutional controls.
ISV = in situ vitrification.
MESC = maintain existing soil cover.
MNA = monitored natural attenuation.
N/A = not applicable.
RTD = removal, treatment, and disposal.
TMV = toxicity, mobility, or volume through treatment.
TRU = Radioactive waste as defined in DOE G 435.1-1, *Implementation Guide for Use with DOE M 435.1-1.*

8.1.2 Z-Ditches Group and 216-Z-1D Ditch North Section

The Z-Ditches decision unit is considered one contiguous contamination area that represents all 200-CW-5 OU waste sites, except the 216-Z-1D Ditch North Section. Initially, the RI Report (DOE/RL-2003-11) identified the Z-Ditches as including only the 216-Z-1D, 216-Z-11, and 216-Z-19 Ditches, while identifying these collective Z-Ditches as the representative site for the remaining analogous 200-CW-5 OU waste sites, 216-Z-20 Tile Field and UPR-200-W-110. Using the Implementation Plan (DOE/RL-98-28) analogous site approach, the remedial decision for the representative Z-Ditches would have been applied to its analogous sites based on establishment of an analogous site relationship. However, the alternative evaluation process presented earlier in the FS identified that due to site proximity, an excavation or barrier action for the area of the three original Z-Ditches would physically encroach on analogous site boundaries thereby making a separate action at these sites more difficult. Consequently, the Z-Ditches were expanded to include the representative Z-Ditches and its analogous sites as a single decision unit with the Z-Ditches recommended alternative now being applied to all 200-CW-5 OU sites, except the 216-Z-1D Ditch North Section.

A Z-Ditches study (Appendix A) was generated to provide information to allow more in-depth evaluation of ISV as a potentially viable and cost-effective alternative for treatment of Z-Ditches contamination, given the high concentration of plutonium and americium present in shallow soils. Alternatives 6A and 6B were formulated for ISV treatment of soil contaminated above 100 nCi/g to operate in conjunction with institutional controls to prevent intrusion to the treated matrix and a barrier over ISV melts to break the direct-contact exposure pathway and control infiltration.

Based on the summary of the detailed analysis of alternatives provided in Table 8-1, the preferred alternative for the Z-Ditches is Alternative 5A. This alternative provides for RTD of low-level contamination and placement of a barrier over plutonium greater than 100 nCi/g. This alternative was selected because it would meet RAOs while providing a cost-effective balance

between long-term protection and permanence in addressing risk from long-lived Z-Ditches radionuclides and short-term risk. This alternative is protective of workers and the environment during RTD of shallow low-level waste and barrier placement. Barrier construction activities and excavation of shallow low-level waste with onsite disposal at ERDF are readily implementable. This alternative is cost-effective relative to other alternatives based on the reduction of overall site risk achieved at significantly lower cost and reduction of long-term stewardship costs gained by shrinking the site footprint by approximately 75 percent.

The 216-Z-1D Ditch North Section was identified earlier in this FS as a discreet portion of the 216-Z-1D Ditch and is not a portion of the Z-Ditches decision unit. Because characterization sampling for the 216-Z-1D Ditch North Section showed no contamination above human-health, ecological, or groundwater protection PRGs, the preferred remedy for this location is Alternative 1, No Action. The no-action alternative for this location meets RAOs and by taking no action is the safest, most implementable, and most cost-effective alternative. Table 8-1 summarizes the analysis of alternatives in support of alternative selection for this group of waste sites.

8.2 PATH FORWARD

This section identifies the path forward for remedy selection for the 200-CW-5 OU waste sites, including the Proposed Plan and post-ROD sampling.

8.2.1 Proposed Plan

The final two CERCLA alternative evaluation criteria are state and community acceptance. These are modifying criteria that will be evaluated outside the scope of this FS. The criterion of state acceptance will be addressed by issuance of the Proposed Plan prepared to document the preferred remedial alternatives for 200-CW-5 OU waste sites. The Proposed Plan will be issued for public review after regulator acceptance of the preferred alternatives. The Proposed Plan details the recommended closure options and documents that the waste sites will be remediated in accordance with the ROD, developed following issuance of the Proposed Plan. The criterion of community acceptance will be evaluated following the issuance of the Proposed Plan for public review and comment.

8.2.2 Post-Record of Decision Sampling

The FS evaluated the Z-Ditches as one decision unit for all contaminated 200-CW-5 OU sites based on historical and RI characterization data presented in the RI Report.

As identified in the Implementation Plan, additional sampling phases conducted post-ROD are meant to augment the remedial investigation data as necessary to confirm the alternative selection, support the remedial design, and provide information for final site closeout. Confirmatory sampling is conducted to confirm that the appropriate remedial alternative was selected. Design sampling is conducted to obtain data and information necessary to design the remedial alternative and refine the cost estimated for the FS. Verification sampling is conducted

to verify that the remedial goals have been met by the implementation of the remedial alternative to enable site closeout.

Table 8-2 presents the post-ROD confirmatory, design, and verification sampling phases and presents assumed data needs for each sampling phase for each potential alternative for the 200-CW-5 OU waste sites, including Z-Ditches decision unit sites and the 216-Z-1D Ditch North Section. This table provides a basis for initiating the data quality objectives process for the confirmatory and design sampling phases. Post-ROD sampling will be determined through data quality objectives identification and a sampling and analysis plan that will be developed to direct the sampling.

Post-ROD data collection will be used to confirm that the correct alternative has been selected and to provide remedial design data. For example, where a remove-and-dispose alternative is implemented, the observational approach during removal will be used. Site locations slated for barrier placement likely will need additional data to confirm the lateral extent and to support barrier design. The 216-Z-1D Ditch North Section slated for no action could need verification sampling, depending on the amount, type, and quality of data available to support the no-action decision. CERCLA operations and maintenance sampling could include the monitoring of natural attenuation and performance monitoring of the cap.

Table 8-2. 200-CW-5 Operable Unit Waste Site Post-Record of Decision Sampling. (2 Pages)

Alternative	Confirmatory Sampling						Design Sampling	Verification Sampling			Operations and Maintenance*
	Confirm Appropriate Remedial Action	Nature of Contamination	Extent of Contamination	Groundwater Protection	Ecological Sampling	Observational Approach	Extent of Contamination	Verify No-Action Alternative	Ecological Sampling	Verify RAO Attainment	Monitor RAO Attainment
Alternative 1 – No Action								•	•	•	
Alternative 2 – MESC/MNA/IC			•		•				•		•
Alternative 3 – RTD						•			•	•	
Alternative 4 – Barrier					•		•		•	•	•
Alternative 5A – RTD with Barrier					•	•	•		•	•	•
Alternative 5B – RTD with Barriers	•					•	•			•	
Alternative 6A – ISV with Barrier and RTD	•	•	•		•	•	•			•	•
Alternative 6A – ISV with Barrier	•	•	•		•		•			•	•

Table 8-2. 200-CW-5 Operable Unit Waste Site Post-Record of Decision Sampling. (2 Pages)

Alternative	Confirmatory Sampling						Design Sampling	Verification Sampling			Operations and Maintenance*
	Confirm Appropriate Remedial Action	Nature of Contamination	Extent of Contamination	Groundwater Protection	Ecological Sampling	Observational Approach	Extent of Contamination	Verify No-Action Alternative	Ecological Sampling	Verify RAO Attainment	Monitor RAO Attainment

NOTE: All 200-CW-5 Operable Unit waste sites, except the 216-Z-1D Ditch North Section, are a portion of the Z-Ditches decision unit.

*Because Z-Ditches contamination is below groundwater protection criteria, groundwater protection is not required at the Z-Ditches. However, because waste would be left in place above preliminary remediation goal concentrations under this alternative, monitoring of groundwater may be required.

RAO = remedial action objective.
MESC/MNA/IC = maintain existing soil cover, monitored natural attenuation, institutional controls.
RTD = removal, treatment, and disposal.
ISV = in situ vitrification.

9.0 REFERENCES

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APPENDIX A

Z-DITCHES STUDY FOR THE 200-CW-5 COOLING WATER OPERABLE UNIT

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Revision 0

Z-DITCHES STUDY FOR THE 200-CW-5 COOLING WATER OPERABLE UNIT

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

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

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Richland, Washington

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Z-DITCHES STUDY FOR THE 200-CW-5 COOLING WATER OPERABLE UNIT

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

Project Hanford Management Contractor for the
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FLUOR
P.O. Box 1000
Richland, Washington

Release Approval **Date**

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TERMS

BCA	bias-corrected accelerated bootstrap method
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CLT	central limit theorem
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
EPC	exposure-point concentration
NEPA	*National Environmental Policy Act of 1969*
OU	operable unit
RCRA	*Resource Conservation and Recovery Act of 1976*
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RTD	removal, treatment, and disposal
TRU	Radioactive waste as defined in DOE G 435.1-1, *Implementation Guide for Use with DOE M 435.1-1*
WIPP	Waste Isolation Pilot Plant

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METRIC CONVERSION CHART

Into Metric Units			Out of Metric Units		
If you know	*Multiply by*	*To get*	*If you know*	*Multiply by*	*To get*
Length			**Length**		
inches	25.40	millimeters	millimeters	0.0394	inches
inches	2.54	centimeters	centimeters	0.394	inches
feet	0.305	meters	meters	3.281	feet
yards	0.914	meters	meters	1.094	yards
miles (statute)	1.609	kilometers	kilometers	0.621	miles (statute)
Area			**Area**		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.0929	sq. meters	sq. meters	10.764	sq. feet
sq. yards	0.836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.591	sq. kilometers	sq. kilometers	0.386	sq. miles
acres	0.405	hectares	hectares	2.471	acres
Mass (weight)			**Mass (weight)**		
ounces (avoir)	28.349	grams	grams	0.0353	ounces (avoir)
pounds	0.454	kilograms	kilograms	2.205	pounds (avoir)
tons (short)	0.907	ton (metric)	ton (metric)	1.102	tons (short)
Volume			**Volume**		
teaspoons	5	milliliters	milliliters	0.034	ounces (U.S., liquid)
tablespoons	15	milliliters	liters	2.113	pints
ounces (U.S., liquid)	29.573	milliliters	liters	1.057	quarts (U.S., liquid)
cups	0.24	liters	liters	0.264	gallons (U.S., liquid)
pints	0.473	liters	cubic meters	35.315	cubic feet
quarts (U.S., liquid)	0.946	liters	cubic meters	1.308	cubic yards
gallons (U.S., liquid)	3.785	liters			
cubic feet	0.0283	cubic meters			
cubic yards	0.764	cubic meters			
Temperature			**Temperature**		
Fahrenheit	(°F-32)*5/9	Centigrade	Centigrade	(°C*9/5)+32	Fahrenheit
Radioactivity			**Radioactivity**		
picocurie	37	millibecquerel	millibecquerel	0.027	picocurie

1.0 PURPOSE AND SCOPE

The purpose of this environmental study is to provide supplemental information for the Z-Ditches by addressing technical and regulatory questions pertaining to data interpretation, equipment capability, and risk reduction potential through the removal, treatment, and disposal alternative. The Z-Ditches are assigned to the 200-CW-5 Operable Unit (OU) for remedial decision making under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) remedial investigation/feasibility study (RI/FS) process. This study will discuss the internal U.S. Department of Energy (DOE) regulatory framework (i.e., DOE orders) and the associated *Code of Federal Regulations* (CFR) applicable to the Z-Ditches. The study will evaluate available excavation methods to remove elevated levels of transuranic constituents (radioactive waste as defined in DOE G 435.1-1, *Implementation Guide for Use with DOE M 435.1-1* [TRU]) and evaluate risk-reduction potential through the removal, treatment, and disposal alternative.

In February 2007, the DOE, the Washington State Department of Ecology, and the U.S. Environmental Protection Agency (EPA) concluded negotiations on milestone changes for completing the CERCLA RI/FS process and the *Resource Conservation and Recovery Act of 1976* (RCRA) field investigation/corrective measures study process for 200 Area (Central Plateau) non-tank-farm OUs. During these negotiations, the EPA and DOE agreed that no additional characterization in the 200-CW-5 OU (Z-Ditches) was required. However, the DOE and EPA agreed that a study would be performed to determine the implementability of potential remedies by answering regulatory and technical questions related to removal of "hot spots" and disposal of the excavated material at the Environmental Restoration Disposal Facility and/or the Waste Isolation Pilot Plant (WIPP). For purposes of this study, a hot spot is considered an area of soil with the potential to contain transuranic radionuclides at concentrations greater than 100 nCi/g and no other sample points in either proximate horizontally or vertically equal to or exceeding 100 nCi/g.

The scope of the study is limited to the Z-Ditches that include the 216-Z-1D, 216 Z-11, and 216-Z-19 Ditches. Although the 216-Z-20 Tile Field and UPR-200-W-110 also are 200-CW-5 OU sites and received the same waste as the Z-Ditches, they are not included in this study because they operated differently than the ditches, do not have data used in this study, and are not expected to be contaminated at hot-spot concentrations. The Z-Ditches operated in chronological sequence from 1944 to 1981 transferring cooling water waste streams from Z Plant operations to the 216-U-10 Pond with the 216-Z-1D Ditch being the first ditch to operate followed by the 216 Z-11 and then 216-Z-19 Ditches. These ditches are co-located (i.e., immediately side-by-side and parallel), received the same Z Plant waste streams, are all backfilled, and their shared location has undergone follow-on site stabilization activities that have obscured ditch boundaries. Further, this area has undergone significant characterization throughout the years of ditch operations. Consequently, these sites are considered to be a single underground contamination area that has been shown to have potentially significant concentrations of TRU constituents that will be the primary factor in remedial decision making.

The scope of this evaluation included the following four main regulatory questions.

- How is a waste designated as TRU?
- What are the regulatory requirements to dispose of TRU waste?
- What options are available for disposal?
- Can the waste be processed to meet the requirements?

Once the regulatory framework is in place, an objective evaluation of excavation methods can be assessed. The excavation methods evaluated will be compliant with existing DOE orders, Federal laws and regulations, and state of Washington laws and regulations.

The objectives of the study are to identify the regulatory requirements associated with TRU constituents in the soil, understand when and how TRU waste is designated, develop a clear understanding of all the existing data, and quantify the risk reduction associated with removing portions of the risk.

2.0 BACKGROUND

This chapter describes the Z-Ditches construction, operations, waste sources, and the waste received. It also describes historical and remedial investigation (RI) characterization activities and the nature and extent of Z-Ditches contamination shown by Z-Ditches characterization to date.

2.1 CONSTRUCTION AND OPERATIONS OF THE Z-DITCHES

The Z-Ditches (Figure 2-1) are a series of three parallel, unlined, and open ditches that from 1944 to 1981 routed cooling water and other wastewaters from the Z Plant to the 216-U-10 Pond for disposal through evaporation and percolation into the soil column. The ditch system operated from 1944 to 1959 conveying cooling water effluents from the 231-Z Plutonium Isolation Plant where plutonium from the bismuth phosphate process at the 221-T Plant was processed for offsite shipment. In 1956, the bismuth phosphate process was shut down and the 231-Z Plutonium Isolation Plant was converted for use on other projects, addressing metallurgical studies, weapons component fabrications, and reactor fuel development. These processes generated cooling water waste streams that, due to coil failures and occasional process upsets, were low-level waste.

The 216-Z-1D Ditch (previously called 216-Z-1 Ditch), operated from 1944 to 1959 and was 1,295 m (4,249 ft) long and 0.6 m (2 ft) deep, with a bottom width of 1.2 m (4 ft), side slopes of 2.5:1, and a minimum grade of 0.05 percent (WHC-EP-0707, *216-U-10 Pond and 216-Z-19 Ditch Characterization Studies*). Originally the ditch flowed from a location approximately 60 m (196 ft) east of the 231-Z Plutonium Isolation Plant but in 1949 the north 457 m (1,500-ft) section of this ditch was abandoned and backfilled. This portion reportedly did not contain significant contamination because coil failures had not as yet had time to develop and no process upset discharges are reported to have occurred. The abandoned portion was replaced with a vitreous clay pipeline, which followed a different path than the old ditch, and a new concrete headwall where the Z-Ditches are now.

The 216-Z-11 Ditch replaced the 216-Z-1D Ditch after high plutonium contamination was discovered in the upper middle portion of 216-Z-1D and operated from 1959 to 1971. The 216-Z-11 Ditch was excavated immediately east of and parallel to the 216-Z-1D Ditch and was of similar design and construction. Material excavated was used to backfill the 216-Z-1D Ditch to grade. The 216-Z-11 Ditch was approximately 797 m (2,615 ft) long.

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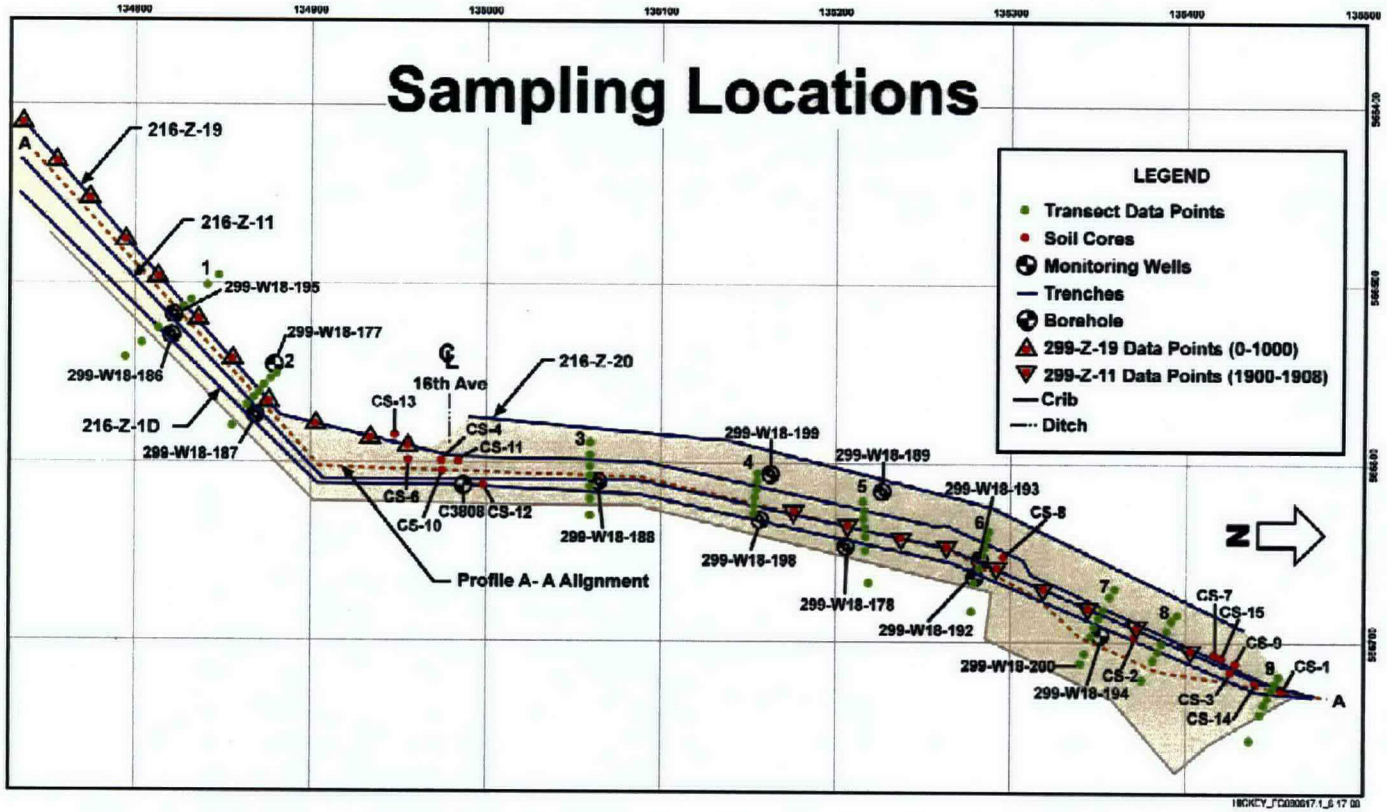
Figure 2 1. Sampling Locations.



The 216-Z-19 Ditch was dug west of and parallel to the 216-Z-11 Ditch and operated from 1971 to 1981 as a replacement ditch for the 216-Z-11 Ditch. Material excavated was used to backfill the 216-Z-11 Ditch to grade. The 216-Z-19 Ditch was similar to that of the previous ditches, except that it was 1.2 m (4 ft) deep (DOE/RL-91-58, *Z Plant Source Aggregate Area Management Study Report*) (WHC-EP-0707). During construction of the 216-Z-19 Ditch, contaminated sediments from approximately 130 m (427 ft) from the 216-Z-1D Ditch inadvertently were excavated so this portion of the ditch was shifted approximately 10.6 m (35 ft) west. The contaminated sediments were reburied in a trench dug parallel to and east of the 216-Z-11 Ditch currently designated UPR-200-W-110, now a 200-CW-5 OU waste site. Because of an accidental discharge in March 1976, three dams were constructed at intervals along the portion of the ditch above 16th Street, to raise the ditch water level above the original contaminated water line and to stop wastewater from reaching the 216-U-10 Pond. Thereafter, wastewater never reached the pond.

The collective Z-Ditches area was deactivated and stabilized in 1981 following construction of the 216-Z-20 File Field as the primary Z Plant wastewater disposal facility. The concrete headwalls, vegetation, and miscellaneous unsalvageable equipment were disposed into the ditch bottom, the previously buried 216-Z-1D and 216-Z-11 Ditches received an additional 0.15 to 0.30 m (0.5 to 1.0 ft) of clean fill, and the entire area was reposted as an Underground Radioactive Area.

The Z-Ditches received the following waste streams during their course of use:

- Process cooling water and steam condensate from the 231-Z Plutonium Isolation Plant
- Cooling water, process sewer effluent, storm sewer, and steam condensate from the 234-5Z Building
- Vacuum pump seal water from the 291-Z Building
- Laboratory waste from the 231-Z Plutonium Isolation Plant
- Liquid effluents from the 236-Z Building.

2.2 EXISTING ANALYTICAL DATA AND THE NATURE AND EXTENT OF CONTAMINATION AT THE Z-DITCHES INITIAL CALIBRATION DATA

This section identifies the Z-Ditches data-collection activities, nature and extent of contamination shown by the data, and application of the data in establishment of exposure-point concentrations (EPC).

Although radionuclide inventory estimates exist, current data provide a more reliable indication of the nature and extent of Z-Ditch contamination because of the uncertain nature of results arrived at using waste stream chemistry methods and the absence of available inventory information for periods of time when the ditch streams were not monitored. DOE/RL-96-81, *Waste Site Grouping for 200 Areas Soil Investigations*, estimated that the 216-Z-1, 216-Z-11, and 216-Z-19 Ditches received 0.14 kg (0.31 lb), 8.07 kg (17.8 lb), and 0.14 kg (0.31 lb) plutonium, respectively, during their periods of active use. These estimates are based on limited waste stream discharge sampling collected over more than 35 years of continuous operation and would not include possible inventory missed due to the absence of stream monitoring data. Further, the inventory estimates available may not be accurate because they are based on waste stream chemistry that could significantly overestimate the quantity of plutonium. Conversely, periodic waste stream sampling would not necessarily reflect discharge accidents and so could underestimate plutonium releases. Further, 216-Z-1D Ditch soil sample results collected in 1959 identified potential plutonium inventory as 3 to 10 kg (6.6 to 22 lb) compared to the much lower 0.14 kg (0.31-lb) inventory estimate based on waste stream chemistry (WHC-EP-0707) showing a significantly divergence between inventory estimates based on soil sample data and estimates based on waste stream chemistry.

2.2.1 Data-Collection Activities and the Nature and Extent of Contamination

The nature and extent of contamination in the 216-Z-11 Ditch was interpreted by using a combination of several reports, including WHC-EP-0707 and DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-CS-1 Steam Condensate Group Operable Units*. These reports provide both historic and analytical information on the construction and operations of the Z-Ditches.

The Z-Ditches have been the focus of several studies starting in 1958. These investigations collected soil, flora, and fauna samples from in and around the three Z-Ditches. The major studies were conducted in 1958–59, 1972–78, 1980, and 2002. Mission changes at the Hanford Site in the 1980s and early 1990s prevented the 1980 study to be completed before 1994.

Each of the studies obtained soil samples that revealed the change in nature and extent of radiological contamination through the period of operations. Chemical analysis of Z-Ditch soil samples was performed only on the 2002 RI samples. The studies included grab sampling and deep and shallow borehole sampling that generally delineated the geologic distribution of the radionuclides beneath and adjacent to the U Pond and Z-Ditches, particularly those areas exceeding 10,000 pCi TRU elements per gram of soil. The samples were gathered from various locations within the southern portion of the Z-Ditches shown in Figure 2-1 and underwent laboratory analysis for radionuclides, including primary waste stream contaminants Cs-137, Pu-239/240, Pu-238, Sr-90, and Am-241.

The 200-CW-5 OU RI conducted in 2002 installed 20 soil probes at the 216-Z-11 Ditch in five transects. The transect probes were installed at portions of the ditch where the highest TRU contamination was expected to ensure placement of a borehole (C3808) in the area of the highest contamination. Each transect location was subjected to a shallow-surface geophysical survey (i.e., ground-penetrating radar) before the soil probes were installed. The results of the ground-penetrating radar survey were interpreted to ensure that the probe locations were free from subsurface debris and to confirm intersection with the original 216-Z-11 Ditch channel. Each probe was logged with a small-diameter gross gamma/passive neutron logging system to determine the gross concentration and type of gamma-emitting constituent present. Borehole C3808 was located just north of the 16th Street culvert and was drilled through the 216-Z-11 Ditch.

In general, the Z-Ditches historical and RI characterization found that maximum contamination exists in the fine sediments and in zones of higher moisture content with maximum concentrations from 1.5 to 2.7 m (5 to 9 ft) below ground surface, decreasing with depth with no significant contamination below 4 m (13 ft). Elevated concentrations of Pu, Am-241, Cs-137, and Ra-226 were found in Z-Ditches soils. However, because plutonium is the most long-lived of these radionuclides and was found at the highest concentrations, it presents the primary risk at the Z-Ditches. Existing analytical data were used to construct contamination isopleths for the Z-Ditches plutonium contamination. The isopleths were constructed using Surfer8.0[1] and (1) using an anisotropic axis rotated 64 degrees counterclockwise from the horizontal to orientate the data with the ditches, and (2) professional judgment on the orientation of the ditches and data. Figure 2-1 illustrates the location of all the sample points used in constructing the isopleths.

Other potentially less significant Z-Ditches contaminants of concern are Am-241, Cs-137, and Ra-226. The americium and radium are generally also located where plutonium concentrations exist at greater concentrations and at concentrations above levels protective to human health and environment. There are only two samples where the Cs-137 value is reported greater than a value that is a risk to human health and the environment, 22.6 and 20 pCi/g, respectively.

The Z-Ditches contain plutonium contamination exceeding 100 nCi/g at 1.2, 2.1, 2.4, and 3.3 m (4, 7, 8, and 11 ft) below ground surface. Isopleths of the plutonium contamination were constructed at these depths to illustrate the spatial extent of contamination exceeding 100 nCi/g. Figures 2-2 through 2-5 illustrate the areal extent of contamination greater than 100 nCi/g. In addition to the spatial extent isopleths, a cross section (Figure 2-6) of the Z-Ditches was generated to illustrate the vertical extent of the plutonium contamination greater than 100 nCi/g and exceeding levels protective to human health and the environment. The above-mentioned figures show three main areas of plutonium contamination potentially above 100 nCi/g. An in-depth examination of the data is presented below.

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[1] Surfer is a trademark of Golden Software, Inc., Golden, Colorado.

Figure 2-2. Plutonium Concentrations at 4 Feet Below Ground Surface.

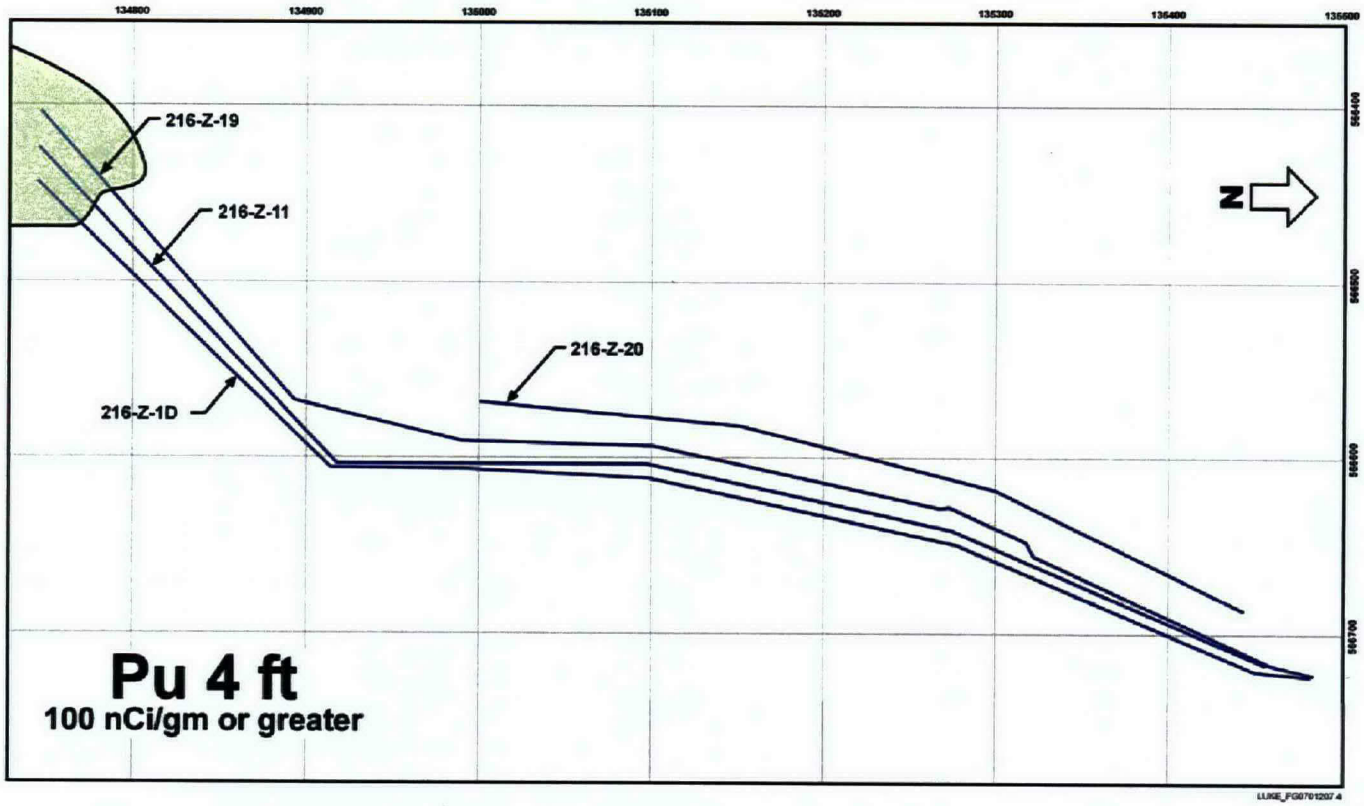


Figure 2-3. Plutonium Concentrations at 7 Feet Below Ground Surface.

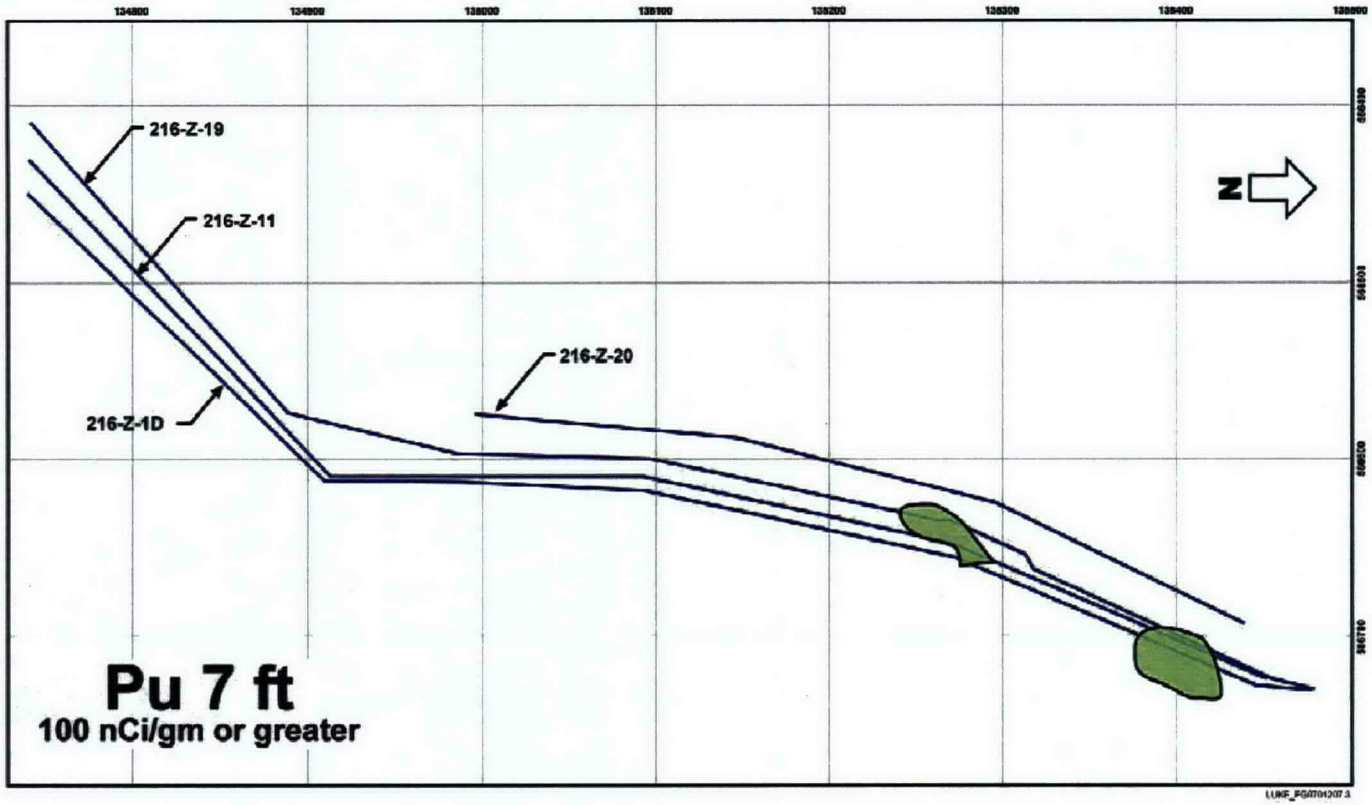


Figure 2-4. Plutonium Concentrations at 8 Feet Below Ground Surface.

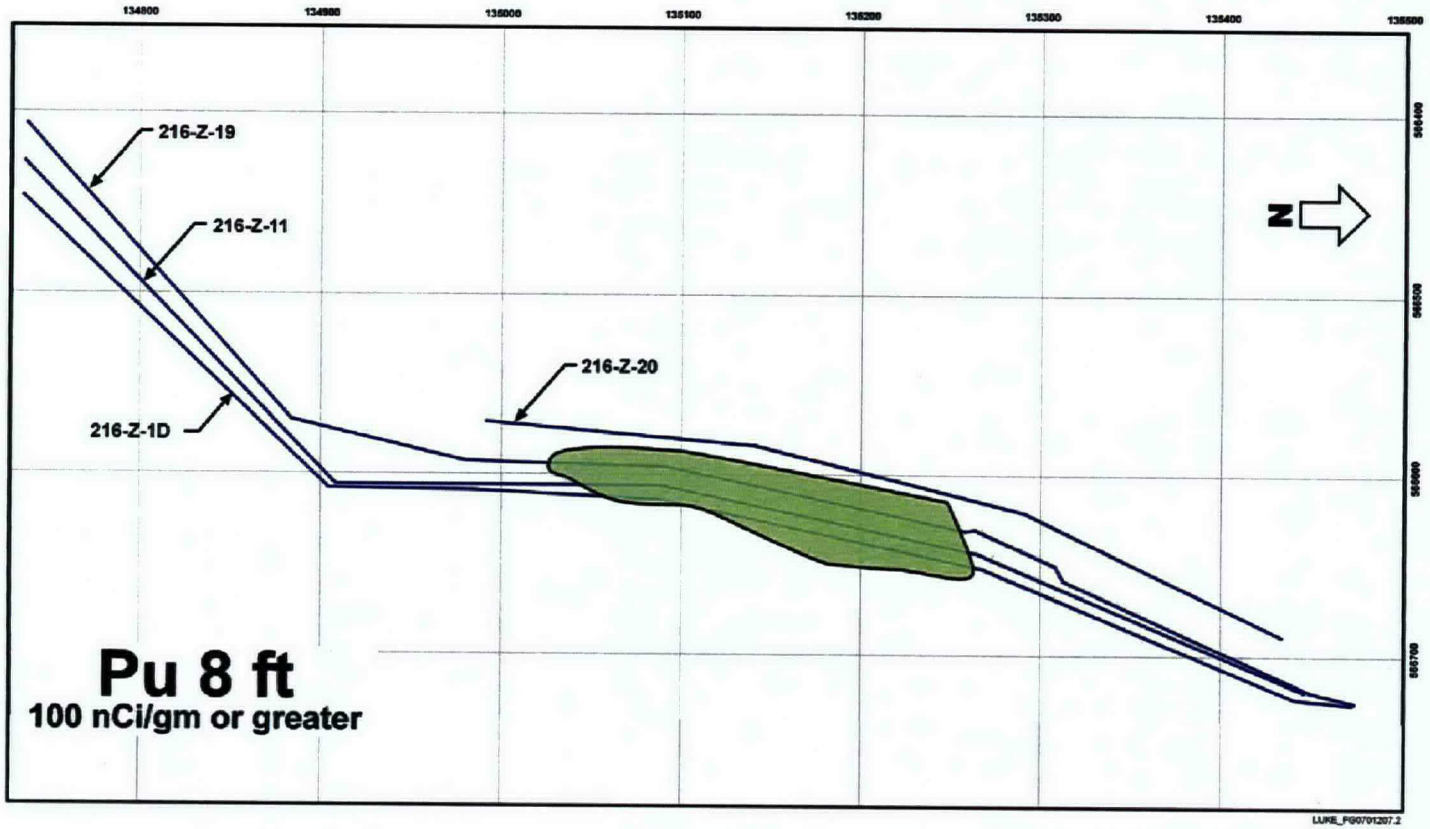
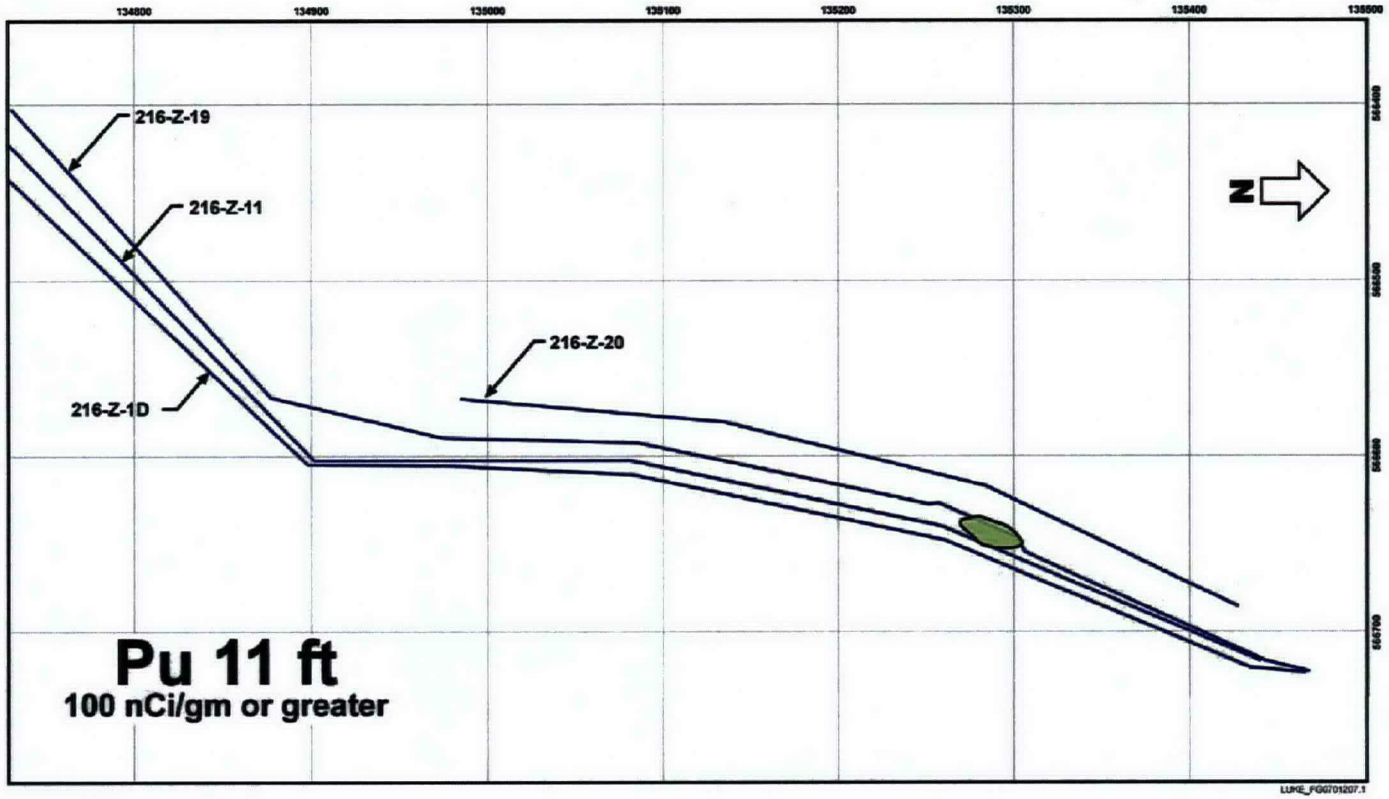


Figure 2-5. Plutonium Concentrations at 11 Feet Below Ground Surface.



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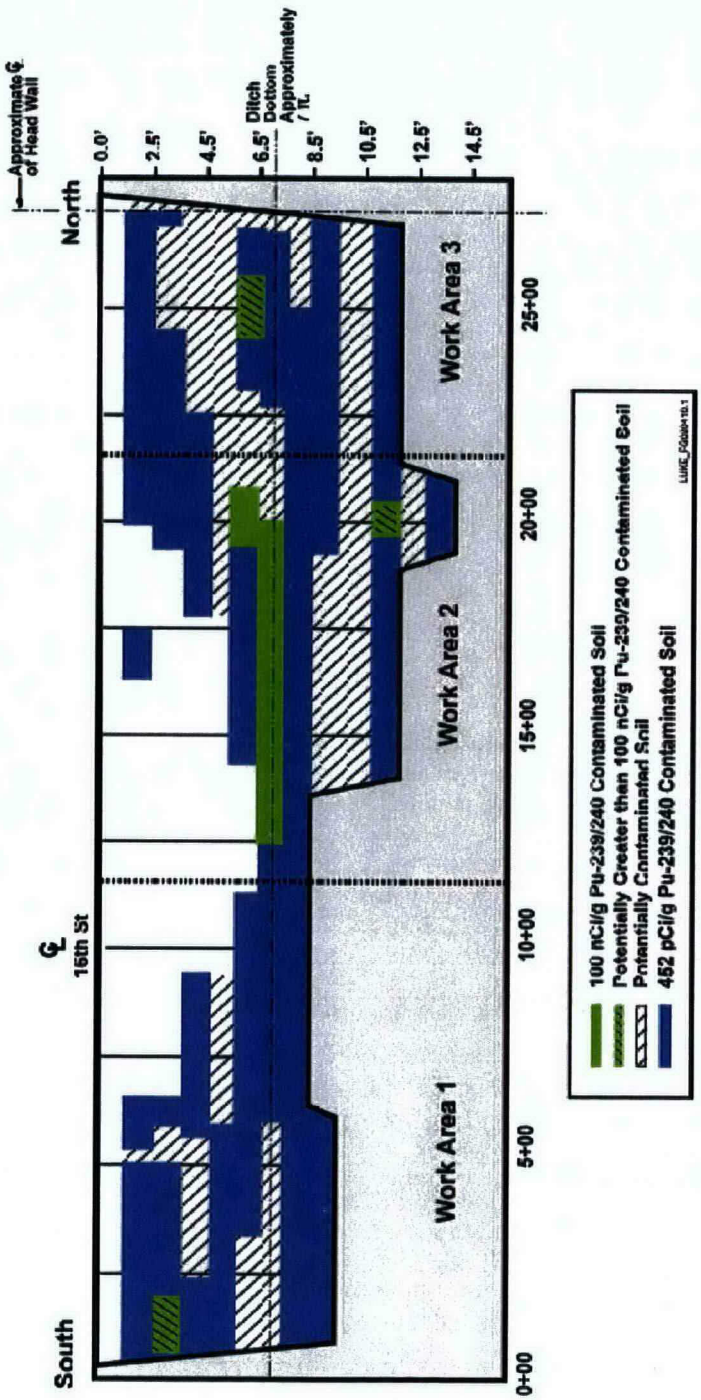

Figure 2-6. Cross Section of Z-Ditch Contaminated Soil.

1

2.2.2 Initial Data Interpretation

The data set used to evaluate the contamination at the Z-Ditches was collected over a period of approximately 43 years (1959 to 2002). During this period, the individual studies continued to refine the Z-Ditch conceptual site model used to evaluate the Z-Ditches during the 200-CW-5 OU RI report stage of the investigation. All the data associated with the Z-Ditches were evaluated in 2002 in accordance with EPA guidance in effect at the time for developing EPCs for risk assessments. An EPC is the concentration for a particular contaminant used to estimate risk from that contaminant in a specified exposure scenario. For the direct-contact-exposure routes, EPCs are represented by concentrations directly measured in shallow soil (generally 4.6 m [15 ft] or less). For the inhalation route, modeling is performed to estimate constituent concentrations in air from particulate or vapor emissions from soil.

After the 200-CW-5 OU RI report (DOE/RL-2003-11) was issued, EPA modified its guidance on estimating EPCs for various data sets. To understand the uncertainties associated with the Z-Ditch data set, the RI data set was evaluated using EPA's revised ProUCL 4.0 analysis tool. ProUCL 4.0 contains statistical methods to address various environmental issues for both data sets with and without nondetects. The Z-Ditch data set has nondetects.

The data group from which EPCs were calculated consists of soil samples collected within the Z-Ditches exposure unit shown in Figure 2-1, as described by the conceptual site models for this study area. EPCs for Z-Ditches contaminants, including Pu-239/240, were calculated from this data using a statistical estimate provided by the ProUCL 4.0 analysis tool. Data reported as Pu-239 was considered the same as the Pu-239/240 and included in the Pu-239/240 calculation because these isotopes present similar risk and because of the uncertainty in differentiating these isotopes in the laboratory. The results from all plutonium isotopes were combined to provide an aggregate total plutonium activity concentration. The results of the initial data evaluation are shown in Table 2-1.

Table 2-1. Nonparametric Upper Confidence Limit Statistics for Full Data Sets. (2 Pages)

Confidence coefficient	95%
Number of bootstrap operations	2,000
Total Plutonium (238, 239, and 239/240)	
Number of valid samples	417
Number of unique samples	233
Minimum	-0.032 pCi/g
Maximum	13,000,000 pCi/g
Mean	39,928 pCi/g
Median	4 pCi/g
Standard deviation	639087
Variance	4.08×10^{11}
Coefficient of variation	16.01
Skewness	20.15

Table 2-1. Nonparametric Upper Confidence Limit Statistics for Full Data Sets. (2 Pages)

Goodness of Fit: Data do not Follow a Discernable Distribution	
95% Useful UCLs	
Student's-t UCL	91,521
95% UCLs (adjusted for skewness)	
95% Adjusted-CLT UCL	124,405
95% Modified-t UCL	96,668
Nonparametric UCLs	
95% CLT UCL	91,406
95% Jackknife UCL	91,521
95% Standard bootstrap UCL	92,499
95% Bootstrap-t UCL	601,466
95% Hall's bootstrap UCL	413,973
95% Percentile bootstrap UCL	101,511
95% BCA bootstrap UCL	161,744
95% Chebyshev UCL	176,345
97.5% Chebyshev UCL	235,373
99% Chebyshev UCL	351,322
Potential UCL to Use	
95% Chebyshev UCL	176,345

BCA = bias-corrected accelerated bootstrap method.
CLT = central limit theorem.
UCL = upper confidence limit.

Table 2-1 identifies the number of samples used in generating the total plutonium statistics. The number of valid samples represents the total number of measurements (censored and uncensored) excluding the missing values. All values not representing a real numerical number are considered as missing values. Specifically, all alphanumeric values including blanks are considered as missing values. In addition, unrealistic big numbers also are considered as missing values. If a data set has no missing value, then the total number of data points equals the number of valid samples. All values not representing a real numerical number are considered as missing values. Specifically, all alphanumeric values including blanks are considered as missing values. In addition, unrealistic big numbers such as 1×10^{31} are considered as missing values and are considered as not valid observations. The number of unique samples or number of distinct samples represents all unique (or distinct) detected values. The number of unique or distinct values is computed for detected values only. This number is especially useful when using bootstrap methods. It is not desirable or advisable to use bootstrap methods when the number of unique samples is less than 4 to 5.

The current statistical evaluation was reperformed for the entire data set using updated EPA guidance. This data run suggests using a 95 percent Chebyshev (mean) UCL for the plutonium EPC concentration of 176,345 pCi/g. However, this and other results shown on Table 2-1 are unusual features that point out the need for additional evaluation of the data set to ensure appropriate data points are used in determining EPCs. Table 2-1 identifies divergent mean and

median values, goodness-of-fit test results that are nonparametric, and use of the 95 percent Chebyshev UCL as the most appropriate UCL. The mean concentration (arithmetic average) is 39,928 pCi/g while the median concentration (the concentration at which half of the values are above and half are below) is only 4 pCi/g. This divergence of the mean and median values is significant, showing that these values have been influenced by several large numbers in the data set. The goodness-of-fit test indicates the data do not follow a discernable distribution, indicating that the data set is nonparametric; therefore, its use may be inconsistent with current EPA guidance. This suggests that the EPC used in the 200-CW-5 OU RI (4,460,000 pCi/g maximum detected value) would not be the value chosen today.

Given the uncertainties associated with the statistical evaluation results above, reevaluation of the data was considered appropriate. An initial step in data reevaluation was to look for potential outliers in the data set. To identify if an outlier is present, Rosner's outlier test was performed on the plutonium data set. Table 2-2 shows the results and reveals that the data set is nonparametric and skewed (i.e., the distribution of the data set is asymmetrical around the mean). A nonparametric data set presents a challenge because the skewness of the data is significant in identifying data points that are potential statistical outliers.

Table 2-2. Rosner's Statistical Outlier Test of the Z-Ditches Plutonium Data Set at 5 Percent Significance.

Number of data points: 417			
Statistical Outlier #	**Mean**	**Standard Deviation**	**Potential Outlier (pCi/g)**
1	39927.98	638320.58	13,000,000
2	8773.96	60931.41	780,000
3	6915.59	47764.55	750,000
4	5120.7	30769.51	380,000
5	4213	24640.04	310,000
6	3470.8	19507.66	270,000
7	2822.31	14415.01	180,000
8	2390.17	11461.26	150,000
9	2029.26	8840.15	98,000
10	1794.04	7460.22	89,000

The results of the Rosner test reevaluation show that up to 10 data points are potential statistical outliers at the 5 percent significance level. The 5 percent level is considered the proper measure due to the uncertainties in the data set. Once these potential outliers (data points) were identified, the physical locations of the samples that generated the data points were examined. Examination of the location of the data points is important to conduct a spatial evaluation and to compare the nature of the contamination to waste-site conditions and data from the surrounding area. This comparison revealed that of the 10 data points identified as statistical outliers, 2 are likely outliers based on comparison with site conditions and data from nearby areas.

Table 2-2 statistical **outlier #1**, the plutonium concentration of 13×10^6 pCi/g reported at the inlet to the 216-U-10 Pond, appears to be a valid outlier and should not be included in

determining EPCs. An evaluation of the data points and logging data around this data point reveals that the concentrations of the other points are several orders of magnitude below this point. Furthermore, it is the only data point at this elevation to indicate a concentration of this magnitude and most likely would represent a localized effect. Based on its spatial location and surrounding data this point could be treated as an outlier in the data set and removed from the EPA calculation.

Table 2-2 statistical **outlier # 2**, the 7.8×10^5 pCi/g, does not appear to be an actual outlier. This data point is located near **outliers # 4, #5, #6, #7,** and **#8** (3.8×10^5, 3.1×10^5, 2.7×10^5, 1.8×10^5, and 1.5×10^5, respectively). The proximity of these points, their similar depth below ground surface, and similar concentrations (although two orders of magnitude lower), would identify all of these data point as consistent with site conditions and therefore should be included in determining EPCs.

Statistical **outlier #3** (7.5×10^5 pCi/g) is located near the northern headwall of the Z-Ditches. An evaluation of this point similar to the evaluation conducted on the previous two points reveals that existing data do not support plutonium contamination at this concentration and that this point can reasonably be considered an outlier and removed from the EPC calculation.

Table 2-2 statistical outliers **#9** and **#10** are not considered in this evaluation because these data points do not represent TRU constituents at potentially TRU waste designation levels and therefore are not considered relevant to this study.

Table 2-3 presents the statistical results after removing outliers #1 and #3. From inspection, the data set has not changed appreciably. It is still a nonparametric data set that results in identifying the 95 percent Chebyshev (mean) UCL as the suggested EPC value. A comparison of the new EPC value of 17,451 pCi/g with the 2004 EPC value shows a reduction of two orders of magnitude between the new and old EPCs. Given that a change in EPC is roughly linear with a change in the associated risk, Z-Ditches risk is now reduced from the 2004 risk of 6.04×10^{-1} to approximately 6.04×10^{-3} for the first 50 years, but still remains greater than 1×10^{-4} during this period.

Table 2-3. Nonparametric Upper Confidence Limit Statistics for Full Data Sets. (2 Pages)

Confidence coefficient	95%
Number of bootstrap operations	2,000
Plutonium Total	
Number of valid samples	415
Number of unique samples	237
Minimum	-0.016
Maximum	780000
Mean	6988
Median	4
Standard deviation	48901
Variance	2.39×10^9

Table 2-3. Nonparametric Upper Confidence Limit Statistics for Full Data Sets. (2 Pages)

Coefficient of variation	6.998
Skewness	11.82
Goodness of Fit: Data do not Follow a Discernable Distribution	
95% Useful UCLs	
Student's-t UCL	10,945
95% UCLs (Adjusted for Skewness)	
95% Adjusted-CLT UCL	14,978
95% Modified-t UCL	13,596
Nonparametric UCLs	
95% CLT UCL	10,936
95% Jackknife UCL	10,945
95% Standard bootstrap UCL	10,882
95% Bootstrap-t UCL	15,250
95% Hall's bootstrap UCL	16,061
95% Percentile bootstrap UCL	11,422
95% BCA bootstrap UCL	13,061
95% Chebyshev UCL	17,451
97.5% Chebyshev UCL	21,979
99% Chebyshev UCL	30,872
Potential UCL to Use	
95% Chebyshev UCL	17,451

BCA = bias-corrected accelerated bootstrap method.
CLT = central limit theorem.
UCL = upper confidence limit.

Simply discarding the two data points identified as outliers is inappropriate. Rather, EPC and risk ranges created by comparing prior and updated EPCs and risk should be established. This allows decision makers to better evaluate the identified risk and associated uncertainties.

In addition, the physical dimensions of the two data points identified as outliers need further examination because the data point sample size and volume represent an extremely small portion of the Z-Ditches. The sample matrix is only approximately 30.5 cm (12 in.) in diameter and 5 cm (2 in.) thick for both sample points compared to the total Z-Ditches area of approximately 10,725.4 m^2 or 1.07 ha (115,458 ft^2 or 2.7 acres). As such, these two data points do not reasonably represent a significant area of potential contamination at concentrations greater than 100 nCi/g and the locations that they represent should be considered similar to the surrounding areas with regard to contamination levels. Nor would such a small area of contamination (much of it removed as sample material), have sufficient mass to designate a standard waste box as TRU waste. Consequently, these points represent a portion of the Z-Ditches that do not represent an area of potential TRU waste generation but an area, like the surrounding areas, where the plutonium contamination exceeds a value that is protective of human health and the environment and will require remediation.

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3.0 SCOPE OF REGULATORY EVALUATION

The scope of this evaluation included evaluation of the U.S. Department of Transportation regulations, DOE orders, and disposal facilities waste acceptance criteria. Each of these conventions discusses various aspects of identifying and managing potential TRU waste. To provide an entire picture for managing potential TRU waste, this evaluation focused on the following questions:

- How is a waste designated as transuranic?
- Do the designation requirements of the regulations apply to the in situ soil matrix?
- If the ditch received discharges after the effective date of the transuranic regulation, is the entire ditch subject to the regulation?
- Can the waste be processed to meet the requirements in DOE O 435.1, *Radioactive Waste Management*?
- What conditions apply to stabilizing for transportation?
- What conditions apply when blending for health and safety reasons?
- What are the regulatory requirements to dispose of transuranic waste and what disposal options are available?

3.1 TRANSURANIC WASTE DESIGNATION

TRU waste is defined as radioactive waste containing more than 100 nCi (3700 Bq) of alpha-emitting TRU isotopes per gram of waste, with half-lives greater than 20 years. Three exceptions to this definition are: (1) high-level radioactive waste; (2) waste that the Secretary of Energy has determined, with the concurrence of the Administrator of the EPA, does not need the degree of isolation required by 40 CFR 191, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes," disposal regulations via an approved waiver; or (3) waste that the U.S. Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with 10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste" (DOE M 435.1-1, *Radioactive Waste Management Manual*, and HNF-EP-0063, *Hanford Site Solid Waste Acceptance Criteria*).

TRU waste is further categorized as either contact- or remote-handled waste depending on surface dose and container characteristics as described in DOE M 435.1-1. DOE G 435.1-1, Chapter III.A, indicates that given the definition of TRU waste provided in the public law and its application pursuant to DOE M 435.1-1; the determination of TRU waste should be made at the time of waste certification; i.e., each time the waste is transferred to another person or facility (see guidance in DOE M 435.1-1, Section III.J).

3.2 APPLICATION OF THE U.S. DEPARTMENT OF ENERGY ORDERS

Although the soil in the Z-Ditches contains TRU constituents, the in situ soil is not regulated under DOE O 435.1. The *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (40 CFR 300) and its implementing regulation, 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan" will determine the need for and extent of excavation necessary to meet protectiveness requirements. CERCLA also requires designation and proper management of excavation waste generated under the CERCLA process. Based on current information, some soil excavated from the Z-Ditches potentially could be TRU waste. Concentration averaging should be used to classify excavated radioactive waste soil. If, after designation, excavated soil is determined to be TRU waste, disposal at a national repository such as the WIPP is currently required.

The CERCLA process includes the RI/FS process, which is used to identify alternative(s) that meet remedial action objectives and applicable or relevant and appropriate requirements. A preferred remedy that meets the remedial action objectives through the implementation of the applicable or relevant and appropriate requirements and protectiveness criteria is presented in a proposed plan. A record of decision documents the preferred alternative decision. DOE Orders are not considered as an applicable or relevant and appropriate requirement for a CERCLA response action. The CERCLA response action must incorporate the requirements of DOE O 435.1, as appropriate, as part of the DOE internal requirements.

However, DOE M 435.1, Chapter I, provides for demonstration of compliance with substantive protectiveness requirements of DOE O 435.1 during the CERCLA process. Paragraph (4) of the Introduction to DOE M 435.1-1 states that any of the requirements in the Manual may be waived or modified through application of a DOE-approved requirements tailoring process, such as the "Necessary and Sufficient Closure Process" in DOE P 450.3, *Authorizing Use of the Necessary and Sufficient Process for Standards-Based Environment, Safety and Health Management*, DOE M 450.3-1, *DOE Closure Process for Necessary and Sufficient Sets of Standards*, and DOE P 450.4, *Safety Management System Policy*; the applicable or relevant and appropriate requirements identification process for actions taken pursuant to the Department's CERCLA authorities; or by an exemption processed in accordance with the requirements of DOE M 251.1-1B, *Departmental Directives Program Manual*. DOE M 251.1-1B, Chapter X, "Exemptions," states that the operations or field office manager has approval authority of the waiver. The series of manuals and implementation guides under DOE P 450.4 contains requirements and guidance for implementing the evaluation processes mentioned above that would allow a waver or modification to any of the individual DOE M 435.1-1 requirements. Chapter VII of DOE M 251.1-1B provides the requirements, including roles and responsibilities, for exempting a DOE site or facility from any of the DOE M 435.1-1 requirements.

3.3 REGULATORY FRAMEWORK OF Z-DITCHES

The Z-Ditches are subject to CERCLA and *National Environmental Policy Act of 1969* (NEPA) regulations as well as DOE orders, in particular DOE O 435.1. Any action at the Z-Ditches must

be compliant with these requirements. Both CERCLA and NEPA incorporate other Federal and state statutes into their evaluations. As such, the underlying question in determining the regulatory status of the waste generated at the Z-Ditches is "*If the ditch received discharges after the effective date of the transuranic regulation, is the entire ditch subject to the regulation?*" DOE policy requires that NEPA values be incorporated into the CERCLA RI/FS documentation; therefore, additional NEPA documentation is not required.

DOE O M 435.1, Chapter III, differentiates between TRU waste disposed of pre- and post-1970 and is intended to apply to waste generated, designated, and disposed as TRU waste after 1970. DOE O M 435.1, Chapter III B (3), specifies the following.

> Pre-1970 Transuranic Waste (i.e., Transuranic waste disposed of before implementation of the 1970 Atomic Energy Commission Immediate Action Directive[2] regarding retrievable storage of transuranic waste) is not subject to the requirements of DOE O 435.1, Radioactive Waste Management, and this Manual. DOE G 435.1-1, Chapter III.A which indicates that given the definition provided in the public law and its application pursuant to DOE M 435.1-1, the determination of transuranic waste should be made at the time of waste certification, that is, each time the waste is transferred to another person or facility (see guidance in DOE M 435.1-1, Section III.J).

Consequently, for the Z-Ditches, DOE O 435.1 management standards will not apply until the waste is generated and/or packaged for disposal and will not apply to in situ soils. Thereafter the TRU regulations will apply, as appropriate, during the CERCLA response action. It should be noted that cooling water waste streams generally were not TRU waste when disposed but were disposed of as low-level waste streams and only reached potential TRU waste levels in soils through accumulation.

3.4 PROCESSING OPTIONS

The DOE O 435.1 identifies specific conditions that apply for soil blending for health and safety reasons and/or stabilizing for transportation. For the mass of the waste matrix used in the TRU determination, guidance from DOE G 435.1-1, Chapter III.A, excludes the mass of added shielding, the container, and any rigid liners but includes the mass of stabilization media and similar materials added to meet waste acceptance criteria. The criteria to meet this requirement are found in DOE G 435.1-1, Chapter III.A, which indicates that the determination of TRU waste should be made at the time of waste certification; i.e., each time the waste is transferred to another person or facility (also see guidance in DOE M 435.1-1, Section III.J).

The waste container or its rigid liner, even if a waste container is overpacked, is not included in the TRU waste determination. Inclusion of the waste container could dilute the entire waste matrix to below TRU waste designation levels (i.e., to less than or equal to 100 nCi [3700 Bq] per gram) and cause reclassification of the waste to low-level waste. Dilution is not permitted by the DOE solely for purposes of reclassifying a waste stream from a TRU waste stream to

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[2] AEC, 1970, *Policy Statement Regarding Solid Waste Burial*, AEC Immediate Action Directive 0511-21.

low-level waste. However, justifiable actions may be taken to process a waste stream for safety or technological reasons that may result in reclassification of the waste as low-level waste.

Consequently, this means that the waste is classified as TRU but requires processing to meet licensed disposal facility waste acceptance criteria or a shipment requirement, then after such processing it can be redesignated and potentially reclassified as low-level waste.

3.5 WASTE DISPOSAL REQUIREMENTS

This section discusses the regulatory requirements to dispose of TRU and low-level waste and the options available for disposal.

An exception to excavation and disposal for TRU waste is referred to as the Degree of Isolation Exception. This exception to the definition of TRU waste is for waste that is determined to not need the degree of isolation that is provided by implementation of the disposal requirements of 40 CFR 191. This allows the Secretary of Energy to make a determination to remove these wastes from the TRU waste definition based on an evaluation of a proposed disposal concept. Such a determination would be provided by the Secretary of Energy and would require EPA Administrator approval.

If a determination is made to excavate and containerize soil, each waste container will be evaluated (e.g., radioassay) against the waste acceptance criteria (HNF-EP-0063) for disposal at WIPP or against the waste acceptance criteria (WCH-191, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*) for disposal at the Environmental Restoration Disposal Facility. This includes the bulk shipment waste acceptance criteria.

3.5.1 Waste Isolation Pilot Plant Waste Acceptance Process and Criteria

For TRU waste that will be disposed offsite at WIPP, the WIPP waste acceptance process and criteria for contact- and remote-handled TRU waste are contained in Appendix A.

3.5.2 Environmental Restoration Disposal Facility Waste Acceptance Process and Criteria

Waste acceptance processes and limits for chemicals, radionuclides, and polychlorinated biphenyls and the general restrictions and physical limits for disposal of waste at the Environmental Restoration Disposal Facility are identified in Appendix B, as are the supplemental waste acceptance criteria for bulk shipments to the Environmental Restoration Disposal Facility.

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4.0 EXCAVATION TECHNIQUES

Underground contaminant removal requires excavations of varying sizes ranging from spot excavations to large areas of several hundred square feet. Regardless of the size of excavation, the amount of contaminated soil sent for disposal should be minimized for economical reasons. One way to minimize material for disposal is by a stepwise process of removing soil in thin layers, monitoring the contamination the layers, and then repeating the process.

The vast majority of excavations are dug with equipment referred to as excavators. An excavator has a jointed boom with a bucket on the end that scoops up soil as it is drawn toward the machine. Buckets can have teeth for faster digging or a smooth lip for finer excavations. Excavators have tracks or rubber tires for mobility. Most rubber-tired excavators have a front loader on the other end of the machine and are referred to as backhoes (Figure 4-1). Excavators with rubber or steel tracks are referred to as trackhoes (Figures 4-2 and 4-3). They rotate on their tracks to maneuver the bucket from side to side while a backhoe stays stationary and only the boom moves from side to side. Excavators range in size from 907 kg (2,000 lb) with 25.4 cm (10-in.)-wide buckets to 59,874 kg (132,000 lb) with 183 cm (72-in.)-wide buckets. Overall dimensions range from 2.7 by 0.7 to 12 by 4.3 m (9 by 2.33 ft to 42 by 14 ft). Maximum digging depth ranges from 1.5 m (5 ft) to more than 10 m (33 ft).

Figure 4-1. Backhoe Excavator.

Figure 4-2. Trackhoe Excavator.

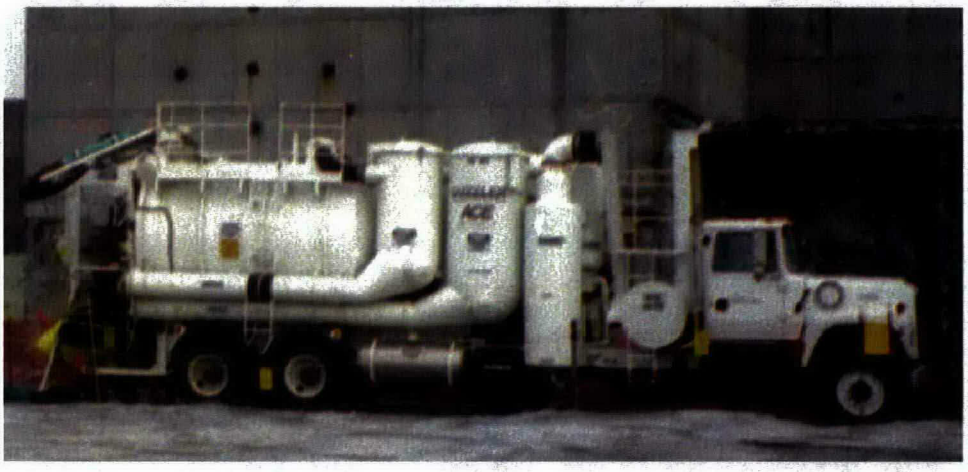
Figure 4-3. Mini Trackhoe Excavator.

A trained operator on an excavator can remove material to a tolerance of about plus or minus 2.5 cm (1 in.) depending on the type of material and the depth of the excavation. Deeper excavations and rocky material are harder to excavate precisely. Laser guides are available for excavators that potentially increase precision and are capable of sensing a one-tenth of an inch change in elevation.

The size of excavator selected for use depends mainly on the depth of excavation. The smaller excavators are more precise, thus minimizing excavated material, but they require repositioning more often than larger models.

Vacuum excavators, commonly called guzzlers (Figure 4-4) have been used for several years on the Hanford Site. They can be used for excavation of granular material. They can be equipped with high-efficiency particulate air filters and used for excavating contaminated soil after obtaining the proper environmental permits. The guzzler can haul the excavated material to a disposal facility or unload it into a storage container. Guzzlers currently in use on the site have a capacity of about 10.7 m^3 (14 yd^3). Use of the guzzler generally requires that someone be down in the excavation to maneuver the suction line. Excavations may be done using shallow lifts of about an inch but in hard packed situations, it may be necessary to first break up the soil using a rake or other implement. Guzzlers are extremely useful when excavating in the vicinity of existing underground utilities.

Figure 4-4. Guzzler.



Excavations covering large areas generally are done with front loaders or scrapers (Figure 4-5). These machines generally are not suitable for small precision excavations. They can however, be used for mass removal of clean cover material.

Figure 4-5. Scraper.

Excavation of soil by hand is an accurate method because lifts of less than 2.5 cm (1 in.) in depth are possible. Under ideal conditions, approximately 1.5 m^3 (2 yd^3) of material per hour can be excavated by hand. Hand excavation combined with machine excavation may be the most economical solution in some cases. However, excavation by hand at the Z-Ditches likely would not be considered appropriate due to high radiological contamination levels to which workers would be exposed.

The preferred method of excavation for removing underground contamination is the CAT 320[3] excavator with a 51 cm (20-in.) smooth-lipped cleanout bucket. The size of excavator selected is dependent on the depth and area of the excavation. For precise excavation, a relatively small excavator is used. Hand or guzzler excavation is preferred in the vicinity of underground utility lines or anywhere damage to existing construction may occur. Table 4-1 shows the relative ranking of each piece of equipment.

[3] CAT 320 is a trademark of Caterpillar Inc., Peoria, Illinois.

Table 4-1. Relative Ranking of Equipment.

Excavation Equipment	Excavation Capacity	Material Handling	Excavation Precision	Contamination Control	Worker Exposure	Site Adaptability	Versatility of End Effectors
Wheeled backhoe	Medium	Single	Medium	Good	Low	Medium	Medium
Trackhoe	High	Single	Medium	Good	Low	High	High
Mini-trackhoe	Low	Single	High	Good	Low	High	Medium
Guzzler	Low	Double	Very High	Very Good	High	Medium	Low
Scraper	High	Double	Low	Poor	Low	Medium	None

Table 4-1 identifies evaluation elements associated with excavations within the Z-Ditches. These elements are in no particular order. The first element assesses the equipment's excavation capacity. This is a measure of the quantity of material moved within a fixed time interval. The second element is a measure of the equipment to load directly into an approved disposal container. The third element is a measure of the equipment's ability to remove thin lifts of material. The fourth element is a measure of the equipment to control the spread of contamination. The fifth element is a measure of the potential remediation worker exposure while the equipment is in operation. The sixth element is a measure of the equipment's ability to work in varied site conditions. The seventh element qualitatively evaluates the equipment's ability to remove and replace end effectors to meet varied site conditions. From inspection, the trackhoe places higher than the other pieces of equipment.

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5.0 COST TO REDUCE EXPOSURE-POINT CONCENTRATIONS

A cost estimate was performed to evaluate removing only the contaminated material above 100 nCi/g. The estimate did not evaluate removing all the material necessary to remediate the Z-Ditches. Rather, this estimate attempts to show the differences associated with removing potential outliers from the data set. The three options systematically remove the potential outliers and associated work required to remove the material contaminated above 100 nCi/g. Section 2.2.2 identified two data points as potential outliers. This cost information provides decision makers with an understanding of the cost associated with treating these two data points as potential TRU material. The cost estimate was developed using guidance from EPA/540/R-00/002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, OSWER 9355.0-75. The cost estimate is presented as three options in Table 5-1.

Table 5-1. Capital-Cost Breakdown of Options 1, 2, and 3.

	Option 1	Option 2	Option 3
	RTD Entire Z-Ditch	RTD Work Areas 2 & 3	RTD Work Area 2
Mobilization/demobilization	$686.9	$654.9	$601.5
Monitoring and sampling	$14,343.5	$13,229.7	$7,929.0
Site work	$563.8	$513.5	$393.2
Soil excavation	$126,244.4	$117,423.8	$70,691.8
Construction staff	$1,456.2	$1,365.2	$1,024.7
Project management	$901.2	$847.0	$645.3
Sub total	$144,196.0	$134,034.1	$81,285.6
Contingency (25%)	$36,049.0	$33,508.5	$20,321.4
Remedial design*	$8,651.8	$8,042.0	$4,877.1
Total project	$188,896.7	$175,584.7	$106,484.2

*For projects with construction costs greater than $10 million, remedial design is planned at 6% of construction costs.
NOTES:
Dollars are in thousands.
Remedial design capital costs are based on EPA/540/R-00/002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, OSWER 9355.0-75, Exhibit 5-8.

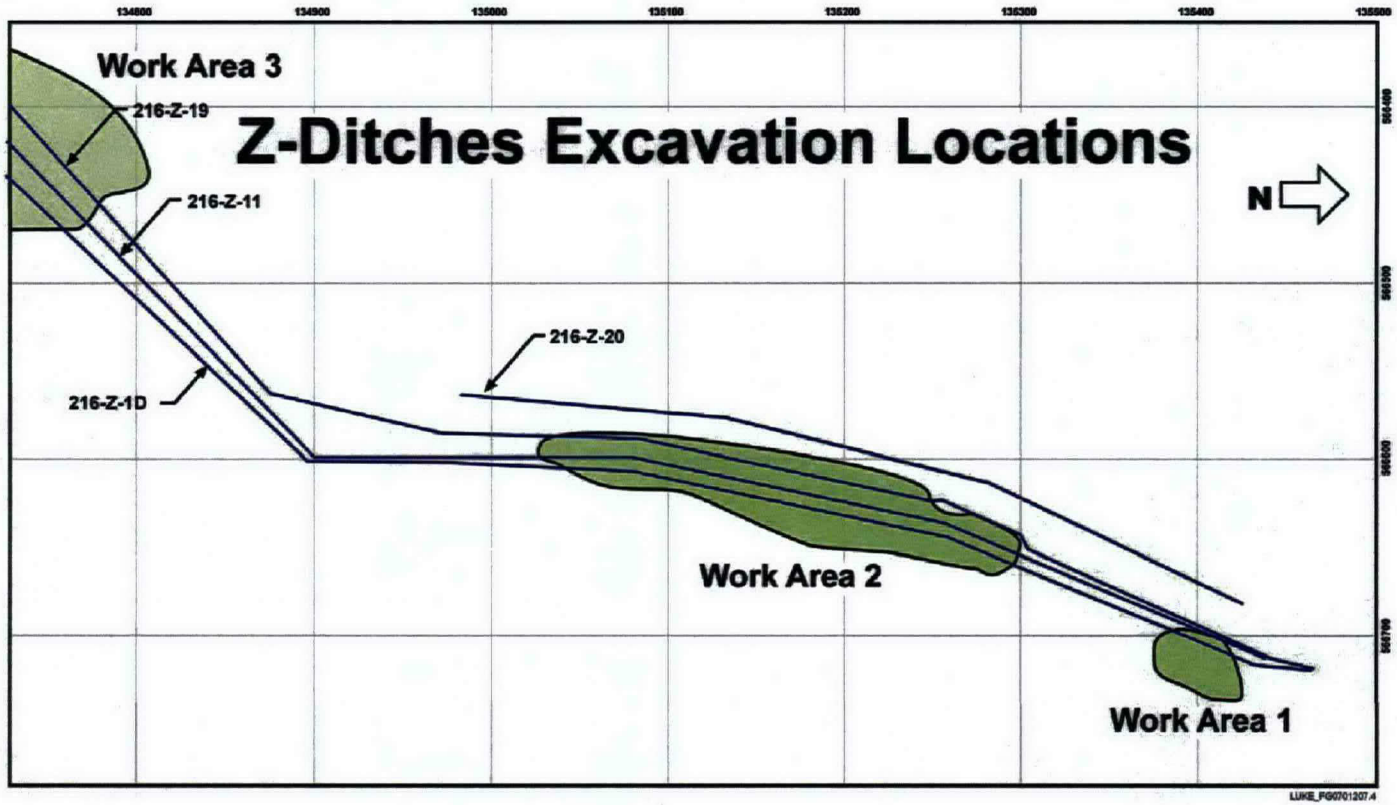
RTD = removal, treatment, and disposal.

The first estimate uses the entire data set (including all outliers) to evaluate the cost associated with removal of this extent of TRU material. Figure 5-1 shows the lateral extent of the material and Figure 2-6 shows the depth of the material to be removed. Elevated contamination is in three distinct areas as shown in Figure 5-1, which identifies these locations as Work Areas 1, 2, and 3. The Option 1 estimate assumes all three work areas are contaminated with material above 100 nCi/g, resulting in removal of all three work areas as TRU waste for a total of 5,331 m^3 (6,973 yd^3) covering approximately 2 ha (5 acres). The Option 2 estimate does not include the cost of excavation for the first outlier (i.e., Work Area 1 [the 13×10^6 pCi/g sample]) as TRU waste. The Option 2 estimate also shows the cost of excavating Work Areas 2 and 3 as TRU

waste for a total of 3,333 m^3 (4,360 yd^3) and covering an area of approximately 1.4 ha (3.4 acres). The Option 3 estimate does not include the cost of excavating Work Areas 1 and 3 and shows only the cost of removing Work Area 2 as TRU waste for a total of 2,963 m^3 (3,875 yd^3) covering approximately 1.2 ha (2.9 acres). Table 5-1 shows the estimates.

The total project cost includes mobilization/demobilization, safely removing the material and loading it into standard waste boxes, assaying the material, storing it at the Hanford Site until disposal at WIPP, obtaining verification samples, and performing site restoration.

Figure 5-1. Z-Ditch Work Locations.



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6.0 RESULTS

This study was undertaken to provide additional information for the waste sites assigned to the 200-CW-5 OU. This study covered the following requirements:

- CFRs applicable to the Z-Ditches
- The internal DOE regulatory framework (i.e., DOE orders)
- Excavation methods available to remove elevated levels of transuranic constituents
- Risk-reduction potential through the removal, treatment, and disposal alternative.

The Z-Ditches currently are included in the 200-CW-5 OU, which is included on the Hanford Site Central Plateau National Priorities List (40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," Appendix B, "National Priorities List"), and so must adhere to CERCLA regulations. In addition, because the Z-Ditches are on Federal property, the DOE has determined that any actions taken at the Z-Ditches must comply with the substantive requirements of NEPA. DOE O 435.1 does not apply to the radioactive constituents currently in the soil but does apply to any remedial excavation actions taken at the Z-Ditches. Therefore, based on current sampling data portions, the Z-Ditches would be designated as potential TRU waste. Dilution of a TRU waste stream solely to reclassify the waste as low-level waste is not permitted by the DOE, unless a waiver is granted. DOE Orders allow divergence from these requirements for the following:

- For protection of personnel
- To transport waste safely
- To meet licensed disposal facility regulatory-required waste acceptance criteria (e.g., to meet a land ban disposal requirement).

Various excavation options exist to remove soils with elevated radioactive constituents. The radioactive material within the Z-Ditches is accessible using standard excavation equipment. The technique envisioned to remove the radioactive material from the Z-Ditches most likely would use a standard excavator using two different excavation buckets. Excavations in uncontaminated soil would use a standard toothed bucket with articulating thumb. Excavations in contaminated soil would be accomplished by removing the contamination in lifts less than 0.3 m (1 ft) using a toothless bucket.

Initial evaluation of the Z-Ditches data indicates three areas of contaminated soil potentially containing TRU constituents at concentrations greater than 100 nCi/g. Following new EPA guidelines identifies a plutonium EPC at the Z-Ditches of 176,345 pCi/g. However, analyzing the entire data set in accordance with EPA/600/R-07/041, *ProUCL Version 4.0 Technical Guide*, indicates two potential outliers. Removing the two data set outliers (Section 2.2.2) from the EPC calculation yields an EPC of 17,451 pCi/g, which potentially reduces risk by a factor of two. However, future risk should be evaluated using a range for EPCs and associated risk to allow decision makers to evaluate the risk and associated uncertainties.

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7.0 REFERENCES

10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste," Title 10, *Code of Federal Regulations*, Part 61.

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

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DOE M 251.1-1B, *Departmental Directives Program Manual*, U.S. Department of Energy, Washington, D.C.

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DOE M 450.3-1, *DOE Closure Process for Necessary and Sufficient Sets of Standards*, U.S. Department of Energy, Washington, D.C.

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APPENDIX A

WASTE ISOLATION PILOT PLANT ACCEPTANCE CRITERIA

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APPENDIX A

WASTE ISOLATION PILOT PLANT ACCEPTANCE CRITERIA

The Waste Isolation Pilot Plant waste acceptance process and criteria for contact-handled transuranic waste are illustrated in Tables A-1 through A-5.

Table A-1. Container Properties. (2 Pages)

Waste Attribute	Waste Acceptance Criteria	Compliance Methods
Payload container description	DOT Type A or equivalent • 208 L (55-gal) drums (direct fill or containing a pipe component) • 208 L (55-gal) drums are <61 cm (24 in.) in diameter (including gasket, locking ring, and torqued accordingly) and <89 cm (34 15/16 in.) tall (fully assembled) • SWBs • 322 L (85-gal) drum (direct fill or 208 L [55-gal] drum overpack)	Site procurement specifications and quality assurance acceptance reports, or manufacturer's fabrication documentation and records demonstrating equivalency with DOT Type A requirements, or testing records showing compliance with 49 CFR 173.461, or comparison to technical criteria/industry standards. Pipe overpack containers and SWB specifications procured consistent with CH-TRAMPAC (DOE, 2005) requirements. Visual inspection to verify container integrity.
Container weights	• ≤454 kg (1,000-lb)/208 L (55-gal) drum • ≤1,814 kg (4,000-lb)/SWB • 208 L (55-gal) drum with inner pipe component—contact Hanford TRU Program.	Records of loaded container weights.
Removable surface contamination	For individual containers and payload assemblies: • ≤20 dpm/100 cm^2 for alpha • ≤200 dpm/100 cm^2 for beta-gamma The fixing of surface contamination to meet these limits is not allowed.	Records of surface contamination surveys taken on individual containers before release from a radiological contamination area.
Container identification and marking	• Bar code label consisting of a unique container identification number • Shipping category • Yellow and magenta—DOT Radioactive sticker. • Mixed—TRU waste marked as "Hazardous Waste" per 40 CFR 262.32. • TRU waste containing polychlorinated biphenyls marked in accordance with 40 CFR 761.40	Visual inspection at time of shipment.

Table A-1. Container Properties. (2 Pages)

Waste Attribute	Waste Acceptance Criteria	Compliance Methods
Confinement requirements	• Maximum layers of confinement allowed is six, including the liner. Smaller number of confinement layer may be required as a waste-stream-profile condition of approval. • Newly generated waste must be packaged with filtered bags or be horsetailed. Filtered bags are considered layers of confinement.	Contents inventory records, which clearly indicate the number of confinement layers.
Filter vents	Payload containers vented using one or more filter(s) that meet the WIPP Hazardous Waste Facility Permit (NM4890139088-TSDF) and the CH-TRAMPAC, Appendix 2.5 (DOE, 2005) specification. Drums with vent clips are not considered vented.	Site procurement specifications and quality assurance acceptance reports, manufacturer's fabrication documentation, and/or records of visual inspection.

49 CFR 173.461, "Shippers – General Requirements for Shipments and Packagings," Demonstration of Compliance with Tests."
40 CFR 262.32, "Standards Applicable to Generators of Hazardous Waste," Subpart C, "Pre-Transport Requirements," "Marking."
40 CFR 761.40, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions," Subpart C, "Marking of PCBs and PCB Items," "Marking Requirements."
DOE, 2005, *Contact-Handled Transuranic Waste Authorized Methods for Payload Control (CH-TRAMPAC).*
NM4890139088-TSDF, *Waste Isolation Pilot Project Hazardous Waste Facility Permit.*

DOT = U.S. Department of Transportation.
SWB = standard waste box.
WIPP = Waste Isolation Pilot Plant.

Table A-2. Radiological Properties. (2 Pages)

Waste Attribute	Waste Acceptance Criteria	Compliance Methods
Radionuclide composition	• Assay measurements • Information on radionuclide composition, with emphasis on quantification of Am-241, Pu-238, Pu-239, Pu-240, Pu-242, U-233, U-234, U-238, Sr-90, and Cs-137	Records of assay data and/or AK documentation.
Fissile material quantity (Pu-239 fissile gram equivalent)*	• ≤200 g (7 oz)/208 L (55-gal) drum (direct fill or containing a pipe component) • ≤325 g (11.5 oz)/SWB • Note that uncertainty must be accounted for in accordance with Appendix B, Section B.2 in HNF-EP-0063.	Records of assay data or AK documentation and calculations using isotopic composition, specific activity of the isotopes, and measured assay values to calculate Pu-239 fissile gram equivalent.
TRU alpha activity concentration	• >100 nCi of alpha-emitting TRU isotopes with half-lives >20 yr/g of waste	Records of assay data or AK documentation and records of calculations showing concentrations of the total TRU radionuclides in the waste matrix.

Table A-2. Radiological Properties. (2 Pages)

Waste Attribute	Waste Acceptance Criteria	Compliance Methods
Pu-239 equivalent activity (PE-Ci)	Untreated waste: • ≤80 PE-Ci/208 L (55-gal) drum • ≤560 PE-Ci/SWB • ≤1100 PE-Ci/208 L (55-gal) drum overpacked in a 322 L (85-gal) drum • ≤1200 PE-Ci/208 L (55-gal) or 322 L (85-gal) drum overpacked into an SWB • ≤1800 PE-Ci/208 L (55-gal) drum containing a pipe component Solidified/vitrified waste: • ≤1800 PE-Ci/any payload container	Records of assay data or AK documentation and records of conversion and calculations using Appendix B of the WIPP waste acceptance criteria (HNF-EP-0063).
Radiation dose rate	• ≤200 mrem/h at the surface of the payload (waste) container and the TRUPACT-II • ≤10 mrem/h at 2 m (6.6 ft)	Measurements shall be made on each CH-TRU waste container with instruments calibrated using sources traceable to a national standard. Internal payload container shielding cannot be used to meet dose rate requirements except for the approved pipe component configuration.
Decay heat	• Less than or equal to the limit established in accordance with the waste stream profile.	Compliance will be in accordance with direction in the waste stream profile and will be based on generator-supplied isotopic and loading data.

*Waste that contains beryllium and/or that has been machine compacted has more restrictive critical safety requirements.
HNF-EP-0063, *Hanford Site Solid Waste Acceptance Criteria*.

AK = acceptable knowledge.
CH-TRU = contact-handled transuranic.
g/SWB = gram per standard waste box.
mrem/h = millirem per hour.
nCi = nanocurie.
PE-Ci = plutonium equivalent curie.
TRU = transuranic.
TRUPACT II = transuranic package transporter II.
WIPP = Waste Isolation Pilot Project.

Table A-3. Physical Properties.

Waste Attribute	Waste Acceptance Criteria	Compliance Methods
Liquids	Liquid waste is prohibited in payload containers except for residual amounts as follows. Residual liquid: • <1 vol% of external container. • <2.5 cm (1 in.) in bottom of internal containers. • Residual liquids containing polychlorinated biphenyls are prohibited. • No detectable liquid with U.S. Environmental Protection Agency code U134 (hydrofluoric acid) waste. Liquid identification: • Generators must specify the quantity and location of all liquids in the container.	AK, radiography, visual examination, and/or packaging records will be used to determine the presence of residual liquids and to ensure that the quantity of liquid satisfies the acceptance criteria. The waste shall contain as little residual liquid as is reasonably achievable by pouring, pumping, and/or aspirating.
Sealed containers	No sealed containers >4 L (1.1 gal) except for waste material type II.2 packaged in metal containers. Sealed containers >4 L (1.1 gal), including rigid liners, shall be vented. Heat-sealed plastic bags must have at least one filter vent. NOTE: See CH-TRAMPAC (DOE, 2005) for waste material type II.2 definition.	AK, radiography, visual examination, and/or packaging records. Taping a lid around the edges to secure it without venting the lid is considered a sealed container. Cross-taping across the lid, puncturing the lid, or crimping the container are acceptable methods for securing materials in internal containers.

DOE, 2005, *Contact-Handled Transuranic Waste Authorized Methods for Payload Control (CH-TRAMPAC).*

AK = acceptable knowledge.

Table A-4. Chemical Properties. (2 Pages)

Waste Attribute	Waste Acceptance Criteria	Compliance Methods
Pyrophoric materials	• <1% (by weight) radionuclide pyrophorics • No nonradionuclide pyrophorics	AK documentation and/or records of procedures, processes, or evidence that shows no presence of pyrophorics or treatment to eliminate the characteristic.
Hazardous waste	• Limited to U.S. Environmental Protection Agency hazardous waste numbers identified as allowable in the WIPP Hazardous Waste Facility Permit (NM4890139088-TSDF) and all Washington State waste codes	Approved Fluor Hanford Waste Profile Sheet. AK documentation and/or records of procedures, processes, or evidence that show hazardous waste codes as listed in Table A-5.
Chemical compatibility	No chemicals or materials that are incompatible	AK and/or records of sampling and analysis.
Explosives, corrosives, and compressed gases	No explosives, corrosives, or compressed gases	Radiography records, visual examination records, or AK documentation, and site policies/procedures prohibiting these items.

Table A-4. Chemical Properties. (2 Pages)

Waste Attribute	Waste Acceptance Criteria	Compliance Methods
Polychlorinated biphenyl concentration	PCBs in any concentration are allowed, but there can be no free flowing liquids in PCB waste.	AK and/or records of sampling and analysis. Information from the generator must include the earliest date of waste generation (i.e., the date of removal from service for disposal), the estimated weight of PCBs in kilograms, and a description of the type of PCB waste (e.g., PCB remediation waste, PCB bulk product waste).

NM4890139088-TSDF, *Waste Isolation Pilot Project Hazardous Waste Facility Permit.*

AK = acceptable knowledge.
PCB = polychlorinated biphenyl.
WIPP = Waste Isolation Pilot Plant.

Table A-5. WIPP-Acceptable RCRA Hazardous Waste Codes.

"D" Series	"F" Series	"P" Series	"U" Series
D004	F001	P015	U002
D005	F002	P030	U003
D006	F003	P098	U019
D007	F004	P099	U037
D008	F005	P106	U043
D009	F006	P120	U044
D010	F007		U052
D011	F009		U070
D018			U072
D019			U078
D021			U079
D022			U103
D026			U105
D027			U108
D028			U122
D029			U133
D030			U134
D032			U151
D033			U154
D034			U159
D035			U196
D036			U209
D037			U210
D038			U220
D039			U226
D040			U228
D043			U239

RCRA = *Resource Conservation and Recovery Act of 1976.*
WIPP = Waste Isolation Pilot Plant.

Waste acceptance requirements for remote-handled transuranic waste are shown in Tables A-6 through A-10.

Table A-6. Container Properties for Shipment in RH-TRU 72-B.

Waste Attribute	Waste Acceptance Criteria	Compliance Methods
Payload container description	RH-TRU waste canister—direct loaded 208 L (55-gal) DOT 7A drums 114 L (30-gal) DOT 7A drums	Site procurement specifications and quality assurance acceptance reports.
Container weights	RH canister, direct loaded—514 kg (1,133 lb) RH canister containing 208 L (55-gal) drums—514 kg (1,133 lb) RH canister Containing 114 L (30-gal) drums— 514 kg (1,133 lb)	Records of measurement of loaded container weight. The canister and contents may be weighed separately.
Removable surface contamination	<20 dpm/100 cm^2 for alpha <200 dpm/100 cm^2 for beta-gamma	Records of surface contamination surveys taken on individual containers before release from a radiological contamination area.
Container identification and marking	Each payload container shall be marked with a unique container identification number.	Records that the container number was visually verified. The record shall include the name of the person that verified the container number and the date of verification.*
Filter vents	RH-TRU canisters and any inner sealed containers >4 L (1.1 gal) in size must be vented or filtered in accordance with Appendix 1.3.5 of NRC, 2002.	Site procurement specifications and quality assurance acceptance reports, manufacturer's fabrication documentation, and records of visual inspection.*

*Newly generated RH-TRU waste must be visually examined by Waste Services personnel during packaging. Retrievably stored RH-TRU waste must have records (e.g., visual examination data forms, packaging logs, loading sheets, or contents inventory sheets) available that demonstrate the attribute has been met.

NRC, 2002, *Safety Analysis Report for the RH-TRU 72-B Shipping Package*, NRC Docket No. 71-9212.

DOT = U.S. Department of Transportation.
RH = remote-handled.
RH-TRU = remote-handled transuranic.

Table A-7. Radiological Properties. (2 Pages)

Waste Attribute	Waste Acceptance Criteria	Compliance Methods
Radionuclide composition	Information on radionuclide composition, with emphasis on the activities and masses of Am-241, Pu-238, Pu-239, Pu-240, Pu-242, U-233, U-234, U-238, Sr-90, and Cs-137. The total activity shall not exceed 82.5 dose equivalent curies per container for acceptance at Solid Waste Operations Complex facilities. NOTE: For WIPP acceptance, the maximum activity level may not exceed 23 Ci/L (averaged over the volume of the RH-TRU canister).	AK documentation, records of radioassay, dose-to-curie conversion, and/or radiochemistry as required by DOE/WIPP-02-3214.

Table A-7. Radiological Properties. (2 Pages)

Waste Attribute	Waste Acceptance Criteria	Compliance Methods
Fissile material quantity (Pu-239 fissile gram equivalent)	FGE plus the error shall be <200 g (7 oz)/RH-TRU waste container. NOTE: The <200 g (7 oz)/RH-TRU waste container limit is driven by the Solid Waste Operations Complex authorization basis. Higher FGE limits, up to 325 g (11.5 oz)/RH waste container, will be considered on a case-by-case basis. Contact Waste Services for guidance. NOTE: Specific FGE limits apply for drums that later will be overpacked into RH-72B canisters for shipment to WIPP. Contact Waste Services for guidance before packaging newly generated RH-TRU waste.	Records of radioassay, dose-to-curie conversion, radiochemistry, and/or AK documentation.
TRU alpha activity concentration	The RH-TRU canister shall contain more than 100 nCi/g of alpha-emitting TRU isotopes with half-lives >20 years.	Records of radioassay, dose-to-curie conversion, radiochemistry, and/or AK documentation. Records of calculations demonstrating compliance with DOE/WIPP-02-3214.
Radiation dose rate	The external radiation dose equivalent rate of individual payload containers shall be ≥200 mrem/h and ≤1000 rem/h at the surface of the WIPP-certified payload container. NOTE: No more than 5% by volume of the RH-TRU waste received at the WIPP may have a surface dose rate in excess of 100 rem/h. Waste generators must coordinate planning with the Hanford TRU Project Group if they will generate RH-TRU waste with dose rates >100 rem/h. Approval is granted on a case-by-case basis. For waste containers that contain shielding, e.g., lead-lined drums, the generator must provide the actual dose rate and the calculated dose rate if the shielding was not present. NOTE: For storage at Solid Waste Operations Complex facilities, waste containers must be shielded to <200 mrem at contact. This may be accomplished through the use of shielded overpack containers. Contact Waste Services for guidance.	Records of radiation dose surveys.
Decay heat	Less than limit established in accordance with waste stream profile.	Compliance will in accordance with direction in the waste stream profile and will be based on generator-supplied isotopic and loading data.

DOE/WIPP-02-3214, *RH TRU Waste Characterization Program Implementation Plan (WCPIP)*.

AK = acceptable knowledge.
FGE = fissile gram equivalent.
RH-TRU = remote-handled transuranic.
WIPP = Waste Isolation Pilot Plant.

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Table A-8. Physical Properties.

Waste Attribute	Waste Acceptance Criteria	Compliance Methods
Liquids	Waste shall contain as little residual liquid as is reasonably achievable by pouring, pumping, and/or aspirating, and internal containers shall contain <2.5 cm (1 in.) of liquid in the bottom of the container. Total residual liquid in any RH-TRU waste container may not exceed 1% by volume of the waste container. RH-TRU waste with U.S. Environmental Protection Agency code U134 (hydrofluoric acid) waste shall have no detectable liquid. Residual liquids containing polychlorinated biphenyls are prohibited.	AK documentation, records of radiography, and/or visual examination.*
Sealed containers	Sealed containers >4 L (1.1 gal) in size are prohibited, except for metal containers packaging solid inorganic waste; this packaging configuration does not generate any flammable gas.	AK documentation, records of radiography, and/or visual examination.*

*Newly generated RH-TRU waste must be visually examined by Waste Services personnel during packaging. Retrievably stored RH-TRU waste must have records (e.g., visual examination data forms, packaging logs, loading sheets, or contents inventory sheets) available that demonstrate the attribute has been met.

AK = acceptable knowledge.
RH-TRU = remote-handled transuranic.

Table A-9. Chemical Properties. (2 Pages)

Waste Attribute	Waste Acceptance Criteria	Compliance Methods
Pyrophoric materials	<1% (by weight) pyrophoric radionuclides No nonradionuclide pyrophoric materials	AK documentation, records of radiography, and/or visual examination.*
Hazardous waste	Limited to EPA hazardous waste numbers identified as allowable in the WIPP Hazardous Waste Facility Permit (NM4890139088-TSDF) and all Washington State waste codes. No hazardous wastes not occurring as co-contaminants with TRU mixed wastes (non-mixed hazardous wastes).	AK documentation showing the waste contains no EPA codes other than those listed in Table A-10.
Chemical compatibility	No wastes incompatible with backfill, seal and panel closures materials, container and packaging materials, shipping container materials, or other wastes.	AK documentation and/or records of verification by visual examination or radiography that the waste meets the assigned waste stream description in the waste profile.

Table A-9. Chemical Properties. (2 Pages)

Waste Attribute	Waste Acceptance Criteria	Compliance Methods
Explosives or compressed gases	No wastes containing explosives or compressed gases.	AK documentation with records of verification through radiography or visual examination.* Information from the generator must include the earliest date of waste generation (i.e., the date of removal from service for disposal), the estimated weight of PCBs in kilograms, and a description of the type of PCB waste (e.g., PCB remediation waste, PCB bulk product waste).
Polychlorinated biphenyls	PCBs in any concentration are allowed, but there can be no free-flowing liquids in PCB waste.	AK documentation with verification through radiography or visual examination.*
Reactives, corrosives, or ignitables	No wastes exhibiting the characteristic of ignitability, corrosivity, or reactivity (EPA hazardous waste numbers of D001, D002, or D003)	AK documentation with verification through radiography or visual examination.*

*Newly generated RH-TRU waste must be visually examined by Waste Services personnel during packaging. Retrievably stored RH-TRU waste must have records (e.g., visual examination data forms, packaging logs, loading sheets, or contents inventory sheets) available that demonstrate the attribute has been met.

NM4890139088-TSDF, *Waste Isolation Pilot Project Hazardous Waste Facility Permit.*

AK = acceptable knowledge.
EPA = U.S. Environmental Protection Agency.
PCB = polychlorinated biphenyl.

Table A-10. WIPP-Acceptable RCRA Hazardous Waste Codes. (2 Pages)

"D" Series	"F" Series	"P" Series	"U" Series
D004	F001	P015	U002
D005	F002	P030	U003
D006	F003	P098	U019
D007	F004	P099	U037
D008	F005	P106	U043
D009	F006	P120	U044
D010	F007		U052
D011	F009		U070
D018			U072
D019			U078
D021			U079
D022			U103
D026			U105
D027			U108
D028			U122
D029			U133

Table A-10. WIPP-Acceptable RCRA Hazardous Waste Codes. (2 Pages)

"D" Series	"F" Series	"P" Series	"U" Series
D030			U134
D032			U151
D033			U154
D034			U159
D035			U196
D036			U209
D037			U210
D038			U220
D039			U226
D040			U228
D043			U239

RCRA = *Resource Conservation and Recovery Act of 1976.*
WIPP = Waste Isolation Pilot Plant.

REFERENCES

40 CFR 262.32, "Standards Applicable to Generators of Hazardous Waste," Subpart C, "Pre-Transport Requirements," "Marking," *Code of Federal Regulations*, Part 262.32.

40 CFR 761.40, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions," Subpart C, "Marking of PCBs and PCB Items," "Marking Requirements," Title 40, *Code of Federal Regulations*, Part 761.40.

49 CFR 173.461, "Shippers – General Requirements for Shipments and Packagings," Demonstration of Compliance with Tests," Title 40, *Code of Federal Regulations*, Part 173.461.

DOE, 2005, *Contact Handled Transuranic Waste Authorized Methods for Payload Control (CH-TRAMPAC)*, Rev. 2, U.S. Department of Energy, Washington, D.C.

DOE/WIPP-02-3214, 2003, *RH TRU Waste Characterization Program Implementation Plan (WCPIP)*, U.S. Department of Energy, Carlsbad Area Office, Carlsbad, New Mexico.

HNF-EP-0063, 2008, *Hanford Site Solid Waste Acceptance Criteria*, Rev. 14, Fluor Hanford, Inc., Richland, Washington.

NM4890139088-TSDF, 2002, *Waste Isolation Pilot Project Hazardous Waste Facility Permit*, New Mexico Environment Department, Santa Fe, New Mexico, November.

NRC, 2002, *Safety Analysis Report for the RH-TRU 72-B Shipping Package*, latest version, NRC Docket No. 71-9212, U.S. Nuclear Regulatory Commission, Washington, D.C.

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

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APPENDIX B

ENVIRONMENTAL RESTORATION DISPOSAL FACILITY WASTE ACCEPTANCE CRITERIA

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APPENDIX B

ENVIRONMENTAL RESTORATION DISPOSAL FACILITY WASTE ACCEPTANCE CRITERIA

Limits for disposal of chemical constituents at the Hanford Site are found in the Environmental Restoration Disposal Facility (ERDF) waste acceptance criteria are contained in WCH-191, *Environmental Restoration Disposal Facility Waste Acceptance Criteria.* The land-disposal restriction treatment standards for dangerous wastes are found in WAC 173-303-140, "Dangerous Waste Regulations," "Land Disposal Restrictions," which by reference includes 40 CFR 268, "Land Disposal Restrictions." Limits for chemicals are shown in Table B-1, and limits for radionuclides are shown in Table B-2.

Table B-1. Chemical Concentration Limits.

Constituent Name	Limit (mg/kg)*
Semivolatile Organic Compounds	
Benzo(a)pyrene	2.5E+04
Benzo(k)fluoranthene	2.5E+04
Pesticides/Polychlorinated Biphenyls	
4,4'DDD	7.6E+05
4.4'DDE	5.4E+05
Polychlorinated biphenyls	500
Beta-BHC (Lindane)	3.3E+03
Metals	
Antimony	1.9E+04
Arsenic	3.0E+03
Barium	9.4E+05
Cadmium	3.9E+04
Chromium (total)	5.9E+04
Chromium VI	5.9E+04
Manganese	4.4E+05
Selenium	4.0E+05
Silver	3.5E+05
Thallium	5.6E+03
Vanadium	3.3E+05
Zinc	3.0E+05

* Public exposure (DOE/RL-93-99, *Remedial Investigation and Feasibility Study Report for the Environmental Restoration Disposal Facility*) is limiting.

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Table B-2. Radionuclide Concentration Limits. (2 Pages)

Constituent	Limit (Ci/m^3)[a]	Notes
Actinium-227	7.5E+04	c
Americium-241	5.0E-02	b, e
Americium-243	5.7E-02	c, e
Carbon-14	5.1E+00	c
Carbon-14 (activated)	5.1E+01	c, d
Cesium-134	Unlimited	--
Cesium-135	8.8E+00	c
Cesium-137	3.2E+01	b
Chlorine-36	3.5E-02	c
Cobalt-60	Unlimited	--
Curium-242	2.0E+04	f
Curium-243	8.5E+01	c, e
Curium-244	4.0E+1	c, e
Curium-245	5.5E-02	c, e
Curium-246	1.1E-01	c, e
Curium-247	3.0E-02	c, e
Curium-248	2.8E-02	c, e
Europium-150	1.7E+02	c
Europium-152	2.1E+07	b
Europium-154	Unlimited	--
Hydrogen-3	Unlimited	--
Iodine-129	8.0E-02	f
Lead-210	5.3E+05	c
Molybdenum-93	5.0E+01	c
Neptunium-237	1.5E-03	b, e
Nickel-59	2.1E+02	c
Nickel-59 (activated)	2.2E+02	f
Nickel-63	7.0E+02	f
Nickel-63 (activated)	7.0E+03	f
Niobium-94	1.2E-02	c
Niobium-94 (activated)	1.2E-01	c, d
Palladium-107	8.3E+02	c
Plutonium-238	1.5E+00	b, e
Plutonium-239	2.9E-02	b, e
Plutonium-240	2.9E-02	b, e
Plutonium-241	6.2E+00	c, e
Plutonium-242	1.1E-01	c
Plutonium-244	3.3E-02	c

Table B-2. Radionuclide Concentration Limits. (2 Pages)

Constituent	Limit (Ci/m^3)[a]	Notes
Potassium-40	9.5E-02	c
Radium-226 + daughters	1.4E-04	b
Radium-228	2.2E-04	b
Samarium-147	9.3E-01	c
Samarium-151	5.3E+04	c
Selenium-79	2.8E+01	c
Strontium-90	7.0E+03	f
Technetium-99	1.3E+00	c
Thorium-228 + daughters	1.2E-04	b
Thorium-232	6.0E-03	c
Tin-126	8.5E-03	c
Uranium-233/234	7.4E-02	b
Uranium-235	2.7E-03	b
Uranium-238 + daughters	1.2E-02	b
Zirconium-93	1.4E+02	C

[a] Radioactive waste Class C limits also apply (10 CFR 61).
[b] DOE/RL-93-99, *Remedial Investigation and Feasibility Study Report for the Environmental Restoration Disposal Facility.*
[c] BHI-00169, *Environmental Restoration Disposal Facility Performance Assessment.*
[d] Limit if nuclide contained in activated metal.
[e] Environmental Restoration Disposal Facility limit is lower of indicated value and transuranic limit of 100 nCi/g.
[f] Class C limit in accordance with 10 CFR 61.

10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste."

Three radionuclides require special consideration with regard to ERDF reporting: Tc-99, C-14, and total uranium. A "trigger level" is established in Table B-3 that identifies a concentration whereby further evaluation is required. Once this level is reported, the waste originator is required to further quantify the total curies of each of these isotopes, based on some quantifiable measurement, before the waste will be accepted for disposal. A potential waste form also must be identified in instances where the trigger level is exceeded. Depending on the total curies and waste form, some means of waste isolation (e.g., solidification, stabilization, and packaging) may be required before disposal is authorized.

Table B-3. Trigger Levels.

Radionuclide	Trigger Level (Total Ci)*
Technetium-99	0.6
Carbon-14	0.4
Total uranium	3.0

*Estimated total for entire profiled waste stream.

Polychlorinated Biphenyl Compounds

Waste containing polychlorinated biphenyl (PCB) concentrations of greater than 50 parts per million (ppm) shall be managed in accordance with 40 CFR 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions." Bulk liquids exceeding 500 ppm PCB concentrations may be disposed of at the ERDF provided the waste is pretreated and/or stabilized to eliminate the presence of free liquids before final disposal.

Liquid waste containing PCB concentrations of greater than 500 ppm cannot be disposed of at the ERDF. Nonliquid PCBs in the form of contaminated soil, rags, or other debris may be disposed of at the ERDF (this includes nonliquid waste with PCB concentrations greater than 500 ppm).

General Restrictions

The following materials are prohibited from being disposed at the ERDF:

- Waste capable of detonation, explosive decomposition or reaction at normal pressures and temperature, or explosive reaction with water. This includes unreacted alkali metal (e.g., sodium). Chemicals that react with atmospheric oxygen to form shock-sensitive organic peroxides are prohibited at concentrations that are capable of generating an explosive reaction.
- Waste capable of generating toxic gases, vapors, or fumes harmful to persons transporting, handling, and disposing the waste
- Gaseous waste packaged at a pressure in excess of 1.5 atmospheres at 20 °C (68 °F)
- Transuranic waste
- Spent nuclear fuel and high-level waste.

The following materials are restricted from disposal at the ERDF until the listed conditions have been met:

- All free-standing liquid has been decanted, solidified with nonbiodegradable sorbent materials, stabilized, or otherwise eliminated (WAC 173-303-140[4][b][ii] and WAC 173-303-140[4][b][iv]).
- Pyrophoric waste, unless treated, prepared, and packaged to be nonflammable before being disposed.
- Solid acid waste that exhibits the characteristic of low pH under the corrosivity tests of WAC 173-303-090(6)(a)(ii) or (iii), "Dangerous Waste Characteristics," "Characteristic of Corrosivity," unless exempted pursuant to WAC 173-303-140 or RCW 70.105.050(2), "Public Health and Safety," "Hazardous Waste Management."

- Refrigerant-bearing equipment containing chlorofluorocarbons, unless chlorofluorocarbon removal has been completed (40 CFR 82, "Protection of Stratospheric Ozone").

- Waste, materials, or containers that may adversely affect waste handlers or compromise facility or waste container performance.

- Dangerous/hazardous waste with greater than 10 percent organic/carbonaceous compounds, unless exempted pursuant to WAC 173-303-140 or RCW 70.105.050(2). (NOTE: The Hanford Site has a global exemption from this requirement for disposal of *radioactive* waste in the ERDF.)

- Waste exceeding the Class C limit, as defined in 10 CFR 61.55, "Licensing Requirements for Land Disposal of Radioactive Waste," "Waste Classification," unless justified by a specific performance assessment.

- Extremely hazardous waste, unless exempted pursuant to WAC 173-303-140 or RCW 70.105.050(2). This includes the Washington State-only extremely hazardous wastes for toxic and persistent compounds (waste codes WT01, WP01, or WP03) as defined in WAC 173-303-100, "Dangerous Waste Regulations," "Dangerous Waste Criteria." Waste that is excluded from disposal at the ERDF because of its classification under the waste code WT01 may be tested using bioassay methods to show that the waste actually should be classified as WT02, which can be accepted at the ERDF.

- Waste containing biological, pathogenic, or infectious material (including "any substance that may harbor or transmit pathogenic organisms" [e.g., septic tank sludge]) unless disinfected.

- Waste containing greater than 1 percent chelating compounds by weight, unless the waste has been solidified or stabilized.

- Waste containing less than 1 percent chelating compounds or that has been solidified or stabilized may be approved for disposal on a case-by-case basis, provided the chelating agents will not result in mobilization of radioisotopes.

Physical Limits

Packaged waste shall be structurally stable for disposal at the ERDF to limit potential subsidence. Packaged waste that is not structurally stable may be accepted at the ERDF on a case-by-case basis and stabilized before disposal. Depending on the waste stream, stabilization may be accomplished by using soil, cement-based or other stabilization agents with acceptable structural characteristics, size reduction, a mixture of biodegradable waste and stabilizing agents, and/or voids filled with stabilization agents. Additional physical limits for waste forms including concrete, steel plate, piping and tube steel, building debris, structural steel, containerized waste, equipment, soft waste, and rebar are defined in the supplemental waste acceptance criteria (0000X-DC-W0001, *Supplemental Waste Acceptance Criteria for Bulk Shipments to the Environmental Restoration Disposal Facility*).

REFERENCES

0000X-DC-W0001, 1997, *Supplemental Waste Acceptance Criteria for Bulk Shipments to the Environmental Restoration Disposal Facility*, Rev. 3, Bechtel Hanford, Inc., Richland, Washington.

10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste," Title 10, *Code of Federal Regulations*, Part 61.

10 CFR 61.55, "Licensing Requirements for Land Disposal of Radioactive Waste," "Waste Classification," Title 10, *Code of Federal Regulations*, Part 61.55.

40 CFR 82, "Protection of Stratospheric Ozone," Title 40, *Code of Federal Regulations*, Part 82.

40 CFR 268, "Land Disposal Restrictions," Title 40, *Code of Federal Regulations*, Part 268.

40 CFR 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions," Title 40, *Code of Federal Regulations*, Part 761.

BHI-00169, 1995, *Environmental Restoration Disposal Facility Performance Assessment*, Rev. 00, Bechtel Hanford, Inc., Richland, Washington.

DOE/RL-93-99, 1994, *Remedial Investigation and Feasibility Study Report for the Environmental Restoration Disposal Facility*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

RCW 70.105, "Public Health and Safety," "Hazardous Waste Management," Title 70, Chapter 105, *Revised Code of Washington*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-303-090(6), "Dangerous Waste Characteristics," "Characteristic of Corrosivity," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-303-100, "Dangerous Waste Regulations," "Dangerous Waste Criteria," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia,' Washington.

WAC 173-303-140, "Dangerous Waste Regulations," "Land Disposal Restrictions," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WCH-191, 2008, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*, Washington Closure Hanford, Richland, Washington. Available online at (http://www.wch-rcc.com/pgs/readroom/WCH/wch191.pdf.

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APPENDIX B

POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

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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
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
OU	operable unit
PCB	polychlorinated biphenyl
RCRA	*Resource Conservation and Recovery Act of 1976*
TBC	to be considered
TSCA	*Toxic Substances Control Act of 1976*
WAC	*Washington Administrative Code*

APPENDIX B

POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

B1.0 IDENTIFICATION OF POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS FOR THE 200-CW-5 OPERABLE UNITS

This appendix identifies and evaluates potential applicable or relevant and appropriate requirements (ARAR) for waste-site remediation in the 200-CW-5 Operable Units (OU). The potential ARARs identified in this appendix have been used to form the basis for the levels to which contaminants must be remediated to protect human health and the environment. The *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) provides for the identification of to-be-considered (TBC) nonpromulgated advisories, criteria, guidance, or proposed standards that may be consulted to interpret remediation goals when ARARs do not exist or are insufficient. Independent of the TBC and ARARs identification process at the Hanford Site, the requirements of U.S. Department of Energy (DOE) directives must be met.

Because the waste sites in the 200-CW-5 OU will be remediated under a CERCLA decision document, remedial and corrective actions at the sites will be required to meet ARARs. This appendix identifies and evaluates potential ARARs for these sites. Final ARARs for remediation will be established in the record of decision based on the selected remedy. In many cases, the ARARs form the basis for the preliminary remediation goals to which contaminants must be remediated to protect human health and the environment. In other cases, the ARARs define or restrict how specific remedial measures can be implemented.

The ARARs identification process is based on CERCLA guidance (EPA/540/G-89/006, *CERCLA Compliance with Other Laws Manual: Interim Final*, and EPA/540/G-89/004, *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final*, OSWER 9355.3-01). Section 121 of CERCLA as amended, requires, in part, that any applicable or relevant and appropriate standard, requirement, criterion, or limitation promulgated under any Federal environmental law, or any more stringent state requirement promulgated pursuant to a state environmental statute, be met (or a waiver justified) for any hazardous substance, pollutant, or contaminant that will remain on site after completion of remedial action.

An "applicable" requirement is a requirement that a private party would have to comply with by law if the same action were being undertaken apart from CERCLA authority. All jurisdictional prerequisites of the requirement must be met for the requirement to be applicable.

"Relevant and appropriate" requirements means those cleanup standards that address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site (40 CFR 300.5, "National Oil and Hazardous Substances Pollution Contingency Plan," "Definitions"). An ARAR may not meet one or more jurisdictional

prerequisites for applicability but still may make sense at the site, given the circumstances of the site and the release. In evaluating the relevance and appropriateness of a requirement, the eight comparison factors in 40 CFR 300.400(g)(2), "Identification of Applicable or Relevant and Appropriate Requirements," are considered:

1. The purpose of the requirement and the purpose of the CERCLA action
2. The medium regulated or affected by the requirement and the medium contaminated or affected at the CERCLA site
3. The substances regulated by the requirement and the substances found at the CERCLA site
4. The actions or activities regulated by the requirement and the remedial action contemplated at the CERCLA site
5. Any variances, waivers, or exemptions of the requirement and their availability for the circumstances at the CERCLA site
6. The type of place regulated and the type of place affected by the release or CERCLA action
7. The type and size of structure or facility regulated and the type and size of structure or facility affected by the release or contemplated by the CERCLA action
8. Any consideration of use or potential use of affected resources in the requirement and the use or potential use of the affected resource at the CERCLA site.

In addition, potential ARARs were evaluated to determine if they fall into one of three categories: chemical-specific, location-specific, or action-specific. These categories are defined as follows.

- Chemical-specific requirements are usually health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of public- and worker-safety levels and site-cleanup levels.
- Location-specific requirements are restrictions placed on the concentration of dangerous substances or the conduct of activities solely because they occur in special geographic areas.
- Action-specific requirements are usually technology- or activity-based requirements or limitations triggered by the remedial actions performed at the site.

In summary, a requirement is applicable if the specific terms or jurisdictional prerequisites of the law or regulations directly address the circumstances at a site. If not applicable, a requirement may nevertheless be relevant and appropriate if (1) circumstances at the site are, based on best professional judgment, sufficiently similar to the problems or situations regulated by the requirement and (2) the requirement's use is well suited to the site. Only the substantive

requirements (e.g., use of control/containment equipment, compliance with numerical standards) associated with ARARs apply to CERCLA on-site activities. ARARs associated with administrative requirements, such as permitting, are not applicable to CERCLA on-site activities (CERCLA, Section 121[e][1]). In general, this CERCLA permitting exemption will be extended to all remedial and corrective action activities conducted at the 200-CW-5 OU.

TBC information is nonpromulgated advisories or guidance issued by Federal or state governments that is not legally binding and does not have the status of potential ARARs. In some circumstances, TBCs will be considered along with ARARs in determining the remedial action necessary for protection of human health and the environment. The TBCs complement the ARARs in determining protectiveness at a site or implementation of certain actions. For example, because soil cleanup standards do not exist for all contaminants, health advisories, which would be TBCs, may be helpful in defining appropriate remedial action goals.

B1.1 WAIVERS FROM APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The U.S. Environmental Protection Agency (EPA) may waive ARARs and select a remedial action that does not attain the same level of site cleanup as that identified by the ARARs. Section 121 of the *Superfund Amendments and Reauthorization Act of 1986* identifies six circumstances in which the EPA may waive ARARs for on-site remedial actions. The six circumstances are as follows.

- The remedial action selected is only a part of a total remedial action (such as an interim action), and the final remedy will attain the ARAR upon its completion.
- Compliance with the ARAR will result in a greater risk to human health and the environment than alternative options.
- Compliance with the ARAR is technically impracticable from an engineering perspective.
- An alternative remedial action will attain an equivalent standard of performance with another method or approach.
- The ARAR is a state requirement that the state has not consistently applied (or demonstrated the intent to apply consistently) in similar circumstances.
- In the case of Section 104 (Superfund-financed remedial actions), compliance with the ARAR will not provide a balance between protecting human health and the environment and the availability of Superfund money for response at other facilities.

No waivers are being requested for the 200-CW-5 OU.

B1.2 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS APPLICABLE TO REMEDIAL ACTIONS FOR WASTE SITES IN THE 200-CW-5 OPERABLE UNITS

Potential Federal and state ARARs are presented in Tables B-1 and B-2, respectively. The chemical-specific ARARs likely to be most relevant to remediation of the 200-CW-5 OU are elements of the Washington State regulations that implement WAC 173-340, "Model Toxics Control Act -- Cleanup," specifically associated with developing risk-based concentrations for cleanup (WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties"). The requirements of WAC 173-340-745 help establish soil cleanup standards for nonradioactive contaminants at waste sites. The state air emission standards are likely to be important in identifying air emission limits and control requirements for any remedial actions that produce air emissions. *Resource Conservation and Recovery Act of 1976* (RCRA) land-disposal restrictions will be important standards during the management of wastes generated during remedial actions.

Action-specific ARARs that could be pertinent to remediation are state solid and dangerous waste regulations (for management of characterization and remediation of wastes and performance standards for waste left in place) and *Atomic Energy Act of 1954* regulations (for performance standards for radioactive waste sites). For radionuclides, all management is governed by DOE O 435.1, *Radioactive Waste Management*. DOE O 435.1 applies independent of the CERCLA ARARs and cannot be waived through the CERCLA process. However, certain requirements of DOE O 435.1 can be met onsite under CERCLA through implementation of CERCLA requirements.

During remediation, a variety of waste streams may be generated under the proposed remedial action alternatives. It is anticipated that most of the waste will be designated as low-level waste. However, quantities of dangerous or mixed waste and polychlorinated biphenyl (PCB)-contaminated waste also could be generated. The great majority of the waste will be in a solid form. Waste management will be conducted in accordance with an approved waste management plan.

The identification, storage, treatment, and disposal of hazardous waste and the hazardous component of mixed waste generated during the remedial action would be subject to the substantive provisions of RCRA. In the state of Washington, RCRA is implemented through WAC 173-303, "Dangerous Waste Regulations," which is an EPA-authorized State RCRA program. The substantive portions of the dangerous waste standards for generation and storage would apply to the management of any dangerous or mixed waste generated during this remedial action. Treatment standards for dangerous or mixed waste that is subject to RCRA land-disposal restrictions are specified in WAC 173-303-140, "Land Disposal Restrictions," which incorporates 40 CFR 268, "Land Disposal Restrictions," by reference.

The *Toxic Substances Control Act of 1976* (TSCA) and regulations at 40 CFR 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions," govern the management and disposal of PCB wastes. The TSCA regulations contain specific provisions for PCB waste, including PCB waste that contains a radioactive component. PCBs also are considered underlying hazardous constituents under RCRA and thus

could be subject to WAC 173-303 and 40 CFR 268 requirements for wastes that also designate as hazardous or mixed wastes.

Removal and disposal of asbestos and asbestos-containing material are regulated under the *Clean Air Act of 1990*, and 40 CFR 61, Subpart M, "National Emission Standards for Asbestos." These regulations provide for special precautions to prevent environmental releases or exposure to personnel of airborne emissions of asbestos fibers during remedial actions. Packaging requirements are identified in 40 CFR 61.52, "Emission Standard." Asbestos and asbestos-containing material would be removed, packaged as appropriate, and disposed of in the Environmental Restoration Disposal Facility (ERDF).

Waste designated as low-level waste that meets ERDF acceptance criteria is assumed to be disposed of at ERDF, which is engineered to meet appropriate performance standards of 10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste." In addition, waste designated as dangerous or mixed waste would be treated as appropriate to meet land-disposal restrictions and ERDF acceptance criteria, and would be disposed of at ERDF. ERDF is engineered to meet minimum technical requirements for landfills under WAC 173-303-665, "Landfills." Applicable packaging and pre-transportation requirements for dangerous or mixed waste generated at the 200-CW-5 OU would be identified and implemented before any waste is removed from the contamination area. Alternate disposal locations may be considered when the remedial action occurs, if a suitable and cost-effective location is identified. Any potential alternate disposal location will be evaluated by the EPA to ensure that it is adequately protective of human health and the environment.

Waste designated as PCB remediation waste likely would be disposed of at ERDF, depending on whether it is low-level waste and meets the waste acceptance criteria. PCB waste that does not meet ERDF waste acceptance criteria would be retained at a PCB storage area that meets the requirements for TSCA storage and would be transported for future treatment (if necessary) and disposal at an appropriate disposal facility.

CERCLA Section 104(d)(4) states that where two or more noncontiguous facilities are reasonably related on the basis of geography, or on the basis of the threat or potential threat to the public health or welfare or the environment, the facilities can be treated as one for purposes of CERCLA response actions. Consistent with this, the 200-CW-5 OU and ERDF would be considered onsite for purposes of Section 104 of CERCLA, and waste may be transferred between the facilities without requiring a permit.

All alternative actions will be performed in compliance with the waste management ARARs. Waste streams will be evaluated, designated, and managed in compliance with the ARAR requirements. Before disposal, waste will be managed in a protective manner to prevent releases to the environment or unnecessary exposure to personnel.

The proposed remedial action alternatives have the potential to generate airborne emissions of both radioactive and criteria/toxic pollutants.

The RCW 70.94, "Washington Clean Air Act," requires regulation of radioactive air pollutants. The state implementing regulation WAC 173-480, "Ambient Air Quality Standards and Emission Limits for Radionuclides," sets standards THAT are as stringent or more so than the

Federal standards under the Federal *Clean Air Act of 1990* and Amendments, and under the Federal implementing regulation, 40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities." The state standards protect the public by establishing exposure standards applicable to even the maximally exposed public individual, be that individual real or hypothetical. To that end, the standards address any member of the public, at the point of maximum annual air concentration in an unrestricted area where any member of the public may be. Radionuclide airborne emissions from the facility are not to exceed amounts that would cause an exposure to any said member of the public of greater than 10 mrem/yr effective dose equivalent. The state implementing regulation WAC 246-247, "Radiation Protection – Air Emissions," which adopts the WAC 173-480 standards, and requires verification of compliance with the 10 mrem/yr standard, would be applicable to the remedial action.

WAC 246-247 further addresses emission sources emitting radioactive airborne emissions by requiring monitoring of such sources. Such monitoring requires physical measurement of the effluent or ambient air. The substantive provisions of WAC 246-247 that require monitoring of radioactive airborne emissions would be applicable to the remedial action.

The above state-implementing regulations further address control of radioactive airborne emissions where economically and technologically feasible (WAC 246-247-040(3) and -040(4), "General Standards," and associated definitions). To address the substantive aspect of these requirements, best or reasonably achieved control technology will be addressed by ensuring that applicable emission control technologies (those successfully operated in similar applications) will be used when economically and technologically feasible (i.e., based on cost/benefit). If it is determined that there are substantive aspects of the requirement for control of radioactive airborne emissions, then controls will be administered as appropriate using reasonable and effective methods.

The Federal implementing regulations also contain requirements for managing asbestos material associated with demolition and waste disposal (40 CFR 61, Subpart M).

Table B-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and To Be Considered for the Remedial Action Sites. (2 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions," 40 CFR 761			
"Applicability," Specific Subsections: 40 CFR 761.50(b)(1) 40 CFR 761.50(b)(2) 40 CFR 761.50(b)(3) 40 CFR 761.50(b)(4) 40 CFR 761.50(b)(7) 40 CFR 761.50(c)	ARAR	These regulations establish standards for the storage and disposal of PCB wastes.	The substantive requirements of these regulations are applicable to the storage and disposal of PCB wastes (e.g., liquids, items, remediation waste, and bulk product waste) at $\geq$ 50 ppm. The specific subsections identified from 40 CFR 761.50(b) reference the specific sections for the management of PCB waste type. The disposal requirements for radioactive PCB waste are addressed in 40 CFR 761.50(b)(7). This is a chemical-specific requirement.

Table B-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and To Be Considered for the Remedial Action Sites. (2 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
Archeological and Historic Preservation Act (1960), 16 USC 469aa-mm	ARAR	Requires that remedial actions at 200-CW-5 Operable Unit waste sites do not cause the loss of any archaeological or historic data. This act mandates preservation of the data and does not require protection of the actual waste site or facility.	Archeological and historic sites have been identified within the 200 Areas; therefore, the substantive requirements of this act are applicable to actions that might disturb these sites. This is a location-specific requirement.
National Historic Preservation Act of 1966, 16 USC 470, Section 106	ARAR	Requires Federal agencies to consider the impacts of their undertaking on cultural properties through identification, evaluation and mitigation processes, and consultation with interested parties.	Cultural and historic sites have been identified within the 200 Areas; therefore, the substantive requirements of this act are applicable to actions that might disturb these types of sites. This is a location-specific requirement.
Native American Graves Protection and Repatriation Act, 25 USC 3001, et seq.	ARAR	Establishes Federal agency responsibility for discovery of human remains, associated and unassociated funerary objects, sacred objects, and items of cultural patrimony.	Substantive requirements of this act are applicable if remains and sacred objects are found during remediation and will require Native American Tribal consultation in the event of discovery. This is a location-specific requirement.
Endangered Species Act of 1973, 16 USC 1531 et seq., subsection 16 USC 1536(c)	ARAR	Prohibits actions by Federal agencies that are likely to jeopardize the continued existence of listed species or to result in the destruction or adverse modification or critical habitat. If remediation is within critical habitat or buffer zones surrounding threatened or endangered species, mitigation measures must be taken to protect the resource.	Substantive requirements of this act are applicable if threatened or endangered species are identified in areas where remedial actions will occur. This is a location-specific requirement.
***Atomic Energy Act of 1954*, 42 USC 2011, et seq.**			
DOE M 435.1-1 Specific subsections: Chapter IV, paragraph (P)(1) through (3)	TBC	Establishes performance objectives and performance assessment criteria for low-level waste disposal facilities.	The specified paragraphs provide criteria consistent with DOE expectations for protection of the public and the environment. This is an action-specific requirement.
Regulations pursuant to the *Resource Conservation and Recovery Act of 1976* and implemented through WAC 173-303, "Dangerous Waste Regulations" (see Table B-2).			

ARAR = applicable or relevant and appropriate requirement.
DOE = U.S. Department of Energy.
PCB = polychlorinated biphenyl.
TBC = to be considered.

Table B-2. Identification of Potential State Applicable or Relevant and Appropriate Requirements and To Be Considered for the Remedial Action Sites. (8 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Dangerous Waste Regulations," WAC 173-303			
"Identifying Solid Waste," WAC 173-303-016	ARAR	Identifies those materials that are and are not solid wastes.	Substantive requirements of these regulations are applicable, because these define how to determine which materials are subject to the designation regulations. Specifically, materials that are generated for removal from the CERCLA site during the remedial action would be subject to the procedures for identification of solid waste to ensure proper management. This is an action-specific requirement.
"Recycling Processes Involving Solid Waste," WAC 173-303-017	ARAR	Identifies materials that are and are not solid wastes when recycled.	Substantive requirements of these regulations are applicable, because these define how to determine which materials are subject to the designation regulations. Specifically, materials that are generated for removal from the CERCLA site during the remedial action would be subject to the procedures for identification of solid waste to ensure proper management. This is an action-specific requirement.
"Designation of Dangerous Waste," "Designation Procedures," WAC 173-303-070(3)	ARAR	Establishes the method for determining whether a solid waste is, or is not, a dangerous waste or an extremely hazardous waste.	Substantive requirements of these regulations are applicable to materials encountered during the remedial action. Specifically, solid waste that is generated for removal from the CERCLA site during this remedial action would be subject to the dangerous waste designation procedures to ensure proper management. This is an action-specific requirement.
"Excluded Categories of Waste," WAC 173-303-071	ARAR	Describes those categories of wastes that are excluded from the requirements of WAC 173-303 (excluding WAC 173-303-050).	The conditions of this requirement are applicable to remedial actions in the 200-CW-5 Operable Unit, should wastes identified in WAC 173-303-071 be encountered. This is an action-specific requirement.
"Conditional Exclusion of Special Wastes," WAC 173-303-073	ARAR	Establishes the conditional exclusion and the management requirements of special wastes, as defined in WAC 173-303-040.	Substantive requirements of these regulations are applicable to materials encountered during the remedial action. Specifically, the substantive standards for management of special waste are applicable to the interim management of certain waste that will be generated during the remedial action. This is an action-specific requirement.
"Requirements for Universal Waste," WAC 173-303-077	ARAR	Identifies those wastes exempted from regulation under WAC 173-303-140 and WAC 173-303-170 through 173-303-9907 (excluding WAC 173-303-960). These wastes are subject to regulation under WAC 173-303-573.	Substantive requirements of these regulations are applicable to materials encountered during the remedial action. Specifically, the substantive standards for management of universal waste are applicable to the interim management of certain waste that will be generated during the remedial action. This is an action-specific requirement.

Table B-2. Identification of Potential State Applicable or Relevant and Appropriate Requirements and To Be Considered for the Remedial Action Sites. (8 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Recycled, Reclaimed, and Recovered Wastes," WAC 173-303-120 Specific Subsections: WAC 173-303-120(3) WAC 173-303-120(5)	ARAR	These regulations define the requirements for recycling materials that are solid and dangerous waste. Specifically, WAC 173-303-120(3) provides for the management of certain recyclable materials, including spent refrigerants, antifreeze, and lead-acid batteries. WAC 173-303-120(5) provides for the recycling of used oil.	Substantive requirements of these regulations are applicable to certain materials that might be encountered during the remedial action. Recyclable materials that are exempt from regulation as dangerous waste and that are not otherwise subject to CERCLA as hazardous substances can be recycled and/or conditionally excluded from certain dangerous waste requirements. This is an action-specific requirement.
"Land Disposal Restrictions," "Land Disposal Restrictions and Prohibitions," WAC 173-303-140(4)	ARAR	This regulation establishes state standards for land disposal of dangerous waste and incorporates, by reference, Federal land-disposal restrictions of 40 CFR 268 that are applicable to solid waste that is designated as dangerous or mixed waste in accordance with WAC 173-303-070(3).	The substantive requirements of this regulation are applicable to materials encountered during the remedial action. Specifically, dangerous/mixed waste that is generated and removed from the CERCLA site during the remedial action for off-site (as defined by CERCLA) land disposal would be subject to the identification of applicable land-disposal restrictions at the point of generation of the waste. The actual off-site treatment of such waste would not be an ARAR to this remedial action, but instead would be subject to all applicable laws and regulations. This is an action-specific requirement.
"Requirements for Generators of Dangerous Waste," WAC 173-303-170	ARAR	Establishes the requirements for dangerous waste generators.	Substantive requirements of these regulations are applicable to materials encountered during the remedial action. Specifically, the substantive standards for management of dangerous/mixed waste are applicable to the interim management of certain waste that will be generated during the remedial action. For purposes of this remedial action, WAC 173-303-170(3) includes the substantive provisions of WAC 173-303-200, "Accumulating Dangerous Waste On-Site," by reference. WAC 173-303-200 further includes certain substantive standards from WAC 173-303-630, "Use and Management of Containers," and 173-303-640, "Tank Systems," by reference. This is an action-specific requirement.
"Model Toxics Control Act -- Cleanup," WAC 173-340 (as amended, February 2001)			
"Soil Cleanup Standards for Industrial Properties," WAC 173-340-745(5)(b) "Terrestrial Ecological Evaluation Procedures," WAC 173-340-7490 "Tables," WAC 173-340-900, Table 749-3	ARAR	Establishes the process and methods used to evaluate risk and to develop cleanup standards for soil and other environmental media.	The substantive requirements of the specified subsections are relevant and appropriate to developing cleanup standards for the selected remedy for the 200-CW-5 Operable Unit. This is a chemical-specific requirement.

Table B-2. Identification of Potential State Applicable or Relevant and Appropriate Requirements and To Be Considered for the Remedial Action Sites. (8 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Minimum Standards for Construction and Maintenance of Wells," WAC 173-160			
WAC 173-160-161	ARAR	Identifies well planning and construction requirements.	The substantive requirements of this regulation are applicable to actions that include construction of wells used for groundwater extraction, monitoring, or injection of treated groundwater or wastes. The requirements of WAC 173-160-161 through 173-160-381 (excluding 173-160-211, 173-160-251, 173-160-261, 173-160-361), 173-160-400, 173-160-420, 173-303-430, 173-160-440, 173-160-450, and 173-160-460 are applicable to groundwater well construction, monitoring, or injection of treated groundwater or wastes in the 200-CW-5 Operable Unit. This is an action-specific requirement.
WAC 173-160-171	ARAR	Identifies the requirements for locating a well.	
WAC 173-160-181	ARAR	Identifies the requirements for preserving natural barriers to groundwater movement between aquifers.	
WAC 173-160-191	ARAR	Identifies the design and construction requirements for completing wells.	
WAC 173-160-201	ARAR	Identifies the casing and liner requirements for water supply wells.	
WAC 173-160-221	ARAR	Identifies the requirements for sealing materials.	
WAC 173-160-231	ARAR	Identifies the requirements for surface seals on water wells.	
WAC 173-160-241	ARAR	Identifies the requirements for formation sealing.	
WAC 173-160-271	ARAR	Identifies the special sealing standards for driven wells, jetted wells, and dewatering wells.	
WAC 173-160-281	ARAR	Identifies the construction standards for artificial gravel-packed wells.	
WAC 173-160-291	ARAR	Identifies the standards for the upper terminal of water wells.	
WAC 173-160-301	ARAR	Identifies the requirements for the temporary surface barrier.	
WAC 173-160-311	ARAR	Identifies the requirements for well tagging.	
WAC 173-160-321	ARAR	Identifies the standards for testing a well.	
WAC 173-160-331	ARAR	Identifies the method for keeping equipment and the water well free of contaminants.	
WAC 173-160-341	ARAR	Identifies the method for ensuring the quality of the well water.	
WAC 173-160-351	ARAR	Identifies the standards for the installation of a pump.	
WAC 173-160-371	ARAR	Identifies the standard for chemical conditioning.	
WAC 173-160-381	ARAR	Identifies the standard for decommissioning a well.	

Table B-2. Identification of Potential State Applicable or Relevant and Appropriate Requirements and To Be Considered for the Remedial Action Sites. (8 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
WAC 173-160-400	ARAR	Identifies the minimum standards for resource protection wells and geotechnical soil borings.	
WAC 173-160-420	ARAR	Identifies the general construction requirements for resource protection wells.	
WAC 173-160-430	ARAR	Identifies the minimum casing standards.	
WAC 173-160-440	ARAR	Identifies the equipment cleaning standards.	
WAC 173-160-450	ARAR	Identifies the well sealing requirements.	
WAC 173-160-460	ARAR	Identifies the decommissioning process for resource protection wells.	
"Radiation Protection – Air Emissions," WAC 246-247			
WAC 246-247-035(1)(a)(ii)	ARAR	This regulation establishes requirements of 40 CFR 61, Subpart H, by reference. Radionuclide airborne emissions from the facility shall be controlled so as not to exceed amounts that would cause an exposure to any member of the public of greater than 10 mrem/yr effective dose equivalent.	Substantive requirements of this standard are applicable because this remedial action may include activities such as excavation, decontamination and stabilization of contaminated areas and equipment, and operation of exhausters and vacuums, each of which may provide airborne emissions of radioactive particulates to unrestricted areas. As a result, requirements limiting emissions apply. This is a risk-based standard for the purposes of protecting human health and the environment. This is an action-specific requirement.
"General Standards," WAC 246-247-040(3) WAC 246-247-040(4)	ARAR	Emissions shall be controlled to ensure that emission standards are not exceeded.	Substantive requirements of this standard are applicable because fugitive, diffuse, and point source emissions of radionuclides to the ambient air may result from activities such as excavation of contaminated soils and operation of exhauster and vacuums, performed during the remedial action. This standard exists to ensure compliance with emission standards. This is an action-specific requirement.

Table B-2. Identification of Potential State Applicable or Relevant and Appropriate Requirements and To Be Considered for the Remedial Action Sites. (8 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Monitoring, Testing, and Quality Assurance," WAC 246-247-075(1) and –(2) and –(4)	ARAR	Establishes the monitoring, testing, and quality assurance requirements for radioactive air emissions from major sources. Effluent flow rate measurements shall be made and the effluent stream shall be directly monitored continuously with an in-line detector or representative samples of the effluent stream shall be withdrawn continuously from the sampling site following the specified guidance. The requirements for continuous sampling are applicable to batch processes when the unit is in operation. Periodic sampling (grab samples) may be used only with lead agency prior approval. Such approval may be granted in cases where continuous sampling is not practical and radionuclide emission rates are relatively constant. In such cases, grab samples shall be collected with sufficient frequency to provide a representative sample of the emissions. When it is impractical to measure the effluent flow rate at a source in accordance with the requirements or to monitor or sample an effluent stream at a source in accordance with the site selection and sample extraction requirements, the facility owner or operator may use alternative effluent flow rate measurement procedures or site selection and sample extraction procedures as approved by the lead agency. Emissions from nonpoint and fugitive sources of airborne radioactive material shall be measured. Measurement techniques may include, but are not limited to sampling, calculation, smears, or other reasonable method for identifying emissions as determined by the lead agency.	Substantive requirements of this standard are applicable because fugitive and nonpoint source emissions of radionuclides to the ambient air may result from activities such as excavation of contaminated soils and operation of exhauster and vacuums, performed during the remedial action. This standard exists to ensure compliance with emission standards. This is an action-specific requirement.
"Monitoring, Testing, and Quality Assurance," WAC 246-247-075(3)	ARAR	Methods to implement periodic confirmatory monitoring for minor sources may include estimating the emissions or other methods approved by the lead agency.	Fugitive and diffuse emissions from the excavation and related activities will require periodic confirmatory measurements to verify low emissions and are applicable. This is an action-specific requirement.

Table B-2. Identification of Potential State Applicable or Relevant and Appropriate Requirements and To Be Considered for the Remedial Action Sites. (8 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Monitoring, Testing, and Quality Assurance," WAC 246-247-075(8)	ARAR	Facility (site) emissions resulting from nonpoint and fugitive sources of airborne radioactive material shall be measured. Measurement techniques may include ambient air measurements, or in-line radiation detector or withdrawal of representative samples from the effluent stream, or other methods as determined by the lead agency.	Fugitive and diffuse emissions of airborne radioactive material due to excavation and related activities will require measurement and are applicable. This is an action-specific requirement.
"General Standards," WAC 246-247-040(4) and "General Standards for Maximum Permissible Emissions," WAC 173-480-050-(1)	ARAR	At a minimum, all emission units shall make every reasonable effort to maintain radioactive materials in effluents to unrestricted areas ALARA. Control equipment of facilities operating under ALARA shall be defined as reasonably available control technology and as low as reasonably achievable control technology.	The potential for fugitive and diffuse emissions due to excavation and related activities will require efforts to minimize those emissions and are applicable. This is an action-specific requirement.
"Emission Monitoring and Compliance Procedures," WAC 173-480-070-(2)	ARAR	Compliance with the public dose standard shall be determined by calculating exposure at the point of maximum annual air concentration in an unrestricted area where any member of the public may be.	Fugitive and diffuse emissions resulting from excavation and related activities will require assessment and reporting and are applicable. This is an action-specific requirement.
"General Regulations for Air Pollution Sources," WAC 173-400			
"General Standards for Maximum Emissions," WAC 173-400-040	ARAR	Requires all sources of air contaminants to meet standards for visible emissions, fallout, fugitive emissions, odors, emissions detrimental to persons or property, sulfur dioxide, concealment and masking, and fugitive dust. Requires use of reasonably available control technology.	Substantive requirements are applicable to the selected remedy. The remedy likely will include or result in various sources of air contaminant emissions (e.g., construction and demolition debris, blowing dust or particulate) that will need to be controlled in accordance with these requirements. This is an action-specific requirement.

Table B-2. Identification of Potential State Applicable or Relevant and Appropriate Requirements and To Be Considered for the Remedial Action Sites. (8 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Emission Standards for Combustion and Incineration Units," WAC 173-400-050 "Emission Standards for General Process Units," WAC 173-400-060 "Emission Standards for Certain Source Categories," WAC 173-400-070 "Emission Standards for Sources Emitting Hazardous Air Pollutants," WAC 173-400-075	ARAR	Requires specifically identified types of emission sources to meet additional standards beyond the general emission standards imposed by WAC 173-400-040. Incorporates the applicable Federal requirements from 40 CFR Parts 60 and 63. Requires use of either reasonably available control technology, best available control technology or maximum achievable control technology, depending on the specific type of emission source.	The substantive requirements are applicable to the selected remedy. The remedy may include or result in one or more defined types of emission sources that would need to be controlled in accordance with these requirements. This is an action-specific requirement.
"Requirements for New Sources in Attainable or Unclassifiable Areas," WAC 173-400-113	ARAR	Incorporates by reference the applicable Federal requirements from 40 CFR 60, "Standards of Performance for New Stationary Sources"; 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants"; and 40 CFR 63, "National Emission Standards for Hazardous Air Pollutants for Source Categories" (maximum achievable control technology). Requires controls to minimize the release of air contaminants resulting from new or modified sources of regulated criteria and toxic air emissions. Emissions are to be minimized through application of best available control technology.	The Hanford Site is located in an area that is currently designated as being in attainment for all criteria air pollutants. The substantive requirements are applicable to the selected remedy. The remedy may include or result in one or more defined types of emission sources that would need to be controlled in accordance with these requirements. Selected remedy may include or result in the emission of regulated pollutants that would need to be controlled in accordance with these requirements. This is an action-specific requirement.

Table B-2. Identification of Potential State Applicable or Relevant and Appropriate Requirements and To Be Considered for the Remedial Action Sites. (8 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Controls for New Sources of Toxic Air Pollutants," WAC 173-460			
"Requirements, Applicability and Exemptions," WAC 173-460-030 "Control Technology Requirements," WAC 173-460-060 "Ambient Impact Requirement," WAC 173-460-070 "Demonstrating Ambient Impact Compliance," WAC 173-460-080 "Class A Toxic Air Pollutants," Known, Probable and Potential Human Carcinogens and Acceptable Source Impact Levels," WAC 173-460-150 "Class B Toxic Air Pollutants and Acceptable Source Impact Levels," WAC 173-460-160	ARAR	Requires best available control technology for regulated emissions of toxic air pollutants and demonstration that emissions of toxic air pollutants will not endanger human health or safety.	The substantive requirements are applicable to the selected remedy. The remedy may include or result in the emission of regulated toxic air pollutants that would need to be controlled in accordance with these requirements. This is an action-specific requirement.
"Asbestos," *Benton Clean Air Authority*, Regulation 1, Article 8			
Section 8.02, "CFR Adoption by Reference" Section 8.03, "General Requirements"	ARAR	Incorporates the Federal requirements of 40 CFR 61 Subpart M and 40 CFR 763 Subpart E by reference. Requires established controls and work practices for managing and disposing regulated asbestos-containing material.	The substantive requirements are applicable to the selected remedy. The remedy may include the removal or disturbance of regulated asbestos-containing material that must be conducted in accordance with the applicable requirements and work practices. This is an action-specific requirement.

ALARA = as low as reasonably achievable.
ARAR = applicable or relevant and appropriate requirement.
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*
TBC = to be considered.

B2.0 REFERENCES

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40 CFR 60, "Standards of Performance for New Stationary Sources," Title 40, *Code of Federal Regulations*, Part 60.

40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," Title 40, *Code of Federal Regulations*, Part 61.

- 40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities."
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- WAC 173-160-161, "How Shall Each Water Well be Planned and Constructed?"
- WAC 173-160-171, "What are the Requirements for the Location of the Well Site and Access to the Well?"
- WAC 173-160-181, "What are the Requirements for Preserving the Natural Barriers to Ground Water Movement Between Aquifers?"
- WAC 173-160-191, "What are the Design and Construction Requirements for Completing Wells?"
- WAC 173-160-201, "What are the Casing and Liner Requirements?"
- WAC 173-160-221, "What are the Standards for Sealing Materials?"
- WAC 173-160-231, "What are the Standards for Surface Seals?"
- WAC 173-160-241, "What are the Requirements for Formation Sealing?"
- WAC 173-160-271, "What are the Special Sealing Standards for Driven Wells, Jetted Wells, and Dewatering Wells?"
- WAC 173-160-281, "What are the Construction Standards for Artificial Gravel-Packed Wells?"
- WAC 173-160-291, "What are the Standards for the Upper Terminal of Water Wells?"
- WAC 173-160-301, "What are the Requirements for Temporary Capping?"
- WAC 173-160-311, "What are the Well Tagging Requirements?"
- WAC 173-160-321, "How do I Test a Well?"

- WAC 173-160-331, "How do I Make Sure My Equipment and the Water Well are Free of Contaminants?"
- WAC 173-160-341, "How do I Ensure the Quality of Drilling Water?"
- WAC 173-160-351, "What are the Standards for Pump Installation?"
- WAC 173-160-371, "What are the Standards for Chemical Conditioning?"
- WAC 173-160-381, "What are the Standards for Decommissioning a Well?"
- WAC 173-160-400, "What are the Minimum Standards for Resource Protection Wells and Geotechnical Soil Borings?"
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- WAC 173-160-430, "What are the Minimum Casing Standards?"
- WAC 173-160-440, "What are the Equipment Cleaning Standards?"
- WAC 173-160-450, "What are the Well Sealing Requirements?"
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- WAC 173-303-073, "Conditional Exclusion of Special Wastes."
- WAC 173-303-077, "Requirements for Universal Waste."
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- WAC 173-400-060, "Emission Standards for General Process Units."
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- WAC 173-400-075, "Emission Standards for Sources Emitting Hazardous Air Pollutants."
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- WAC 173-460-080, "Demonstrating Ambient Impact Compliance."
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APPENDIX C

TABLES FOR THE BASELINE HUMAN-HEALTH, SCREENING-LEVEL ECOLOGICAL, AND GROUNDWATER PROTECTION RISK ASSESSMENTS

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TERMS

BCG	biota concentration guide
bgs	below ground surface
COEC	contaminant of ecological concern
CONV	conventional parameter
CZ	contaminated zone
DC	direct contact
EPC	exposure-point concentration
GWP	groundwater protection
N/A	not available
ND	nondispersion
PEF	particulate emissions factor
PEST/PCB	pesticide/polychlorinated biphenyl
RBC	risk-based concentration
RCRA	*Resource Conservation and Recovery Act of 1976*
RESRAD	RESidual RADioactivity (dose model)
RI	remedial investigation
SVOC	semivolatile organic compound
SZ	saturated zone
VF	volatilization factor
VOC	volatile organic compound
WIDS	*Waste Information Data System* database

APPENDIX C

TABLES FOR THE BASELINE HUMAN-HEALTH, SCREENING-LEVEL ECOLOGICAL, AND GROUNDWATER PROTECTION RISK ASSESSMENTS

This appendix contains tables that support the discussion of risk in Chapter 3.0 of the feasibility study, which summarizes the detailed risk assessment presentation in the remedial investigation.. Tables C-1 through C-14 are a key subset of those in DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-CS-1 Steam Condensate Group Operable Units*. DOE/RL-2003-11 documents performance of the human-health, screening-level ecological, and groundwater protection risk assessments for waste sites of the 200-CW-5 Operable Unit within the scope of this feasibility study. In a few cases, most notably the RESidual RADioactivity (RESRAD) analyses, this appendix uses updated information not used in the remedial investigation reports.

Table C-1. Summary of Contaminants of Potential Concern at the Representative 216-Z-11 Ditch.

Constituent Name	216-Z-11 Ditch	
	Shallow Zone	Deep Zone
Nitrite (as N)	•	•
Boron	•	•
Chromium		•
Copper	•	•
Hexavalent chromium	•	•
Mercury	•	•
Molybdenum	•	•
Aroclor-1254	•	•
Aroclor-1260	•	•
Americium-241	•	•
Cesium-137	•	•
Neptunium-237		•
Plutonium-238	•	•
Plutonium-239/240	•	•
Radium-226	•	•
Strontium-90	•	•
Thorium-230	•	•
Acetone	•	•
Bis(2-ethylhexyl) phthalate	•	•
Methylene chloride	•	•

NOTE: Information is from DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-CS-1 Steam Condensate Group Operable Units.*

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Table C-2. Comparison of True Mean Shallow Soil Concentrations from the 216-Z-11 Ditch to Soil Human-Health Risk-Based Concentrations.

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Average Detected Result	Industrial Soil RBC*	Does Average Concentration Exceed Industrial Soil RBC?
CONV	Nitrite	mg/kg	2	2	100%	38	350,000	No
METAL	Boron	mg/kg	4	4	100%	6.7	315,000	No
METAL	Copper	mg/kg	4	4	100%	20	129,500	No
METAL	Hexavalent chromium	mg/kg	3	1	33%	0.33	10,500	No
METAL	Mercury	mg/kg	4	2	50%	0.19	1,050	No
METAL	Molybdenum	mg/kg	4	3	75%	1.7	17,500	No
PEST/PCB	Aroclor-1254	mg/kg	4	1	25%	13	70	No
PEST/PCB	Aroclor-1260	mg/kg	4	1	25%	19	66	No
SVOC	Bis(2-ethylhexyl) phthalate	mg/kg	3	1	33%	0.13	9,375	No
VOC	Acetone	mg/kg	3	3	100%	0.0080	3.15×10^{6}	No
VOC	Methylene chloride	mg/kg	3	2	67%	0.0053	17,500	No

NOTE: Constituent statistics and analytical results from Table 5-23 of DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-CS-1 Steam Condensate Group Operable Units.*

*WAC 173-340-745 calculations or CLARC Version 3.1, Table, Method C (Ecology 94-145).

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Ecology 94-145, *Model Toxics Control Act Cleanup Levels & Risk Calculations (CLARC) Version 3.1.*
WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties."

CONV = conventional parameter.
PEST/PCB = pesticide/polychlorinated biphenyl.
RBC = risk-based concentration.
SVOC = semivolatile organic compound.
VOC = volatile organic compound.

Table C-3. Comparison of Maximum Shallow-Zone Soil Concentrations from the 216-Z-11 Ditch to Industrial Ambient Air Risk-Based Concentrations.

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Maximum Detected Result	PEF or VF (m^3/kg)	1/PEF or 1/VF (kg/m^3)	Max Air Concentration (mg/m^3) [a]	Industrial Ambient Air RBC (mg/m^3) [b]	Does Maximum Air Concentration Exceed Ambient Air Industrial RBC?
METAL	Boron	mg/kg	4	4	100%	24	1.32×10^{9}	7.58×10^{-10}	1.80×10^{-8}	0.020	No
METAL	Copper	mg/kg	4	4	100%	30	1.32×10^{9}	7.58×10^{-10}	2.30×10^{-8}	--	--
METAL	Hexavalent chromium	mg/kg	3	1	33%	0.54	1.32×10^{9}	7.58×10^{-10}	4.09×10^{-10}	2.98×10^{-7}	No
METAL	Mercury	mg/kg	4	2	50%	0.66	1.32×10^{9}	7.58×10^{-10}	4.98×10^{-10}	--	--
METAL	Molybdenum	mg/kg	4	3	75%	0.77	1.32×10^{9}	7.58×10^{-10}	5.83×10^{-10}	--	--
PEST/PCB	Aroclor-1254	mg/kg	4	1	25%	52	1.32×10^{9}	7.58×10^{-10}	3.94×10^{-8}	4.38×10^{-5}	No
PEST/PCB	Aroclor-1260	mg/kg	4	1	25%	78	1.32×10^{9}	7.58×10^{-10}	5.88×10^{-8}	4.38×10^{-5}	No
SVOC	Bis(2-ethylhexyl) phthalate	mg/kg	3	1	33%	0.042	1.32×10^{9}	7.58×10^{-10}	3.18×10^{-11}	0.0063	No
VOC	Acetone	mg/kg	3	3	100%	0.014	12,554	7.97×10^{-5}	1.12×10^{-6}	0.35	No
VOC	Methylene chloride	mg/kg	3	2	67%	0.0080	2,425	4.12×10^{-4}	3.30×10^{-6}	0.053	No
CONV	Nitrite	mg/kg	2	2	100%	43	$1.32\text{x}10^{9}$	$7.58\text{x}10^{-10}$	$3.3\text{x}10^{-8}$	--	--

NOTE: Constituent statistics and analytical results from Table 5-29 of DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-CS-1 Steam Condensate Group Operable Units.*

[a] Maximum detected result divided by PEF or VF, as appropriate.
[b] WAC 173-340-750 and CLARC, Version 3.1, calculations.

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Ecology 94-145, *Model Toxics Control Act Cleanup Levels & Risk Calculations (CLARC) Version 3.1.*
WAC 173-340-750, "Cleanup Standards to Protect Air Quality."

-- = not available.
CONV = conventional parameter.
PEF = particulate emissions factor.
PEST/PCB = pesticide/polychlorinated biphenyl.
RBC = risk-based concentration.
SVOC = semivolatile organic compound.
VF = volatilization factor.
VOC = volatile organic compound.

Table C-4. Parameters Used for RESRAD Analysis. (7 Pages)

Description	Parameter	Units	216-Z-11 Ditch	Rationale and Citation
Exposure pathways	Industrial, direct-contact scenario	--	External gamma: active Inhalation: active Plant ingestion: suppressed Meat ingestion: suppressed Milk ingestion: suppressed Aquatic foods: suppressed Drinking water: suppressed Soil ingestion: active Radon: suppressed	Based on 200-CW-5 Operable Unit Work Plan (DOE/RL-99-66) conceptual exposure model and refinement of the model as part of the RI
	Groundwater protection scenario	--	External gamma: suppressed Inhalation: suppressed Plant ingestion: suppressed Meat ingestion: suppressed Milk ingestion: suppressed Aquatic foods: suppressed Drinking water: active Soil ingestion: suppressed Radon: suppressed	
R011 – CZ	Area of CZ	m^2	972	Site-specific areas from WIDS
	Thickness of CZ (industrial-DC)	m	4.6	Assumes that site is contaminated at 95% upper confidence limit from surface to 4.6 m bgs
	Thickness of CZ (no cover GWP)	m	6	Represents actual thickness of contamination based on RI results
	Length parallel to aquifer flow	m	9	--
	Radiation dose limit (industrial scenario)	mrem/yr	15	10 CFR 835
	Elapsed time since waste placement	yr	0	Environmental samples were collected in 1999
Exposure-point concentration	--	pCi/g	chemical-specific	All data are decayed to 2002

Table C-4. Parameters Used for RESRAD Analysis. (7 Pages)

Description	Parameter	Units	216-Z-11 Ditch	Rationale and Citation
R013 – cover and CZ hydrological data	Cover depth (no cover, industrial, direct contact and groundwater protection)	m	0	No cover
	Cover depth (cover, industrial, direct contact)	m	1	Represents actual conditions of cover based on RI results
	Cover material density (cover, industrial, direct contact)	g/cm^3	1.5	--
	Cover erosion rate (cover, industrial, direct contact)	m/yr	0.001	RESRAD default
	Density of CZ	g/cm^3	1.8	Site-specific values based on RI results
	CZ erosion rate	m/yr	0.001	RESRAD default
	CZ total porosity	unitless	0.33	Site-specific values based on physical property samples from RI and WHC-EP-0883
	CZ field capacity	unitless	0.2	Site-specific values based on physical property samples from RI and WHC-EP-0883
	CZ hydraulic conductivity	m/yr	22	WHC-SD-EN-SE-004
	CZ parameter	unitless	4.05	RESRAD Table E.2 (ANL/EAD-4); CCN 070578
	Average annual wind speed	m/sec	3.4	--
	Evapotranspiration coefficient	unitless	0.656	DOE/RL-2003-11
	Precipitation	m/yr	0.16	Based on 16 cm (6.3 in.) average annual rainfall (DOE/RL-90-07)

Table C-4. Parameters Used for RESRAD Analysis. (7 Pages)

Description	Parameter	Units	216-Z-11 Ditch	Rationale and Citation
R013 – cover and CZ hydrological data (Continued)	Irrigation rate (industrial, direct contact)	m/yr	0	Assumes no irrigation
	Irrigation rate (groundwater protection)	m/yr	0.76	--
	Irrigation mode	--	Overhead	RESRAD default
	Runoff coefficient (groundwater protection)	unitless	0.2	RESRAD default
	Watershed area for nearby stream or pond (groundwater protection)	m^2	1.00×10^6	RESRAD default
	Accuracy for water/soil computations (groundwater protection)	unitless	0.001	RESRAD default
R014 – SZ hydrological data	Density of SZ	g/cm^3	2.23	Site-specific value based on RI results and BHI-01177
	SZ total porosity	unitless	0.158	Site-specific values based on physical property samples from RI and WHC-EP-0883
	SZ effective porosity	unitless	0.158	Site-specific values based on physical property samples from RI and WHC-EP-0883
	SZ field capacity	unitless	0.04	Site-specific values based on physical property samples from RI and WHC-EP-0883
	SZ hydraulic conductivity	m/yr	5519	WHC-SD-EN-SE-004
	SZ parameter	unitless	4.05	RESRAD Table E.2 (ANL/EAD-4); CCN 070578
	Water table drop rate	m/yr	0.001	RESRAD default
	Well pump intake depth below water table	m	4.6	Typical RCRA well screen length
	ND or mass-balance	--	ND	RESRAD default
	Well pumping rate	m^3/yr	250	RESRAD default

Table C-4. Parameters Used for RESRAD Analysis. (7 Pages)

Description	Parameter	Units	216-Z-11 Ditch	Rationale and Citation
R015 – Uncon-taminated and unsaturated strata hydrological data	Number of unsaturated strata	--	3	Site-specific
	Thickness - Strata 1 (groundwater protection)	m	4	Site-specific values based on RI results and current water table elevation data
	Thickness - Strata 2 (groundwater protection)	m	30	Site-specific values based on RI results and current water table elevation data
	Thickness - Strata 3 (groundwater protection)	m	23.2	Site-specific values based on RI results and current water table elevation data
	Soil density (Strata 1) (groundwater protection)	g/cm^3	1.98	Hanford formation gravel-dominated sequence
	Soil density (Strata 2) (groundwater protection)	g/cm^3	1.5	Hanford formation sand-dominated sequence and Cold Creek unit
	Soil density (Strata 3) (groundwater protection)	g/cm^3	2.23	Ringold Unit E silty sandy gravel
	Total porosity/effective porosity (Strata 1) (groundwater protection)	unitless	0.253	Site-specific value based on RI results and BHI-01177
	Total porosity/effective porosity (Strata 2) (groundwater protection)	unitless	0.435	Site-specific values based on physical property samples from RI and WHC-EP-0883
	Total porosity/effective porosity (Strata 3) (groundwater protection)	unitless	0.158	Site-specific values based on physical property samples from RI and WHC-EP-0883
	Field capacity (groundwater protection)	unitless	0.04	Site-specific values based on physical property samples from RI and WHC-EP-0883
	Soil-specific parameter (groundwater protection)	unitless	4.05	RESRAD Table E.2 (ANL/EAD-4); CCN 070578
	Hydraulic conductivity (Strata 1) (groundwater protection)	m/yr	757	--
	Hydraulic conductivity (Strata 2) (groundwater protection)	m/yr	138	--
	Hydraulic conductivity (Strata 3) (groundwater protection)	m/yr	552	WHC-SD-EN-SE-004

Table C-4. Parameters Used for RESRAD Analysis. (7 Pages)

Description	Parameter	Units	216-Z-11 Ditch	Rationale and Citation
R016 – Distribution coefficients and leach rates for individual radionuclides	Distribution coefficients for contaminated zone, uncontaminated zone, and SZ	mL/g	Am-241: 300 Co-60: 1200 Cs-137: 1500 Cm-244: 100 Eu-152/154/155: 300 H-3: 0 Na-22: 10 Ni-63: 300 Np-237: 15 Pu-238/239/240: 200 Ra-226/228: 20 Sr-90: 20 Tc-99: 0 Th-228/230/232: 1000 U-232/234/235/238: 3 Sb-125: 0 Se-79: 0	PNNL-11800
	Saturated leach rate	L/yr	0	RESRAD default
R017 – Inhalation and external gamma	Inhalation rate	m^3/yr	7300	WDOH/320-015
	Mass loading for inhalation	g/m^3	0.0001	WDOH/320-015
	Exposure duration	year	30	WAC 173-340-750 and EPA/540/R-92/003
	Inhalation shielding factor	unitless	0.4	RESRAD default
	External gamma shielding factor	unitless	0.8	WDOH/320-015
	Indoor time fraction (industrial scenario)	unitless	0.137	200 Area industrial scenario; 8,760 h/yr, for calculation of indoor fraction onsite (60% of 2,000 h/yr)
	Outdoor time fraction (industrial scenario)	unitless	0.091	200 Area industrial scenario; 8,760 h/y, for calculation of outdoor fraction onsite (40% of 2,000 h/yr)
	Shape factor	unitless	1	RESRAD default

Table C-4. Parameters Used for RESRAD Analysis. (7 Pages)

Description	Parameter	Units	216-Z-11 Ditch	Rationale and Citation
R018 – Ingestion pathway data, dietary parameters	Soil ingestion (industrial, direct contact)	g/yr	36.5	WDOH/320-015
	Drinking water intake	L/yr	Not used	WDOH/320-015
	Drinking water intake	L/yr	730	Assumes drinking a volume of 2 L/day
	Drinking water contamination fraction	unitless	Not used	RESRAD default
	Drinking water contamination fraction	unitless	1	Assumes that all of the water is contaminated groundwater
R019 – Ingestion pathway data, non-dietary parameters	Depth of soil mixing layer	m	0.15	RESRAD default
	Groundwater fractional use - drinking water	unitless	Not used	RESRAD default
	Groundwater fractional use – drinking water	unitless	1	Assumes that all of the water used is groundwater

Table C-4. Parameters Used for RESRAD Analysis. (7 Pages)

Description	Parameter	Units	216-Z-11 Ditch	Rationale and Citation

10 CFR 835, "Occupational Radiation Protection."
ANL/EAD-4, *User's Manual for RESRAD, Version 6.*
BHI-01177, *Borehole Summary Report for the 216-B-2-2 Ditch.*
CCN 070578, "Estimation of the Soil-Specific Exponential Parameter(s)."
DOE/RL-90-07, *Remedial Investigation/Feasibility Study Work Plan for the 100-BC-1 Operable Unit, Hanford Site, Richland, Washington.*
DOE/RL-99-66, *Steam Condensate/Cooling Water Waste Group Operable Units RI/FS Work Plan; Includes: 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 Operable Units.*
DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-CS-1 Steam Condensate Group Operable Units.*
EPA/540/R-92/003, *Risk Assessment Guidance for Superfund: Volume I -- Human Health Evaluation Manual (Part B. Development of Risk-Based Preliminary Remediation Goals), Interim*, Publication 9285.7-01B.
PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site.*
Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.
WAC 173-340-750, "Cleanup Standards to Protect Air Quality."
WDOH/320-015, *Hanford Guidance for Radiological Cleanup.*
WHC-EP-0883, *Variability and Scaling of Hydraulic Properties for 200 Area Soils, Hanford Site.*
WHC-SD-EN-SE-004, *Site Characterization Report: Results of Detailed Evaluation of the Suitability of the Site Proposed for Disposal of 200 Areas Treated Effluent.*

-- = not available.
bgs = below ground surface.
CZ = contaminated zone.
DC = direct contact.
GWP = groundwater protection.
ND = nondispersion.
RCRA = *Resource Conservation and Recovery Act of 1976.*
RESRAD = RESidual RADioactivity (dose model).
RI = remedial investigation.
SZ = saturated zone.
WIDS = *Waste Information Data System* database.

Table C-5. RESRAD Dose Results – Without Cover.

Scenario	Total Dose (mrem/yr)	Time (years)	Primary Radionuclide	Percentage of Total Dose	Primary Pathway
Industrial, No Cover, Direct Contact	**216-Z-11 Ditch**				
	4.5×10^4	0	Plutonium-239	58%	Ground
			Radium-226	24%	
	4.5×10^4	1	Plutonium-239	58%	Ground
			Radium-226	24%	
	4.4×10^4	50	Plutonium-239	59%	Ground
			Radium-226	24%	
	4.2×10^4	150	Plutonium-239	61%	Ground
			Radium-226	23%	
	4.2×10^4	200	Plutonium-239	61%	Ground
			Radium-236	23%	
	4.0×10^4	300	Plutonium-239	63%	Ground
			Radium-226	22%	
	3.9×10^4	400	Plutonium-239	64%	Ground
			Radium-226	21%	
	3.8×10^4	500	Plutonium-239	66%	Ground
			Radium-226	20%	
	3.4×10^4	1,000	Plutonium-239	71%	Ground
			Radium-226	16%	

Table C-6. RESRAD Risk Results – Without Cover.

Scenario	Total Risk	Time (years)	Primary Radionuclide	Percentage of Total Risk	Primary Pathway
Industrial, No Cover, Direct Contact	**216-Z-11 Ditch**				
	0.28	0	Plutonium -239	24%	Ground
			Radium-226	66%	
	0.28	1	Plutonium -239	24%	Ground
			Radium-226	66%	
	0.27	50	Plutonium -239	25%	Ground
			Radium-226	67%	
	0.25	150	Radium-226	66%	Ground
			Plutonium -239	26%	
	0.25	200	Radium-226	65%	Ground
			Plutonium -239	27%	
	0.24	300	Radium-226	64%	Ground
			Plutonium -239	28%	
	0.22	400	Radium-226	63%	Ground
			Plutonium -239	30%	
	0.21	500	Radium-226	62%	Ground
			Plutonium -239	31%	
	0.17	1,000	Radium-226	55%	Ground
			Plutonium-239	38%	

Table C-7. RESRAD Dose Results – With Cover.

Scenario	Total Dose (mrem/yr)	Time (years)	Primary Radionuclide	Percentage of Total Dose	Primary Pathway
Industrial, Cover, Direct Contact	**216-Z-11 Ditch**				
	0.043	0	Radium-226	99%	Ground
	0.044	1	Radium-226	99%	Ground
	0.077	50	Radium-226	100%	Ground
	0.25	150	Radium-226	100%	Ground
	0.45	200	Radium-226	100%	Ground
	1.5	300	Radium-226	100%	Ground
	4.7	400	Radium-226	100%	Ground
	15	500	Radium-226	100%	Ground
	3.4×10^{4}	1000	Plutonium-239	71%	Soil Ingestion

Table C-8. RESRAD Risk Results – With Cover.

Scenario	Total Risk	Time (years)	Primary Radionuclide	Percentage of Total Risk	Primary Pathway
Industrial, Cover, Direct Contact	**216-Z-11 Ditch**				
	9.2×10^{-7}	0	Radium-226	99%	Ground
	9.3×10^{-7}	1	Radium-226	99%	Ground
	1.7×10^{-6}	50	Radium-226	100%	Ground
	5.3×10^{-6}	150	Radium-226	100%	Ground
	9.6×10^{-6}	200	Radium-226	100%	Ground
	3.1×10^{-5}	300	Radium-226	100%	Ground
	1.0×10^{-4}	400	Radium-226	100%	Ground
	3.3×10^{-4}	500	Radium-226	100%	Ground
	1.7×10^{-1}	1000	Radium-226	55%	Ground

Table C-9. Comparison of Shallow-Zone Soil Exposure-Point Concentrations to Background Concentrations and to Ecological Screening Levels for Nonradionuclides. (2 Pages)

Constituent Name	Constituent Class	Units	Exposure-Point Concentration	90th Percentile Background Concentration	Does the EPC Exceed Background?	Soil Indicator Value [a] (Wildlife)	COEC?	Justification
216-Z-11 Ditches [b]								
Nitrite	CONV	mg/kg	5	N/A	N/A	N/A	No	No ecological indicator value
Arsenic	METAL	mg/kg	6.2	20	No	7	No	Below background
Barium	METAL	mg/kg	88	132	No	102	No	Below soil indicator value
Beryllium	METAL	mg/kg	0.25	1.5	No	N/A	No	Below background
Boron	METAL	mg/kg	24	N/A	N/A	N/A	No	No ecological indicator value
Cadmium	METAL	mg/kg	0.050	1.0	No	14	No	Below background
Chromium	METAL	mg/kg	11	18.5	No	67	No	Below background
Copper	METAL	mg/kg	30	22	Yes	217	No	Below soil indicator value
Hexavalent chromium	METAL	mg/kg	0.54	N/A	N/A	67	No	Below soil indicator value
Lead	METAL	mg/kg	7.1	10	No	118	No	Below background
Magnesium	METAL	mg/kg	4,760	N/A	N/A	N/A	No	No ecological indicator value
Mercury	METAL	mg/kg	0.66	0.33	Yes	5.5	No	Below soil indicator value
Molybdenum	METAL	mg/kg	0.77	N/A	N/A	7	No	Below soil indicator value
Nickel	METAL	mg/kg	11	19.1	No	980	No	Below background
Silver	METAL	mg/kg	0.69	0.73	No	N/A	No	Below background
Vanadium	METAL	mg/kg	58	85.1	No	N/A	No	Below background
Zinc	METAL	mg/kg	63	67.8	No	360	No	Below background

Table C-9. Comparison of Shallow-Zone Soil Exposure-Point Concentrations to Background Concentrations and to Ecological Screening Levels for Nonradionuclides. (2 Pages)

Constituent Name	Constituent Class	Units	Exposure-Point Concentration	90th Percentile Background Concentration	Does the EPC Exceed Background?	Soil Indicator Value[a] (Wildlife)	COEC?	Justification
Aroclor-1254	PEST/PCB	mg/kg	52	N/A	N/A	0.65	Yes	Exceeds ecological indicator value
Aroclor-1260	PEST/PCB	mg/kg	78	N/A	N/A	0.65	Yes	No ecological indicator value

[a] WAC-173-340-900, "Tables," Table 749-3, "Ecological Indicator Soil Concentration (mg/kg) for Protection of Terrestrial Plants and Animals."

[b] Constituent statistics and analytical results from Table 5-39 of DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-CS-1 Steam Condensate Group Operable Units.*

Aroclor is an expired trademark.

COEC = contaminant of ecological concern.
CONV = conventional parameter.
EPC = exposure-point concentration.
N/A = not available.
PEST/PCB = pesticide/polychlorinated biphenyl.

Table C-10. Comparison of Shallow-Zone Soil Exposure-Point Concentrations to Background and to Ecological Screening Values for Radionuclides (units in pCi/g).

Constituent Name	Number of Samples	Number of Detects	Frequency of Detection	Exposure-Point Concentration	90th Percentile Background Concentration	Exceeds Background?	BCG [a]	COEC?	Justification
216-Z-11 Ditches [b]									
Americium-241	286	284	99%	76,152	N/A	U	4,000	Yes	Exceeds BCGs
Cesium-137	187	184	98%	951	0.919	Yes	20	Yes	Exceeds BCGs
Plutonium-238	62	54	87%	5,500	0.0047	Yes	5,400	Yes	Exceeds BCGs
Plutonium-239	15	15	100%	780,000	N/A	U	6,000	Yes	Exceeds BCGs
Plutonium-239/240	268	266	99%	132,229	0.0192	Yes	6,000	Yes	Exceeds BCGs
Radium-226	12	12	100%	5,200	0.815	Yes	50	Yes	Exceeds BCGs
Radium-228	4	2	50%	0.81	N/A	U	40	No	Below BCG
Strontium-90	30	23	77%	23	0.167	Yes	20	Yes	Requires further evaluation
Thorium-228	4	1	25%	0.66	N/A	U	N/A	No	No BCGs
Thorium-232	4	1	25%	0.71	1.32	No	2,000	No	Below background
Uranium-233/234	4	1	25%	0.36	1.1	No	5,000	No	Below background
Uranium-238	4	2	50%	0.77	1.1	No	5,000	No	Below background

[a] DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*, Table 6.4.
[b] Constituent statistics and analytical results from Table 5-40 of DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-CS-1 Steam Condensate Group Operable Units.*

BG = biota concentration guide.
COEC = contaminant of ecological concern.
N/A = not available.
U = undetermined.

Table C-11. Comparison of True Mean Deep-Zone Soil Concentrations from the 216-Z-11 Ditch to Soil Risk-Based Concentrations for Groundwater Protection.

Constituent Class	Constituent Name	Units	Number of Samples	Number of Detects	Frequency of Detection	Average Detected Result	GWP RBC*	Does True Mean Exceed GWP RBC?
CONV	Nitrite (as NO_2)	mg/kg	3	3	100%	33	13	Yes
METAL	Boron	mg/kg	11	11	100%	2.9	11	No
METAL	Total chromium	mg/kg	11	11	100%	11	2,000	No
METAL	Copper	mg/kg	11	11	100%	16	263	No
METAL	Hexavalent chromium	mg/kg	10	4	40%	0.47	18	No
METAL	Mercury	mg/kg	11	2	18%	0.075	2.1	No
METAL	Molybdenum	mg/kg	11	10	91%	1.0	16	No
PEST/PCB	Aroclor-1254	mg/kg	11	1	9%	4.7	0.99	Yes
PEST/PCB	Aroclor-1260	mg/kg	11	1	9%	7.1	8.2	No
SVOC	Bis(2-ethylhexyl) phthalate	mg/kg	10	3	30%	0.14	14	No
VOC	Acetone	mg/kg	10	10	100%	0.0075	29	No
VOC	Methylene chloride	mg/kg	10	9	90%	0.0060	0.025	No

NOTE: Constituent statistics and analytical results from Table 5-26 of DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-CS-1 Steam Condensate Group Operable Units.*

WAC 173-340-745 calculation or CLARC Version 3.1, Table, Method C (Ecology 94-145).

Aroclor is an expired trademark.

Ecology 94-145, *Model Toxics Control Act Cleanup Levels & Risk Calculations (CLARC) Version 3.1.*
WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties."

CONV = conventional parameter.
GWP = groundwater protection.
PEST/PCB = pesticide/polychlorinated biphenyl.
RBC = risk-based concentration.
SVOC = semivolatile organic compound.
VOC = volatile organic compound.

Table C-12. RESRAD Dose Results for Groundwater Protection.

Scenario	Total Dose (mrem/yr)	Time (years)	Primary Radionuclide	Percentage of Total Dose	Primary Pathway
Groundwater Protection, No Cover	216-Z-11 Ditch				
	0.0	0	--	--	Drinking water
	0.0	1	--	--	Drinking water
	0.0	50	--	--	Drinking water
	0.0	150	--	--	Drinking water
	0.0	200	--	--	Drinking water
	0.0	300	--	--	Drinking water
	0.0	400	--	--	Drinking water
	0.0	500	--	--	Drinking water
	0.0	1,000	--	--	Drinking water

NOTE: RESRAD calculation assumed no soil cover.

RESRAD = RESidual RADioactivity (ANL/EAD-4, *User's Manual for RESRAD, Version 6*).

Table C-13. RESRAD Risk Results for Groundwater Protection.

Scenario	Total Risk	Time (years)	Primary Radionuclide	Percentage of Total Risk	Primary Pathway
Groundwater Protection, No Cover	216-Z-11 Ditch				
	0.0	0	--	--	Drinking water
	0.0	1	--	--	Drinking water
	0.0	50	--	--	Drinking water
	0.0	150	--	--	Drinking water
	0.0	200	--	--	Drinking water
	0.0	300	--	--	Drinking water
	0.0	400	--	--	Drinking water
	0.0	500	--	--	Drinking water
	0.0	1,000	--	--	Drinking water

NOTE: RESRAD calculation assumed no soil cover.

RESRAD = RESidual RADioactivity (ANL/EAD-4, *User's Manual for RESRAD, Version 6*).

Table C-14. 216-Z-11 Ditch Contaminants Modeled with STOMP.

Americium-241	Strontium-90
Cesium-137	Thorium-230
Plutonium-239	Aroclor-1254
Plutonium-239/240	Aroclor-1260

NOTE: From DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-CS-1 Steam Condensate Group Operable Units.*

Aroclor is an expired trademark.

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

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APPENDIX D

COST ESTIMATE BACKUP

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TERMS

ERDF	Environmental Restoration Disposal Facility
FH	Fluor Hanford, Inc.
FP	fixed price
FS	feasibility study
IC	institutional control
ISV	in situ vitrification
MESC/MNA/IC	Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls
QA	quality assurance
RCT	radiological control technician
RTD	removal, treatment, and disposal
SWB	standard waste box
TRU	Radioactive waste as defined in DOE G 435.1-1, *Implementation Guide for Use with DOE M 435.1-1*
WIPP	Waste Isolation Pilot Plant

APPENDIX D

COST ESTIMATE BACKUP

D1.0 INTRODUCTION

The cost estimates for the feasibility study (FS) are developed in accordance with guidance specified in EPA/540/R-00/002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, OSWER 9355.0-75. The cost estimates provide a discriminator for deciding between similar protective and implemental alternatives for a specific waste site. Therefore, the costs are relational, not absolute, costs for the evaluation of the alternatives. Cost estimates for the alternatives are developed using the MAESTRO[1] Estimator cost models developed by the Fluor Hanford, Inc. (FH), Project Controls and Estimating department.

The estimates have been based on actual pricing information derived from historical experience. The units used may have been factored/adjusted by the estimator and/or task lead, as appropriate, to reflect influences by the contract, work site, or other identified special conditions. Historical information from similar Hanford Site planning and construction well-drilling activities has been applied to this estimate.

The costs are presented in present-net-worth values. The present-net-worth value method is used to evaluate costs that occur during different time periods and allows for cost comparisons of alternatives based on a single cost number for each alternative. The present-net-worth value represents the dollars that would need to be set aside today to ensure that funds would be available in the future as they are needed to execute the remedial alternative.

Present-net-worth costs are estimated using the real discount rate published in Appendix C of OMB Circular No. A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, effective through January 2008. Programs with durations longer than 30 years use the 30-year interest rate of 3.0 percent. Present-net-worth costs are discussed for each alternative in the following subsections. The period of analysis for the present-net-worth cost is 150 years based on Klein et al., 2002, "Consensus Advice #132: Exposure Scenarios Task Force on the 200 Area."

EPA/540/R-00/002 recommends including the nondiscounted costs in the FS. Nondiscounted constant dollar costs demonstrate the impact of a discount rate on the total present value cost. The nondiscounted costs are calculated for 150-year duration and are presented for comparison purposes only.

This FS does not evaluate the economies associated with implementing multiple sites or groups with a common alternative or aggregated remediation. They will be considered in the future as part of long-range planning and through the post-record-of-decision activities, such as remedial design. Potential areas of cost sharing to reduce overall remediation costs include the following:

- Remediating all waste sites with a common preferred alternative at the same time
- Sharing mobilization/demobilization costs
- Sharing surveillance and maintenance costs
- Sharing barrier performance monitoring costs.

[1] MAESTRO is a copyright of Schwaab Technology Solutions, Inc., Newman Lake, Washington.

D2.0 BASIS OF ESTIMATES

The remedial alternatives are discussed in detail in Chapters 5.0 and 6.0 of this FS. This appendix summarizes the alternatives described in the FS and provides backup information and assumptions used in developing the cost estimates for the remedial alternatives.

Table D-1 provides an overview of the site information used for the cost estimates. Table D-2 provides a summary of the costs for the alternatives.

D2.1 GLOBAL ASSUMPTIONS

D2.1.1 Labor

Fixed-price (FP) construction craft labor rates are those listed in Appendix A of the *Site Stabilization Agreement for All Construction Work for the U.S. Department of Energy at the Hanford Site* (commonly known as the Hanford Site Stabilization Agreement). The Hanford Site Stabilization Agreement rates include base wage, fringe benefits, and other compensation as negotiated between FH and the National Building and Construction Trades Department American Federation of Labor-Congress of Industrial Organizations. Other factors to cover additional costs for Workman's Compensation, *Federal Insurance Contributions Act*, and state and Federal unemployment insurance to develop a fully burdened rate by craft have been incorporated. The labor rates used are for 2007.

FH labor rates for management, engineering, safety oversight, and technical support are based on the FH approved planning rates for fiscal year 2007.

D2.1.2 Markups

D2.1.2.1 Direct Cost Factors

Sales tax has been applied to all materials and equipment purchases at 8.3 percent.

Construction consumables are estimated at 3.5 percent of FP direct craft labor costs to allow for small tools, tape, plastics, gloves, etc.

General supervisor factor of 3 percent has been applied to FP craft labor hours.

General requirements factor of 5 percent has been applied to cover incidental labor for hauling personnel and materials along with other miscellaneous labor.

Table D-1. Capital-Cost Breakdown for the 200-CW-5 Operable Unit (Dollars in Thousands). 1

	Alternative 2	Alternative 3	Alternative 4	Alternative 5A	Alternative 5B	Alternative 6A	Alternative 6B
	MESC/MNA/IC	RTD Work Areas 1, 2, and 3	Barrier	Barrier Work Area 2 - RTD Work Areas 1 and 3	RTD Work Area 2, Full Site Barriers Work Areas 1 and 3	ISV, Barrier, Work Area 2 - RTD Work Areas 1 and 3	ISV Work Area 2 and Barrier All Work Areas
Mobilization/ Demobilization	$0	$858.0	$377.0	$1,034.6	$474.4	$1,910.5	$1,526.9
Monitoring & Sampling	$0	$4,236.0	$12.9	$1,764.0	$2,489.8	$3,898.6	$2,152.4
Site Work	$0	$2,852.5	$196.9	$2,112.3	$970.9	$2,410.2	$528.6
Soil Excavation	$0	$96,804.1	$0	$20,64.5	$76,162.7	$20,641.5	$0
Treatment	$0	$0	$0	$0	$0	$165,090.5	$165,090.5
Cap	$0	$0	$8,023.0	$2,712.8	$5,092.8	$2,712.8	$7,805.5
Construction Staff	$1.2	$4,454.8	$1,327.0	$3,773.2	$2,085.7	$3,944.0	$1,574.8
Project Management	$2.4	$2,477.9	$794.1	$2,111.6	$1,202.9	$5,745.6	$4,470.6
Sub Total	$3.6	$111,683.3	$10,730.9	$34,149.9	$88,479.0	$206,353.6	$183,149.3
Contingency (30%)	$1.1	$33,505.0	$3,219.3	$10,245.0	$26,543.7	$61,906.1	$54,944.8
Remedial Design *	$20.0	$8,711.3	$837.0	$2,663.7	$6,901.4	$16,095.6	$14,285.6
Total Capital Project	$24.7	$153,899.6	$14,787.1	$47,058.6	$121,924.1	$284,355.3	$252,379.8
Duration of Field Work (Days)	60	1,040	394	676	337	1,439	1,439

*Remedial design capital costs are based on EPA/540/R-00/002, Exhibit 5-8.

For projects with construction costs from $500,000 to $2 million – remedial design is planned at 12% of construction costs.
For projects with construction costs from $2 million to $10 million – remedial design is planned at 8% of construction costs.
For projects with construction costs greater than $10 million – remedial design is planned at 6% of construction costs.
For Alternative 2, the remedial design is planned at $20,000.
EPA/540/R-00/002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, OSWER 9355.0-75.
ISV = in situ vitrification.
MESC/MNA/IC = Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls.
RTD = removal, treatment, and disposal.

Table D-2. Site Summary Sheet for 200-CW-5 Operable Unit Capital Costs, Periodic Costs, Nondiscounted Costs, and Present-Worth Costs.

200-CW-5 Operable Unit Feasibility Cost Study (Dollars in Thousands)				
Alternative	**Total Capital Cost**	**Nondiscounted Annual & Periodic Cost**	**Non-discounted Cost**	**Total Present-Worth Cost**
Alt 2 – MESC/MNA/IC	$24.7	$42,476.9	$42,501.6	**$9,950.1**
Alt 3 – RTD Work Areas 1, 2, and 3	$153,899.6	$0	$153,899.6	**$145,742.9**
Alt 4 – Barrier	$14,787.1	$98,738.0	$113,525.1	**$37,218.7**
Alt 5A – Barrier Work Area 2 – RTD Work Areas 1 and 3	$47,058.6	$43,583.0	$90,641.6	**$55,558.8**
Alt 5B – RTD Work Area 2, Full Site Barrier Work Areas 1 and 3	$121,924.1	$75,238.2	$197,162.3	**$137,508.7**
Alt 6A – ISV with Barrier Work Area 2 – RTD Work Areas 1 and 3	$284,355.3	$14,201.7	$298,557.0	**$268,655.0**
Alt 6B – ISV Area 2 and Barrier All Work Areas	$252,379.8	$96,122.0	$348,501.7	**$256,033.9**

ISV = in situ vitrification.
MESC/MNA/IC = Maintain Existing Soil Cover, Monitored Natural Attenuation, and Institutional Controls.
RTD = removal, treatment, and disposal.

D2.1.2.2 Indirect Cost Factors

FP contractor overhead, profit, bond, and insurance costs have been applied at 26.5 percent on FP labor, materials, and equipment.

FH general and administrative of 16.53 percent has been applied to all FH labor, material, and equipment. General and administrative also is applied to the FP contractor costs.

D2.1.3 General Assumptions

FH cost estimating templates for site remediation are used as the basis for each waste-site cost estimate.

- Construction labor, material, and equipment units are estimated based on standard commercial estimating resources and databases: Means, 2001, *ECHOS Environmental Remediation Cost Data – Unit Price*; Means, 2007, *Facility Construction Cost Data*; Richardson's *Process Plant Construction Estimating Standards*; and the Equipment Watch *Rental Rate Blue Book for Construction Equipment*. The units may have been factored or adjusted by the estimator as appropriate to reflect influences by contract, work site, or other identified project or special conditions.

- Quotes from local commercial sources are used for materials that need to be acquired for the construction of barriers or temporary improvements.

- Equipment rates are based on 21 working days per month.
- Equipment operation is based on one shift of 8 hours per day.
- Workweek equals 5 days per week.
- Work stoppages or shutdowns caused by inclement weather are not factored into the estimates or planning schedules for this study.
- Work delays or stoppages caused by waiting for laboratory results or approval for backfilling waste-site excavations are not factored into the estimates or planning schedules for this study.
- The cost estimates include costs for design, work plan preparation, or any other preparation costs normally associated with activities occurring before field mobilization.
- Remedial design capital costs are based on EPA/540/R-00/002, Exhibit 5-8. The following guide is used in this study.
  - For projects with construction costs less than $100,000 – remedial design is planned at 20 percent of construction costs.
  - For projects with construction costs from $100,000 to $500,000 – remedial design is planned at 15 percent of construction costs.
  - For projects with construction costs from $500,000 to $2 million – remedial design is planned at 12 percent of construction costs.
  - For projects with construction costs from $2 million to $10 million – remedial design is planned at 8 percent of construction costs.
  - For projects with construction costs greater than $10 million – remedial design is planned at 6 percent of construction costs.
- Escalation has not been included in the calculations. All costs are present day (fiscal year 2008).
- Contingency rates are based on EPA/540/R-00/002, Section 5.4.
- All borrow source materials are assumed to come from an on-site source. During the remedial design, the actual borrow source location will be identified and will comply with all *National Environmental Policy Act of 1969* requirements.

D2.1.4 Long-Term Groundwater-Monitoring Costs

Each alternative, except the No-Action Alternative, includes annual inspections and maintenance costs for periodic groundwater monitoring. The cost associated with periodic groundwater monitoring is distributed equally over applicable closure zones. The following is a description of the periodic groundwater costs.

Periodic groundwater sampling will be performed in each closure zone located at the facility. Each closure zone will contain three monitoring wells that will be sampled during the periodic sampling event. The present-worth cost for the periodic groundwater-monitoring program will be the same

for each closure zone. That cost then will be divided equally among the sites within that closure zone. A summary of the facility closure zones associated with this FS is presented as follows.

Closure Zone	Number of Sites in Each Closure Zone
Plutonium Finishing Plant	40

Based on historical information from similar Hanford Site planning, the cost to install a compliant monitoring well is approximately $180,000 per well. It is assumed that this cost includes all required labor and material.

- Cost to install wells (3 wells) = $180,000/well × 3 wells
  = $540,000

Maintenance will be performed on each of the wells every 5 years during the 150-year active monitoring period. In addition, each of the wells will be replaced once every 30 years.

- Maintenance costs (3 wells) = $5,000/well × 3 wells
  = $15,000 every 5 years
- Replacement costs (3 wells) = $180,000/well × 3 wells
  = $540,000 every 30 years

During each sampling event, three groundwater samples will be collected for analysis. The analyses and cost per analysis are listed below.

- Am-241 = $125/sample × 3 samples/event = $375/event
- Pu-238, -239, -240, -241 = $300/sample × 3 samples/event = $900/event
- Volatile organic compounds = $85/sample × 3 samples/event = $255/event
- Tc-99 = $150/sample × 3 samples/event = $450/event

Total analytical cost per sampling event is $1,980.

The labor cost of doing all the paperwork, labeling, monitoring, and delivery to the laboratory is approximately $300 per well sampled.

- Total labor cost = $300/well × 3 wells
  = $900/sampling event

Total cost to collect and analyze samples per sampling event is $2,880.

Sampling events will occur at the following frequencies:

Year 1 through 30 years (life)	Semiannually (two sampling events).

The present-worth cost to conduct a periodic groundwater-monitoring program for each closure zone for 30 years was calculated.

The present-worth cost for a long-term groundwater-monitoring program is $680,153.

As a comparison, the nondiscounted present-worth cost for a long-term groundwater-monitoring program was calculated to compare the effect of a discount rate on the total project cost.

Present-worth nondiscounted costs for a long-term groundwater-monitoring program is $4,129,200.

The present-worth cost, on a per-site basis, will be added to the calculated costs. The long-term groundwater-monitoring cost per site for the Plutonium Finishing Plant closure zone is shown below. The nondiscounted long-term groundwater-monitoring cost per site is presented in parentheses.

Closure Zone	Number of Sites in Each Closure Zone	Cost per Site
Plutonium Finishing Plant	40	$17,004 ($103,230)

This cost will be added into the costs for the Alternatives 2, 4, 5A, 5B, 6A, and 6B.

D2.2 NO-ACTION ALTERNATIVE

The No-Action Alternative represents a situation where no legal restrictions, access controls, or active remedial measures are applied to the waste site. Taking no action implies "walking away from the waste site" and allowing the waste to remain in its current configuration, affected only by natural processes. No maintenance or institutional controls are included in this alternative.

Because the No-Action Alternative assumes no further actions will be taken at a waste site, costs are assumed to be zero.

D2.3 INSTITUTIONAL CONTROLS

Institutional controls, which can have one-time or recurring costs (capital, annual operations and maintenance, or periodic), are non-engineering or legal/administrative measures to reduce or minimize the potential for exposure to site contamination or hazards by limiting or restricting site access.

Examples include institutional controls plans, restrictive covenants, property easements, zoning, deed notices, advisories, groundwater use restrictions, and site information databases. An institutional controls plan would describe the controls for a site and the way in which they would be implemented. A site information database would provide a system for managing data necessary to characterize the current nature and extent of contamination. Institutional controls are project-specific costs that can be an important component of a remedial alternative and, as such, generally should be estimated separately from other costs, usually on a sub-element basis. Institutional controls may need to be updated or maintained, either annually or periodically.

The institutional controls cost model used for this alternative was developed by the FH Project Controls and Estimating department. The duration for institutional controls only considers the initial, "year-one" period. The annual/periodic activities were based on a 150-year duration.

The primary annual/periodic costs associated with this alternative are surveillance and cover maintenance, monitored natural attenuation, and long-term groundwater monitoring. The costs for

these annual/periodic activities were estimated based on the area of the individual waste sites or groups. Table D-2 provides the summary of the capital cost and present-net-worth value estimates.

The unit cost for surveillance and maintenance was assumed to be the same as the current unit cost for surveillance and maintenance activities conducted annually on the waste sites. The unit cost accounts for such activities as site radiation surveys, and repair of the existing soil cover on the sites where it is present. Because the existing soil cover is maintained annually, costs for replacing all or large portions of the existing cover at specified intervals (i.e., every 20 years) are considered unnecessary.

The costs associated with natural attenuation monitoring are divided into three components: radiological surveys of surface soils, spectral gamma logging of vadose-zone boreholes, and groundwater monitoring. The costs to perform radiological surveys of surface soils at waste sites are assumed to be similar to those for current survey practices at the sites and are included in the surveillance and maintenance costs.

Vadose-zone monitoring costs assume spectral gamma logging of one borehole per waste site to a 15 m (50 ft) depth once every 5 years for a 150-year duration. This monitoring is considered for sites with high concentrations of contaminants in the shallow zone or near the bottom of crib and trench structures. It also assumes that the service life of vadose-zone boreholes is 30 years. Costs are included for logging and periodic replacement of these boreholes for a 150-year duration.

Groundwater-monitoring costs are described in detail in Section D2.1.4.

General Assumptions

The general assumptions for this alternative are as follows.

- Costs were calculated based on the specific area of the site. The calculated costs are presented in Tables D-1 and D-2.
- The same-sized construction crews will be used for all sites.
- Fencing and monuments/signs for institutional controls and fencing maintenance are included.
- The Institutional Controls Alternative consists of seven general activities: implementation of institutional controls, site inspection and surveillance, existing cover maintenance, natural attenuation monitoring, reporting, site reviews, and groundwater and vadose-zone monitoring.
- The prices that make up the cost estimate were obtained from one of the following sources:
  - Means, 2001
  - Means, 2007
  - Experience on similar projects.

D2.4 REMOVAL, TREATMENT, AND DISPOSAL

The Z-Ditch site is excavated to the required depth and contaminated material is removed to the Environmental Restoration Disposal Facility (ERDF) and the Waste Isolation Pilot Plant (WIPP) for disposal. Excavation quantities are different for each of the Z-Ditch work areas. Alternative 3 uses removal, treatment, and disposal (RTD) (ERDF and WIPP waste) for the full length of the Z-Ditch; Alternatives 5A and 6A use RTD of Work Areas 1 and 3; and Alternative 5B uses shallower RTD of Work Area 2. The cost summary showing the total capital and present-worth estimated costs for the alternatives having RTD as a primary component are shown in Table D-2.

D2.4.1 General Assumptions

The general assumptions for this alternative are as follows.

- Fieldwork such as mobilization/demobilization, excavation, backfill, revegetation, and some of the post-construction work will be contracted to an FP contractor. The project management, radiological control technician (RCT) support, sampling, and safety oversight will be performed by FH. The waste disposal work involved with hauling from the site to ERDF and ERDF dumping cost/fees will be performed by the environmental restoration contractor responsible for ERDF.

- Mobilization and startup include site training; mobilization of equipment and personnel; installation of temporary construction fences; construction of staging/container storage areas and access roads; and setting up office, change, and storage trailers with utilities, temporary survey buildings, and decontamination areas.

- The excavation sites will have contaminated waste removed. The sides of the excavation will be sloped at 1.5:1 to the bottom of the excavation. During the removal process, heavy equipment will be kept out of the excavation site.

- For excavation sites, overburden will be removed with a 1.5 to 2.3 m^3 (2- to 3-yd^3) excavator and two haul trucks. The soil will be stockpiled near the waste site. A highway truck with a water tank trailer is used to control dust during this activity. The production rate for one crew is 111.6 m^3/h (146 yd^3/h).

- Contaminated waste will be excavated using a 1.5 to 2.3 m^3 (2- to 3-yd^3) hydraulic crawler excavator. The contaminated soil will be directly placed into lined ERDF containers and hauled from the excavation site. A highway truck with a water tank trailer is used to control dust during this activity. Depending on the volume of waste to move, one to four crews can be working at a site. Crew labor consists of one operator, one laborer, and one truck driver. The production rate for one crew is 45.9 m^3/h (60 yd^3/h). An FH RCT supports the work at 1½ hours per excavation crew hour.

- Air sampling will be performed during the excavation of contaminated soil. A minimum of two samples will be taken per day. The planning cost per sample is $520. The sampling crew consists of one sampler and one RCT.

Soil samples will be taken of the overburden, from ERDF containers, and for verification at the completion of the excavation. The soil-sampling costs are based on the contaminants expected to be found at the sites and are as follows.

- Noncontaminated soil sampling
  - Maximum of six samples or one sample per cubic yard, whichever is less
  - Quality assurance (QA) sample required: 1
  - Planning cost per sample: $754
  - The soil being sampled is the overburden that is uncontaminated and will not be removed from the site.
- Sampling required for waste going to ERDF
  - One sample required for every 70 containers
  - Minimum of six samples per site
  - QA samples required: a minimum of 1 sample or 5 percent of total ERDF samples, whichever is greater
  - Planning cost per sample: $452.
- Pre-verification process sampling
  - One sample required per 2,500 m^2 (50 × 50 m) (26,899 ft^2 [82 × 82 ft])
  - Minimum of six samples per site
  - QA samples required: a minimum of 2 samples or 5 percent of total the samples, whichever is greater
  - Planning cost per sample: $2,227
  - These samples are the preliminary samples needed to see if all of the required waste has been removed from a site being excavated.
  - This process is expected to happen twice during the excavation process.
  - If the samples show that the site has met the requirement, then the verification process will start.
- Verification process sampling
  - One sample required per 625 m^2 (25 × 25 m) (6,724 ft^2 [82 × 82 ft])
  - Minimum of six samples per site
  - QA samples required: a minimum of 2 or 5 percent of total the samples, whichever is greater
  - Planning cost per sample: $9,314
  - These samples are the final samples needed to see if all of the required waste has been removed from a site being excavated.
  - This process happens once during the excavation process.
- Sampling crews
  - Verification sampling – 1 hour for each sample taken by a crew consisting of one FH RCT and a sampler technician
  - Other sampling (air, ERDF, noncontaminated) – 2 hours for each sample taken by a crew consisting of one FH RCT and a sampler technician.

- The ERDF container handling and loading process starts with a site haul truck picking up an empty container at the staging area. The container is moved to a preparation area where laborers install a bed liner, and then inspected by a half-time RCT. The haul truck and container proceed to the loading area. After loading, the liner is sealed and the container is secured by laborers. The container is moved to the survey building where three RCTs inspect and survey the container and truck for contamination. From there, the haul truck and container are weighed on a platform scale and then driven to the storage area. The container is unloaded from the truck at the storage area. Three trucks are required to support each contaminated excavation crew.

- ERDF disposal fee, transportation, and handling costs are estimated at $867 per container. An environmental restoration contractor driver and truck/trailer will move a loaded container to ERDF and place an empty container in the staging area. The estimated costs include the rental of the containers used. For planning purposes, the capacity of an ERDF container is 9.9 m^3 (13 yd^3) of contaminated waste.

- Backfilling consists of three different operations.
  - The moving of the stockpiled overburden back to the excavation site will require one crew. The equipment used by a crew is one 3.8 m^3 (5-yd^3) loader and two haul trucks. Labor is one operator and two truck drivers. The production rate for one crew is 210.3 m^3/h (275 yd^3/h).
  - The moving of borrow material to the excavation site typically is performed by one crew hauling from an onsite pit source. The equipment used by a crew is one 3.8 m^3 (5-yd^3) loader, four 12.2 m^3 (16-yd^3) end dump trucks with 12.2 m^3 (16-yd^3) trailers, and one 4,000-gal water truck. Labor is one operator and five truck drivers. The production rate for one crew is 141.4 m^3/h (185 yd^3/h).
  - Spreading and compaction of the backfill at the site is performed by one crew. The equipment used per crew is one 300-hp dozer and one 4,000-gal water truck. Labor consists of one operator, one truck driver, and one laborer. The production rate for one crew is 141.4 m^3/h (185 yd^3/h).

- Revegetation of the waste site includes planting native dry-land grass using tractors with seed drills and hand broadcasting, hand-planting sagebrush seedlings, and irrigation for four times in the spring or early summer. All disturbed areas, such as around the waste site, stockpile, staging areas, and access roads, will be replanted.

- The FH Project Management team consists of a part-time project manager, with a full-time field supervisor and part-time engineering support. QA, Radiological Control, and Safety also provide oversight along with other support for contract management and project controls. Total hours for this staff are planned at 22.5 hours per day. The duration of this work is based on total project duration.

- The FP contractor field supervisory team consists of a full-time construction manager and field supervisor, along with part-time QA, construction safety, and clerical support. Two pickup trucks are included in the cost. Total hours for this staff are planned at 21 hours per day. The duration of this work is based on total project duration.

- Demobilization includes demobilization of equipment and personnel, removing temporary construction fences, construction of staging/container storage areas, access roads, office/change/storage trailers, temporary survey buildings, and decontamination areas.

D2.4.2 Excavations of Soil Greater than 100 nCi/g Transuranic Radionuclides

Excavations at sites that include soil potentially containing greater than 100 nCi/g transuranic radionuclides will require special handling of the packaged soil and disposal of that soil at WIPP. Excavation includes mobilization/demobilization, removal of clean soil, backfilling the site, and other site work. For the cost estimate, the volume of soil requiring disposal at WIPP was based on the length and width dimensions of the bottom of the waste site and the depth of the dig. The potential lateral spread of contaminants is not included. Soil removal required for side slopes and access during the excavation is addressed in Section D2.4.1. Soil with alpha contaminants will require special handling during RTD. The following assumptions apply.

- The contaminated soil is placed into WIPP standard waste boxes (SWB). For planning purposes, each box is expected to handle 1.15 m^3 (1.5 yd^3) of waste.

- The field crews can fill, cover, inspect, sample, radiological survey, and move two SWBs per hour. The boxes are direct-loaded with a small hydraulic excavator at the waste site.

- The filled SWBs are moved to a decontamination area, then to a field survey area before being temporarily staged at the waste-site container storage area.

- The SWB is field screen/surveyed at the site before shipment to the Central Waste Complex. Two technicians, two scientists, and one equipment operator perform the field-screening work at the site.

- Waste shippers will provide oversight of the field operation and the required waste designation reports to support shipment to the Central Waste Complex.

- After the initial field screening/survey of the waste, those SWBs determined to contain transuranic radionuclides are moved six SWBs per truckload to the Central Waste Complex.

- The Central Waste Complex will perform processing, headspaces sampling, nondestructive analysis, and temporary storage. The waste storage rate is $12,872 per SWB.

- After completion and acceptance of the waste profile study, the SWBs are shipped to WIPP for storage. Six SWBs can be loaded on a truck for shipment to WIPP. The planning cost of one truck trip to WIPP is $12,500.

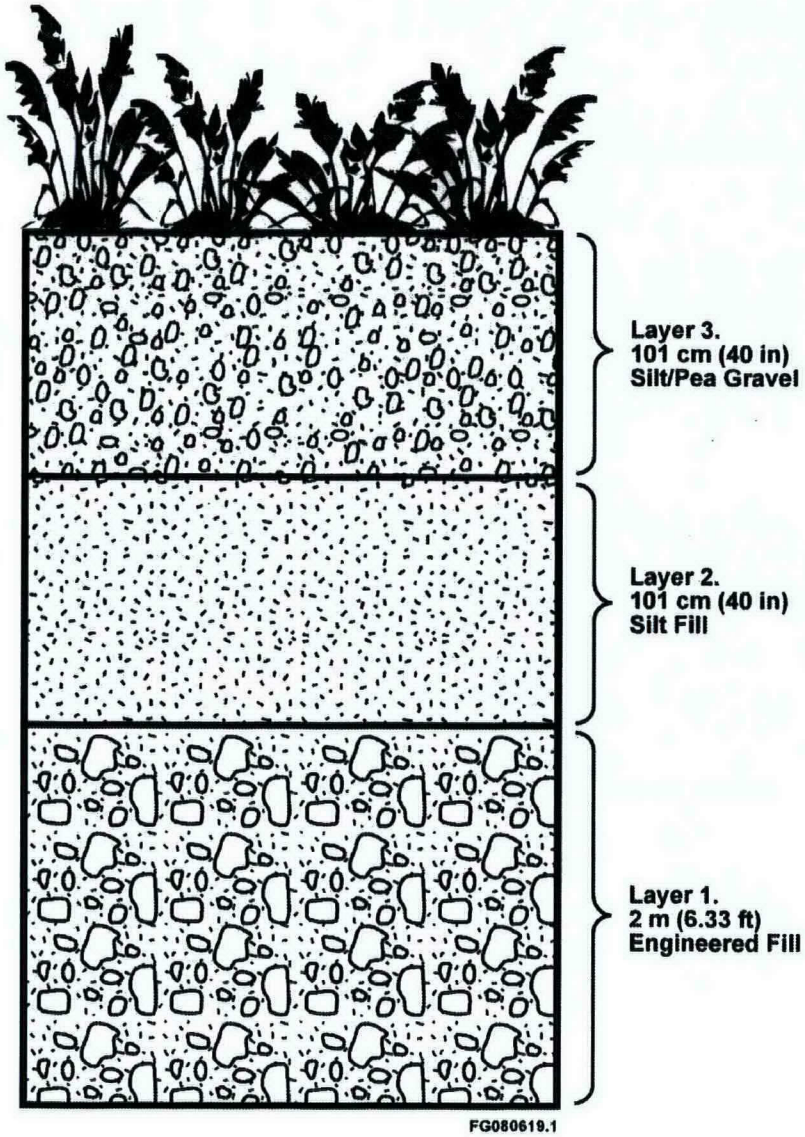
- At this time, there are no handling costs or storage rates for the SWBs after arriving at WIPP.

D2.5 BARRIERS

Alternative 4 includes a barrier constructed over the ditches. For Alternative 5A, the barrier will be constructed over the ditches at Work Area 2 after the RTD work has been completed at Work Areas 1 and 3; Alternative 5B removes the material in Work Area 2 and places a barrier on Work Areas 1 and 3. Alternative 6A provides for a barrier over Work Area 2 (in situ vitrification [ISV] area) after RTD of Work Areas 1 and 3. Alternative 6B provides for a barrier over the entire site, including Work Area 2 (ISV area). For planning purposes, the side overlap for all barriers will be 6 m (20 ft) for all exterior sides. The cost summary showing the total capital and present-worth estimated costs for the alternatives having a barrier as a component are shown in Table D-2.

Figure D-1 shows details of the assumed barrier design.

Figure D-1. Barrier.



General Assumptions

The general assumptions for this alternative are as follows.

- All borrow source materials are assumed to come from an onsite source. During the remedial design, the actual borrow source location will be identified and will comply with all NEPA requirements.

- Fieldwork such as mobilization/demobilization, borrow site excavation, barrier fill, revegetation, and some of the post-construction work will be contracted to an FP contractor. Project management, RCT support, sampling, and Safety oversight will be performed by FH.

- Mobilization and startup include site training, mobilization of equipment and personnel, installation of temporary construction fences, construction of access roads, and setting up offices and storage trailers with utilities. Air sampling will be performed during the construction of the first layer of the barrier. A minimum of two samples will be taken per day. The planning cost per sample is $520. The sampling crew consists of one sampler and one RCT.

- Revegetation of the waste-site barrier includes planting native dry-land grass using tractors with seed drills and hand broadcasting, hand-planting sagebrush seedlings, and irrigation for four times in the spring or early summer. All disturbed areas, such as around the barrier, stockpile, staging areas, and access roads, will be replanted.

- The FH Project Management team consists of a part-time project manager, with a full-time field supervisor and part-time engineering support. QA, Radiological Control, and Safety also provide oversight along with other support for contract management and project controls. Total hours for this staff are planned at 22.5 hours per day. The duration of this work is based on total project duration.

- The FP contractor field supervisory team consists of a full-time construction manager and field supervisor, along with part-time QA, construction safety, and clerical support. Two pickup trucks are included in the cost. Total hours for this staff are planned at 21 hours per day. The duration of this work is based on total project duration.

- Demobilization will include demobilization of equipment and personnel, and removal of temporary construction fences, access roads, and office/storage trailers.

- There are two onsite sources for the fill materials to construct the three soil/fill layers. The source for engineered fill is located at Pit 30 approximately halfway between the 200 East and 200 West Areas. This pit is assumed to have the sufficient quantity for this project. The source for the silt required for Layers 1 and 2 is located at Area C about 3.2 km (2 mi) south of the 200 West Area.

- The pea gravel and fractured basalt will be supplied by offsite vendors or from commercial gravel pits. These materials are delivered to the waste site by the vendor.

- All barrier sites are considered to have settled and are compacted enough to support construction of a barrier without further settling. Dynamic compaction is not used to pre-compact the site.

- The barrier sites are considered level and will not require additional pre-leveling before the start of construction.

The evapotranspiration monofill barrier will consist of the following three different layers.

- The bottom layer will be constructed of 2 m (6.33 ft) of engineered fill. The construction of the engineered fill requires the excavation of suitable borrow from an onsite pit source. The estimated time to complete the fill is based on the production rate of a 5-yd^3 loader excavating at the pit. All material is screened with a grizzly mounted on a surge bin to remove 10 cm (4 in.) or larger rocks. Five 12.2 m^3 (16-yd^3) end dump trucks with 12.2 m^3 (16-yd^3) trailers are needed to keep up with the loader. One 4,000-gal water truck provides dust control at the pit. The production rate for this work is 141.4 m^3/h (185 yd^3/h). The spreading and compaction equipment used at the barrier is a 250- to 300-hp dozer with a U-blade to spread fill, and two 12-ton vibratory tandem rollers. A 4,000-gal water truck provides dust control.

- To produce a smooth surface to prevent low areas, the surface of engineered fill is fine graded. Work involves a 5-yd^3 loader, 12-ton vibratory single drum roller, a laser-leveling equipped dozer, and a water truck. The production rate is 2,500 yd^2/h to fine grade the fill surface area. One laborer supports the grader operator as a grade checker. Two engineer technicians set up the grade and elevation control.

- The second layer will be constructed of 101.6 cm (40 in.) of silt fill. The construction of this layer involves excavating and hauling the silt from the onsite pit to the barrier. This layer is 51 cm (20 in.) deep. The estimated time to complete the fill is based on the production rate of a 5-yd^3 loader excavating at the pit. Five 12.2 m^3 (16-yd^3) end dump trucks with 12.2 m^3 (16-yd^3) trailers are needed to keep up with the loader. One 4,000-gal water truck provides dust control at the pit. The production rate for this work is 141.4 m^3/h (185 yd^3/h). At the barrier, the silt is spread with two 90- to 120-hp low-ground-pressure dozers. The silt is scarified to prevent overcompaction. A truck with a 4,000-gal water trailer provides dust control at the barrier.

- The top layer will be constructed of 101.6 cm (40 in.) of silt/pea gravel fill. This layer requires a fill material consisting of silt with 15 percent pea gravel added by weight. The silt is excavated with a 4- to 5-yd^3 loader and hauled from the site silt source by two dump trucks to a process area near the pit. Pea gravel will be provided from a commercial source. The supplier will haul and stockpile the gravel at the silt process area. A 4- to 5-yd^3 loader and a pug mill with belt loader are used to mix the silt and gravel. The hauling from the process area is the same as described for the second layer. Spreading also is the same as the second layer. The side slopes of the barrier will be covered with 1-ft-deep fractured basalt with silt to fill in the void spaces in the rock.

- The side slopes of the barrier will be fine graded before placing fractured basalt. The work involves a 100- to 150-hp dozer with laser controls, a 4- to 5-yd^3 loader, one 12-ton

vibratory single drum roller, and a water tanker. The production rate is 2,500 yd^2/h for the engineered fill surface area. One laborer supports the dozer operator and the water truck driver. Two engineer technicians set up the grade and elevation control.

- A geotextile is placed on the side slopes. This item of work covers the placement of needle-punched 120 mil polypropylene geotextile on the side slopes. The production rate is 300 yd^2/h. Three laborers place and splice the fabric. One operator with a 2.5-yd^3 loader and a teamster with a flatbed truck support the work.

- The top layer of the side slopes is covered with 12-in.-deep fractured basalt with silt. The fractured basalt is from a commercial source and is delivered to the site by the supplier. The silt is from the onsite pit and is hauled to the barrier. The equipment used to spread the basalt is a 5-yd^3 loader, 300-hp dozer with rippers, and 1/4-time 4,000-gal water truck. Two equipment operators and 1/4-time truck driver operate the equipment. One laborer supports the operators as a grade checker and helps place fractured basalt. The placement of the silt involves excavating at the pit, hauling to the barrier, and spreading on the fractured basalt. This work occurs at the same time as the placement of the fractured basalt to ensure that the silt is worked into the basalt. The excavation and hauling from the pit uses one 5-yd^3 loader and three 12.2 m^3 (16-yd^3) end dump trucks with 12.2 m^3 (16-yd^3) trailers. The placement and mixing with the basalt use one 5-yd^3 loader. A 4,000-gal water truck is used for dust control. Two operators, four truck drivers, and one laborer operate the equipment and support the work. The production rate for this work is 70 yd^3/h.

- Instrumentation is not included for either of the barrier designs.

- After completion of the barrier construction work, a 1.2 m (4-ft) steel post with chain fence will be built around the site. The fence location is at the toe of the barrier slope.

- Surveillance and maintenance costs for the Barrier Alternative include barrier performance monitoring and repair costs. For purposes of this FS, all sites will assume annual repairs to the cap (replacement of 15.2 cm [24 in.] of topsoil layer and revegetation over 10 percent of the barrier area). This is considered a conservative estimate because the barrier has been designed to require minimal maintenance, particularly after vegetation has been established.

- During the construction of the barrier, compaction testing will be performed on the different layers. The bottom and sand layers will require that a minimum level of compaction has been reached. The top two layers will be tested to ensure that the fill does not become overcompacted.

D2.6 IN SITU VITRIFICATION

The ISV process will be used by Alternatives 6A and 6B to vitrify contaminated soils in Work Area 2 beneath the ditch, reducing the risk posed by direct contact with the material, and impeding intrusion into the residual untreated contaminants. The exact number and configuration of melts, and the components and configuration of the offgas treatment system, would be determined in the remedial design phase. Treatability testing will most likely be necessary to support design. For Alternative 6A, RTD as described above will be used at Work Areas 1 and 3 and a barrier will be

placed over the ISV melts of Work Area 2 to clean up contaminated soil. For Alternative 6B, a barrier will be placed over the entire site upon completion of the ISV process. The cost summary showing the total capital and present-worth estimated costs for the alternatives having ISV as a primary component are shown in Table D-2.

General Assumptions

The general assumptions for the ISV alternative are as follows.

- Fieldwork such as mobilization/demobilization, ISV, excavation, backfill, revegetation, and some of the post-construction work will be contracted to an FP contractor. The project management, RCT support, sampling, and safety oversight will be performed by FH. The waste disposal work involved with hauling from the site to ERDF and ERDF dumping cost/fees will be performed by the environmental restoration contractor responsible for ERDF.

- Mobilization and startup include site training; mobilization of equipment and personnel; installation of temporary construction fences; installation of electrical power lines to feed site; construction of staging/container storage areas and access roads; and setting up office, change, and storage trailers with utilities, temporary survey buildings, and decontamination areas.

- A layer of clean fill would be placed on top of the base soils to provide a working surface for placement of the electrodes and injection of conductive material between the electrodes.

- Melts, including off-gas treatment, are assumed to cost $1,623/ton, based on DOE, 2004, *Screening-Level Evaluation of Remedial Alternatives for Pit 9 TRU Waste at Los Alamos National Laboratory*, which has been adjusted to fiscal year 2007 and for location. Additional information came from discussions with AMEC, Earth and Environmental Inc.

- The melts would result in a contiguous block of glass at the waste site.

- The melting operation would be a continuous operation for the duration of the ISV work. The planning for this work requires two sets of melting equipment. One set will be in operation while the other set will be in the process of being moved and set up for the next melt.

- Backfilling of the waste site will be required after the melts to match the surrounding ground surface. This work will start 6 months after the last melt has been completed to give the site adequate time to cool.

- Backfilling consists of two different operations.
  - The moving of borrow material to the excavation site typically is performed by one crew hauling from an onsite pit source. The equipment used by a crew is one 3.8 m^3 (5-yd^3) loader, five 12.2 m^3 (16-yd^3) end dump trucks with 12.2 m^3 (16-yd^3) trailers, and one 4,000-gal water truck. Labor is one operator and six truck drivers. The production rate for one crew is 141.4 m^3 (185 yd^3/h).
  - One crew will spread and compact the backfill at the ISV site. The equipment used per crew is one 300-hp dozer and one 4,000-gal water truck. Labor consists of one operator,

one truck driver, and one laborer. The production rate for one crew is 141.4 m^3 (185 yd^3/h).

- Revegetation of the waste site includes planting native dry-land grass using tractors with seed drills and hand broadcasting, hand-planting sagebrush seedlings, and irrigation for four times in the spring or early summer. All disturbed areas, such as around the waste site, stockpile, staging areas, and access roads, will be replanted.

- The FH Project Management team consists of a part-time project manager, with a full-time field supervisor and part-time engineering support. QA, Radiological Control, and Safety also provide oversight along with other support for contract management and project controls. Total hours for this staff are planned at 22.5 hours per day. The duration of this work is based on total project duration.

- The FP contractor field supervisory team consists of a full-time construction manager and field supervisor, along with part-time QA, construction safety, and clerical support. Two pickup trucks are included in the cost. Total hours for this staff are planned at 21 hours per day. The duration of this work is based on duration of the RTD work for Work Areas 1 and 3 and the final site work need to complete Work Area 2. The FP contractor field supervisory team for the ISV portion of the project is included in the unit cost of the ISV work.

- Demobilization includes demobilization of equipment and personnel, removing temporary construction fences, electrical power lines to feed site, construction of staging/container storage areas, access roads, office/change/storage trailers, temporary survey buildings, and decontamination areas.

The cost estimate does not include the following items:

- Additional site characterization to support design
- Treatability studies
- Management/disposal of secondary waste streams from the offgas system
- Post-cooling evaluation of melt (seismics and soil sampling).

Tables D-1 and D-2 show the cost summary for the total capital and present-worth estimated costs.

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APPENDIX E

RISK ASSESSMENT FOR INADVERTENT INTRUDER SCENARIO

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TERMS

bgs	below ground surface
HAB	Hanford Advisory Board
PRG	preliminary remediation goal
RESRAD	RESidual RADioactivity (dose model)
Tri-Parties	U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology

APPENDIX E

RISK ASSESSMENT FOR INADVERTENT INTRUDER SCENARIO

E1.0 INTRODUCTION

In HAB 132, "Exposure Scenarios Task Force on the 200 Area," the Hanford Advisory Board (HAB) requested that the U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology (Tri-Party Parties) evaluate the dose to potential intruders when considering former waste sites for closure. In its response to the HAB, the Tri-Party Parties committed to evaluating doses to the intruder and a number of other exposure scenarios (Klein, et al., 2002, "Consensus Advice #132: Exposure Scenarios Task Force on the 200 Area") Intruder assessment results are a consideration in the Chapter 6.0 evaluation of remedial alternatives against CERCLA balancing criteria.

This appendix presents an analysis of an intruder scenario for determining excavation depth should excavation be selected for the 216-Z-11 Ditch. The 216-Z-11 Ditch consists of three ditches: 216-Z-11, 216-Z-1D, and 216-Z-19. Previously, these ditches were analyzed as one entity. Because most of the contamination resides in the 216-Z-1D and 216-Z-19 Ditches, this analysis addresses the ditches separately to avoid drawing generalized conclusions based on results from one ditch.

The reasonably anticipated land use for the 200 Areas is continued industrial activities for the foreseeable future, based on DOE/EIS-0222-F, *Final Hanford Comprehensive Land Use Plan Environmental Impact Statement* and 64 FR 61615, "Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement (HCP EIS)." For locations within the industrial area, the U.S. Department of Energy dose limits for the protection of workers and the affected public will be in effect for the duration of facility management operations. After a period of 50 years, it is assumed that active waste management and processing operations will have ceased but that public entry to the site will remain restricted for an additional 100 years by enforcement of institutional controls.

The inadvertent intruder scenario is based on the possibility that after 150 years or 500 years institutional controls have failed and an individual unwittingly (through human error or lack of knowledge concerning the location of contaminants) gains access to the site and engages in an activity that results in contact with wastes left in place. From this 150-year point in time forward, a dose of 15 mrem/yr above background will be used as a target dose goal and an operational guideline for achievement of a 10^{-4} to 10^{-6} cancer risk range. The dose at 150 years and 500 years was calculated for evaluation against the 15 mr/yr above background dose goal. Therefore, the evaluation in this risk assessment focuses on the 15 mrem/yr standard.

The following three intruder scenarios have been proposed for evaluation and are discussed in more detail in subsequent paragraphs:

- Future construction trench worker
- Future well driller
- Future rural resident.

E1.1 FUTURE CONSTRUCTION TRENCH WORKER INTRUDER SCENARIO

The future construction trench worker would encounter contaminants by inadvertently excavating a utilities trench (or other construction activity such as the excavation of a basement or building foundation). The worker is assumed exposed for 8 hours a day for 5 days. The dose to the worker is the sum of the contributions from inhaling resuspended dust, inadvertently ingesting soil, and receiving direct exposure at the center of a 200 m^2 (2,150 ft^2) area of contaminated soil for 40 hours.

E1.2 FUTURE WELL DRILLER INTRUDER SCENARIO

This exposure scenario involves inadvertently drilling a well at a waste site. The drill cuttings (i.e., uncontaminated and contaminated soil) are assumed to have been spread over the work area near the well. Based on the evaluations for DOE/ORP-2000-01, *Maintenance Plan for the Hanford Immobilized Low-Activity Tank Waste Performance Assessment* and WCH-191, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*, a 0.3 m (1-ft) diameter well for this evaluation is assumed. Although consistent with the diameters used in Hanford Site performance assessments, this diameter is larger than the range of well diameters commonly found in local communities (10 to 25 cm [4 to 10 in.]). Use of this well diameter may overestimate the dose associated with this exposure scenario. The area on which the driller spreads the cuttings is assumed to be 200 m^2 (2,150 ft^2) (a size historically used in Hanford Site performance assessments).

In the well driller intruder scenario, the soil mixing depth is assumed to be 15 cm (6 in.), a depth used in other onsite performance assessments. The worker at the well drilling site is assumed exposed for 8 hours a day for 5 days. The dose to the worker is the sum of the contributions from inhaling resuspended dust, inadvertently ingesting soil, and receiving direct exposure at the center of the 200 m^2 (2,150 ft^2) slab for 40 hours.

E1.3 FUTURE RURAL RESIDENTIAL INTRUDER SCENARIO

This scenario assumes that a receptor resides within the area and has planted a garden using the drill cuttings taken from a well drilled through the waste site, as discussed above in the well driller scenario. The dose to the resident is the sum of the contributions from direct exposure to the radiation field in the garden, inhalation of resuspended dust, ingestion of soil at the same rates as the future well driller, and consumption of garden produce grown in the contaminated soil. Consumption of groundwater is not included in this evaluation because groundwater in this area currently is under remediation and is not available for use. This scenario is consistent with other inadvertent intruder evaluations conducted within the Central Plateau.

The resident is assumed to spread the waste over a garden 200 m^2 (2,150 ft^2) in area and to a depth of 15 cm (6 in.). The garden area was taken from another risk assessment (DOE/ORP-2000-24) and is based on an area large enough to supply a significant portion of a

person's vegetable and fruit diet, yet small enough to produce a higher (more conservative) estimation of dose. The resident is assumed to spend 20 percent of the time in the garden, 60 percent of the time indoors exposed to dust from the garden, and 20 percent of the time off site.

Of the three scenarios proposed for evaluation, the future rural resident exposed to contaminated cuttings from groundwater well drilling is considered the worst-case scenario, primarily because of the exposure time. This scenario is the only one analyzed in the remainder of this appendix.

E2.0 CONCEPTUAL SITE MODEL

The data on contamination in the waste site are partitioned into 1.5 m (5-ft) increments of depth, with all contaminated increments being assigned a concentration equal to the highest concentration measured within any increment. The contamination concentration then is reduced based on decay for 150 years and for 500 years, assuming no transport of the contaminants during those years. After 150 years or 500 years, as the well drilling intersects the incremental layers, the total amount of radioactivity in the well cuttings is assumed to be thoroughly mixed with surface soil such that the contamination in the garden is of uniform concentration. The specifications on the garden are provided in Table E-1.

Table E-1. Residential Intruder Garden Specifications.

Parameter	Value
Diameter of borehole (feet)	1
Area of borehole (square feet)	0.785
Volume of cuttings in each increment (cubic feet)	3.93
Density of garden soil (grams per cubic centimeter) (pounds per cubic foot)	1.5 93.6
Garden area (square feet)	2,153
Garden volume (cubic feet)	1,077
Garden soil mass (pounds)	100,760

The contaminant data for the analysis are taken for the 216-Z-11 Ditch from Appendix A of DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-CS-1 Steam Condensate Group Operable Units.*

The following screening occurred on the undecayed (current) data.

- Radionuclides with half-lives less than 15 years (resulting in 10 half-lives at the end of institutional control) were not included because each radionuclide would decay to insignificant levels.

- Current concentrations less than 1 pCi/g were not included.
- Combined Pu-239/Pu-240 values were evaluated as Pu-239 because Pu-239 is the more likely contaminant and its health risk is slightly greater than that for Pu-240.
- Gross alpha and gross beta measurements were not included.
- Values less than the detection limit were not included.
- Total strontium was evaluated as Sr-90.
- Radionuclides commonly found in the earth's crust that showed relatively uniform concentrations to the greatest depth sampled (e.g., K-40) were assumed to be at background concentrations and thus not included.

The resulting soil column concentration values used for the rural residential intruder analysis are presented in Tables E-2, E-3, and E-4 for the three waste sites evaluated. These concentrations are current concentrations, not concentrations at the end of institutional control. The tables are in 1.5 m (5-ft) increments from ground surface to the estimated bottom of the contaminated zone. The exposure-point concentration for the rural residential intruder is based on dilution of the drill cuttings from being spread over the garden and mixed with soil. Figure E-1 represents the conceptual site model for the exposure scenario.

Table E-2. 216-Z-11 Ditch Current Maximum Concentrations by Depth Below Ground Surface (picoCuries per gram).

Depth (ft)	Am-241	Pu-238	Pu-239 [a]
0	3,094	3,388	40,000
5	3,094	3,388	40,000
10	3,094	3,388	40,000
15	3,094	b	40,000
20	b	b	b
25	b	b	b
30	b	b	b
35	b	b	b
40	b	b	b
45	b	b	b
50	b	b	b

Source: DOE/RL-2003-11, *Remedial Investigation Report for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units.*

[a] Pu-239/Pu-240 values represented as totally Pu-239.
[b] Zero or negligible results.

Table E-3. 216-Z-1D Ditch Current Maximum Concentrations by Depth Below Ground Surface (picoCuries per gram).

Depth (ft)	Am-241	Pu-238	Pu-239 [a]	Ra-226
0	b	b	b	b
5	7,870,000	5,252	780,000	5,200
10	7,870,000	b	780,000	b
15	b	b	b	b
20	b	b	b	b
25	b	b	b	b
30	b	b	b	b
35	b	b	b	b
40	b	b	b	b
45	b	b	b	b
50	b	b	b	b

Source: DOE/RL-2003-11, *Remedial Investigation Report for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units.*

[a] Pu-239/Pu-240 values represented as Pu-239.
[b] Zero or negligible results.

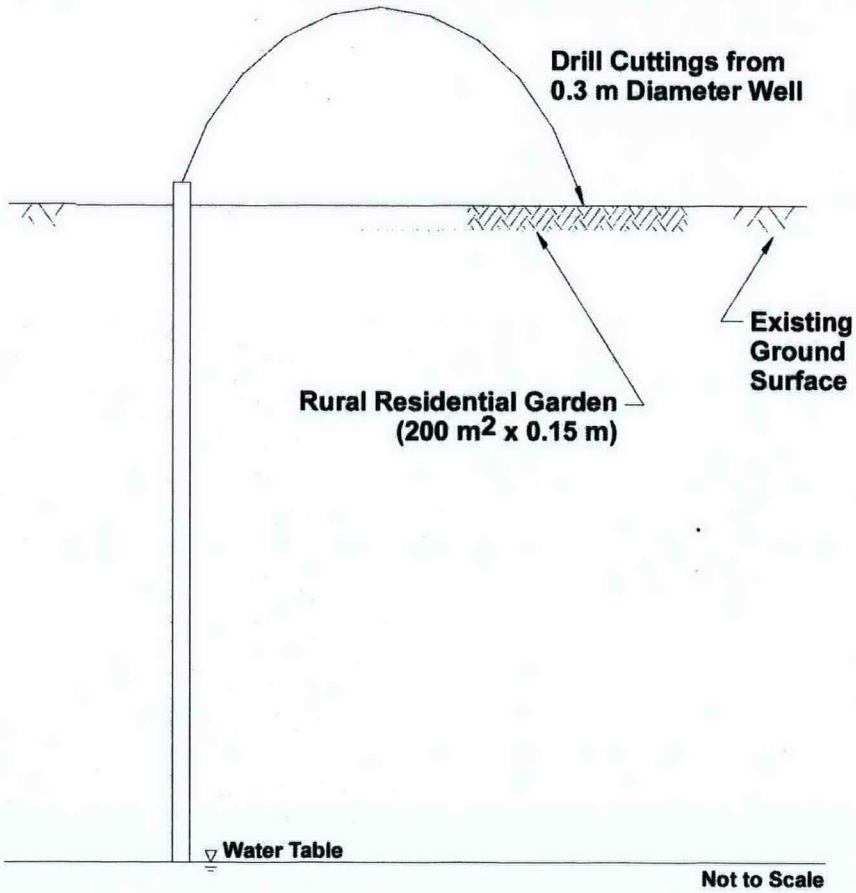
Table E-4. 216-Z-19 Ditch Current Maximum Concentrations by Depth Below Ground Surface (picoCuries per gram).

Depth (ft)	Am-241	Pu-238	Pu-239 [a]
0	27,951	b	13,000,000
5	27,951	5,500	13,000,000
10	27,951	5,500	13,000,000
15	b	b	b
20	b	b	b
25	b	b	b
30	b	b	b
35	b	b	b
40	b	b	b
45	b	b	b
50	b	b	b

Source: DOE/RL-2003-11, *Remedial Investigation Report for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-SC-1 Steam Condensate Group Operable Units.*

[a] Pu-239/Pu-240 values represented as Pu-239.
[b] Zero or negligible results.

Figure E-1. Conceptual Site Model for the Rural Residential Intruder Scenario.



E3.0 RISK ASSESSMENT METHODOLOGY

Residential intruder health risk resulting from radioactive contaminants was evaluated using the RESidual RADioactivity (RESRAD) computer model (ANL 2002, *RESRAD for Windows*). The baseline input file was the same as the industrial, direct-contact exposure scenario without cover. The input parameters used for the industrial exposure scenario are listed in Appendix C, Table C-4 of this feasibility study. The principal changes to the inputs for the intruder analysis were the diluted concentrations in the garden and the area of the contaminated zone. The intruder scenario includes the plant ingestion exposure pathway, which the industrial scenario did not use. Therefore, the exposure pathways used for the intruder scenario include external gamma, inhalation, plant ingestion, and soil ingestion.

An iterative process was used to determine if excavation of the contaminated zone is required to protect the residential intruder. First, the analysis included all the 1.5 m (5-ft) incremental layers (i.e., no excavation). Next, the uppermost 1.5 m (5-ft) layer was removed from the analysis to simulate the contaminated soil removal. Subsequent layers were removed one at a time until all

the contamination was gone. The dose values calculated for each iteration allow generation of a table of intruder dose versus excavation depth. Examination of the table suggests at which excavation depth the 15 mrem/yr standard can be achieved.

Finally, RESRAD was used to determine the individual radionuclide target concentration for the residential intruder scenario, assuming 150 years of decay. These target concentrations are the average soil column concentrations that would result in a 15 mrem/yr dose to the intruder. Because radionuclide impacts to human health are additive, these individual radionuclide concentrations are applicable when the radionuclide is the only one present. For multiple radionuclides, the sum of the fractions of the individual radionuclide soil concentration divided by the individual radionuclide target concentration must be compared to the number "1," which represents the cumulative dose benchmark of 15 mrem/yr.

E4.0 ANALYTICAL RESULTS AND CONCLUSIONS

Table E-5 presents the 150-year dose to the intruder by excavation depth for each of the Z-Ditch waste sites. Table E-6 presents the 500-year doses. The dose decreases as more soil is excavated. Individual radionuclide target concentrations for the intruder scenario are presented in Table E-7 for each waste site. Table E-8 presents the sum of the fractions for each waste site assuming no excavation. The soil concentrations used are the average soil concentrations in the contaminated zone, not those of any individual 1.5 m (5-ft) increment. Similarly, the target concentrations were calculated based on an average concentration in the soil column.

Table E-5. Dose at 150 Years by Excavation Depth (millirem per year).

Excavation Depth[a] (ft bgs)	Site		
	216-Z-11 Ditch	216-Z-1D Ditch	216-Z-19 Ditch
0	25	3.3×10^3	5.5×10^3
5	19	3.3×10^3	3.7×10^3
10	13	1.6×10^3	1.8×10^3
15	6.2	b	b
20	b	b	b
25	b	b	b
30	b	b	b
35	b	b	b
40	b	b	b
45	b	b	b
50	b	b	b

[a] Dose compared to the 15 mrem/yr standard to determine excavation depth needed.
[b] Zero or negligible results.

Table E-6. Dose at 500 Years by Excavation Depth (millirem per year).

Excavation Depth [a] (ft bgs)	Site		
	216-Z-11 Ditch	216-Z-1D Ditch	216-Z-19 Ditch
0	24	2.0×10^3	5.4×10^3
5	18	2.0×10^3	3.6×10^3
10	12	950	1.8×10^3
15	5.9	b	b
20	b	b	b
25	b	b	b
30	b	b	b
35	b	b	b
40	b	b	b
45	b	b	b
50	b	b	b

[a] Compare dose to the 15 mrem/yr standard to determine excavation depth needed.
[b] Zero or negligible results.

Table E-7. Individual Radionuclide Target Concentrations (picoCuries per gram).

Site	Am-241	Cs-137	Pu-238	Pu-239	Ra-226
216-Z-11 Ditch	2.0×10^4	*	9.6 × 104	2.7×10^4	*
216-Z-1D Ditch	4.0×10^4	*	1.9×10^5	5.3×10^4	4.0×10^2
216-Z-19 Ditch	2.7×10^4	*	1.3×10^5	3.6×10^4	*

*Contaminant is not present.

Table E-8. Sum of the Fractions of Average Soil Column Concentration Divided by Average Target Concentration.

Site	Am-241	Pu-239	Ra-226	Sum*
216-Z-11 Ditch	0.2	1.5	*	1.7
216-Z-1D Ditch	200	15	13	230
216-Z-19 Ditch	1.1	370	*	370

*Contaminant is not present.

Following is a summary for each waste site:

- For the 216-Z-11 Ditch – The dose to the intruder without any excavation is 25 mrem/yr with 150 years of radioactive decay and 24 mrem/yr with 500 years of decay. The dose primarily is from Pu-239, which is located 0 to 6.2 m (0 to 20 ft) below ground surface

(bgs) at concentrations greater than the individual preliminary remediation goal (PRG). This contamination will not decay to less than the PRG in more than 10,000 years.

- 216-Z-1D Ditch – The dose to the intruder without any excavation is 3,300 mrem/yr with 150 years of radioactive decay and 2,000 mrem/yr with 500 years of decay. The dose primarily is from Am-241, for which the majority of the contamination is located from 1.5 to 4.6 m (5 to 15 ft) bgs at concentrations significantly greater than the PRG. There also is a significant contribution from Pu-239, which is collocated with the Am-241 and Ra-226 (located 3.1 to 4.6 m [10 to 15 ft] bgs). This contamination will not decay to less than PRGs in more than 10,000 years.

- 216-Z-19 Ditch – The dose to the intruder without any excavation is 5,500 mrem/yr with 150 years of radioactive decay and 5,400 mrem/yr with 500 years of decay. The dose primarily is from Pu-239, which is located from to 0 to 4.6 m (0 to 15 ft) bgs at concentrations greater than the PRG. There is a less significant contribution from Am-241, which is co-located with the Pu-239. This contamination will not decay to less than the PRGs in more than 10,000 years.

As summarized in Table E-9, all of the Z-Ditches would require excavation to achieve the 15 mrem/yr dose target criterion for the intruder scenario. With incremental removal of soil (with depth referenced from ground surface), these waste sites exhibit differing decreases in risk at various depths (dependent on radionuclide concentration and depth distribution).

Table E-9. Excavation Depths to Meet 15 Millirem per Year Target Dose Goal for Intruder at 150 and 500 Years.

Waste Site	Excavation Depth (ft) 150 Years	Excavation Depth (ft) 500 Years
216-Z-11 Ditch	10	10
216-Z-1D Ditch	15	15
216-Z-19 Ditch	15	15

E5.0 REFERENCES

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APPENDIX F

Z-DITCHES SUMMARY DATA SHEETS

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TERMS

CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
H_1	Hanford formation gravel-dominated facies
H_2	Hanford formation sand-dominated facies
MDL	minimum detection level
MESC/MNA/IC	maintain existing soil cover, monitored natural attenuation, and institutional controls
Tri-Parties	U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989)
TRU	Radioactive waste as defined in DOE G 435.1-1, *Implementation Guide for Use with DOE M 435.1-1*
WIDS	*Waste Information Data System* database

APPENDIX F

Z-DITCHES SUMMARY DATA SHEETS

F1.0 INTRODUCTION

During renegotiation of *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al., 1989) M-15 milestones in 2005 and 2006 (Chapter 1.0 of the main text), the Tri-Parties (U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology) undertook a supplemental data quality objectives process to support completion of remedial investigation/feasibility study processes for Central Plateau operable units. The purpose of the data quality objective process was to identify supplemental data that would fill remedial investigation data gaps and allow completion of remedial decision making. For the 200-CW-5 Operable Unit waste sites within the scope of this feasibility study (Chapter 2.0 of the main text), the Tri-Parties agreed that existing data are sufficient for *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) decision making (DOE/RL-2007-02, *Supplemental Remedial Investigation/ Feasibility Study Work Plan for the 200 Areas Central Plateau Operable Unit*s, Volume 1, Appendix C). Summary sheets have been prepared for the 200-CW-5 Operable Unit waste sites to support the Tri-Parties' understanding of the existing data. The data sheets provide key information to better define the nature and extent of contamination reflected in the contaminant distribution model for each waste site and to help refine the overall conceptual site model (Chapter 2.0 of the main text) to aid the feasibility study evaluation process.

The data summary sheets are a compilation of available information on the following key elements used in refinement of the conceptual site model for each 200-CW-5 Operable Unit waste site:

- Site identification
- Site location
- Type of site
- Site construction
- Operating history
- Effluent volume discharged
- Period of operation
- Inventory information
- Vicinity waste sites
- Characterization summary
- Data
- References.

The data summaries prepared for the supplemental data quality objectives used the most recent version of RPP-26744, *Hanford Soil Inventory Model, Rev. 1* (SIM), to represent the contaminant inventory at each waste site. The SIM was developed between 1999 and 2005 to project inventory estimates for all major Hanford Site 200 Area waste-disposal sites and

unplanned release sites in support of a Pacific Northwest National Laboratory effort to develop site-wide inventory estimates for historical Hanford Site operations. SIM provides inventory estimates for almost 300 waste disposal and unplanned release sites. SIM is an extension of the Hanford-Defined Waste Model, a previous activity undertaken to develop inventory estimates for materials stored in the Hanford Site's single- and double-shell tanks. In both the SIM and the Hanford-Defined Waste models, inventory estimates were developed by combining best estimates of waste compositions with waste volume discharge data. SIM inventory estimates are sensitive to the "waste composition" estimates. In the early 2000 time period when SIM input data were being compiled for Z Plant waste sites, little chemical process data were available for historical Z Plant operations. Thus, this limited amount of Z Plant chemical processing information was used to project a similar waste composition for plant effluents being discharged to the Z Cribs. However, information uncovered since the completion of SIM leads to a better understanding of the complexity of Z Plant liquid waste discharges and leads to the conclusion that much of the SIM inventory estimate data for Z Plant waste sites has a high level of uncertainty.

Significant information about the Z Plant operations comes from recent documents associated with current decommissioning and decontamination activities. The Z Plant complex facilities have been associated with many facets of plutonium processing and component fabrication. Over the more than 50 years of Z Plant operational history, these activities changed to meet the critical needs at that point in time. As chemical processes changed so did waste-stream compositions and processing facilities. Thus, documentation needed for facility decommissioning and decontamination activities also provides considerable insight into waste-stream compositions. Information gleaned from Z Plant decommissioning and decontamination documentation will be extremely valuable in any future revisions of SIM. In the mean time, SIM inventory estimates for Z Plant waste sites will not be used in site remediation decisions. Inventory estimates for Z Plant waste sites will be based on historical and site characterization information. Sources of inventory information for Z Plant waste sites in the 200-CW-5 Operable Unit are documented in the data summary tables in this appendix.

F2.0 SUMMARY DATA SHEETS

Summary data sheets that provide the bases for the conceptual models for the 200-CW-5 Operable Unit waste sites are provided as Tables F-1 through F-5.

Table F-1. Summary Data Sheet, Data-Needs Priority Summary for the 216-Z-11 Ditch (200-CW-5 Operable Unit). (2 Pages)

Background	
Site Identification	216-Z-11 Ditch
Site Location	200 West Area, Plutonium Finishing Plant zone
Type of Site	CERCLA past-practice – Ditch
Operating History	The 216-Z-11 Ditch is a backfilled, surface-stabilized ditch that ran from the east side of the 234-5Z Building southward to the 216-U-10 Pond. The ditch is currently co-located within a large, posted Underground Radioactive Material area that also includes the 216-Z-1D and 216-Z-19 Ditches. When active, the unit was a long narrow ditch with 2.5:1 sloped sides and a 0.05% grade. The 216-Z-11 Ditch was installed to replace the 216-Z-1D Ditch. The 216-Z-11 Ditch received liquid waste from Plutonium Finishing Plant process sewer, and the 291-Z and 231-Z Buildings until the ditch was deactivated in 1971. The 216-Z-11 Ditch was replaced by the 216-Z-19 Ditch. During the 1960s, a special Space Nuclear Auxiliary Power program was operating in Z Plant. The program isolated Pu-238 and released an unknown amount of Pu-239/240 to the 216-Z-11 Ditch as waste. Structures associated with this unit include the remnants of the 216-Z-1D and 216-Z-19 Ditches, UPR-200-W-110, the 216-U-10 Pond, and the culvert beneath 16th Street. Upon retirement in 1971, the ditch was backfilled to grade. The Z Plant effluent was rerouted to the 216-Z-19 Ditch. Additional backfill material was added to the 216-Z-11 Ditch when the 216-Z-19 Ditch was deactivated and backfilled in 1981.
Vicinity Waste Sites	Z-Ditches waste group
Current Status	Retired, backfilled, and stabilized

Potential Remedial Alternatives

X for viable alternatives	**No Action**	**MESC/MNA/IC**	**Removal, Treatment, and Disposal**	**Barrier**	**Removal, Treatment, and Disposal and Barrier**	**In Situ Treatment, Removal, Treatment, and Disposal, and Barrier**	**Other**
	No (data indicate significant contamination at site)	X	X	X	X	X	None

Table F-1. Summary Data Sheet, Data-Needs Priority Summary for the 216-Z-11 Ditch (200-CW-5 Operable Unit). (2 Pages)

Data Evaluation and Gaps Analysis

Data	Known's	Data Uncertainties	Are supplemental data required to support decision making?
C3808 299-W18-178 299-W18-188 299-W18-198 299-W18-199 C3816 C3817 C3818 C3819 C3820 C3821 C3825 C3834 C3835 C3836 299-W18-192 299-W18-193 299-W18-194 C3810 C3811 C3812 C3813 C3814 C3815	Soil data taken from Borehole C3808 showed a barium concentration around 80,000 µg/kg from 1.5 to 31 m (5 to 102 ft) below ground surface, and a peak concentration of 117,000 µg/kg at 61 m (200 ft). Chromium concentrations around 10,000 µg/kg were detected from 3 to 4.5 m (10 to 14.8 ft). There were two depths where chromium concentrations were higher. At 31 m (102 ft), the concentration was 18,500 µg/kg, and at 61 m (200 ft), the concentration was 19,400 µg/kg. Manganese was detected from 1.5 to 4.5 m (5 to 14.8 ft) at a concentration around 350,000 µg/kg. The chromium concentration at 16 m (52.5 ft) was 397,000 µg/kg and tapered off to 217,000 µg/kg at 68 m (223 ft). Nitrate was detected at 4.5 m (14.8 ft) with a concentration of 47,500 µg/kg. Vanadium was detected from 1.5 to 7.6 m (5 to 25 ft) above 50,000 µg/kg. At 16 m (52.5 ft), the concentration was 78,900 µg/kg. The concentration remained above 30,000 µg/kg until 68 m (223 ft). Plutonium-239/240 was detected in the soil at 3 and 3.8 m (10 and 12.5 ft) at a concentration of 2,780 pCi/g and 4,840 pCi/g respectively. At 4.5 m (14.8 ft), the concentration dropped to 67.7 pCi/g at 5.3 m (17.4 ft). Americium-241 was detected at 3 and 3.8 m (10 and 12.5 ft) at a concentration of 649 and 919 pCi/g, respectively. Spectral gamma logging of Borehole C3808 showed plutonium from 0.8 to 3 m (2.5 to 10 ft) with a zone of high plutonium concentration at the 2.9 m (9.5-ft) level in a layer approximately 7.6 cm (3 in.) thick. <u>299-W18-178</u> No manmade radionuclides were detected above minimum detection limits in this borehole.		Early agreement that supplemental data are not required.

References/Bibliography:

- *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq.
- CP-12134, *Borehole Summary Report for Borehole C3808 in the 216-Z-11 Ditch, 200-CW-5, U-Pond/Z-Ditches Cooling Water Operable Unit.*

Proposed activities:

Removal, treatment, and disposal of site to remove low-level waste and placement of an isolation and intrusion barrier over remaining area of suspect TRU waste.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*
MESC/MNA/IC = maintain existing soil cover, monitored natural attenuation, and institutional controls.
TRU = Radioactive waste as defined in DOE G 435.1-1, *Implementation Guide for Use with DOE M 435.1-1.*

Table F-2. Summary Data Sheet, Data-Needs Priority Summary for the 216-Z-1D Ditch (200-CW-5 Operable Unit).

Background	
Site Identification	216-Z-1D Ditch
Site Location	200 West Area, Plutonium Finishing Plant zone
Type of Site	CERCLA past-practice – Ditch
Operating History	The 216-Z-1D Ditch is a backfilled, surface-stabilized unit that runs from a point east of the 231-Z Building, curving southward to the 216-U-10 Pond. In 1949, the northern portion of the ditch was backfilled. A portion of the covered ditch is located inside the Plutonium Finishing Plant security fence. The backfilled portion of the ditch was replaced with an underground pipeline (see site code 200-W-125 [WIDS]) for 231-Z Building effluent. The southern portion of the ditch is co-located within a large Underground Radioactive Material area that also includes the 216-Z-11 and 216-Z-19 Ditches. The 216-Z-1D Ditch was used to transfer liquid waste from the 231-Z, 234-5Z, and 291-Z Buildings to the 216-U-10 Pond. The 216-Z-1D Ditch is associated with the 200-W-125 Pipeline, the 216-Z-11 and 216-Z-19 Ditches; the pipeline at the north end of the ditch; the stabilized 216-U-10 Pond; and the 231-Z Building outfall. The site was excavated in 1944. In 1949, the upper 526 m (1,725 ft) of the ditch was backfilled and replaced with a pipeline (200-W-125). After a release of plutonium and americium from the 231-Z Building occurred in 1959, the open portion of the ditch (a long, shallow channel with 2.5:1 sloped sides and a grade of 0.05%) from the pipeline southward to the 216-U-10 Pond (measuring 611 m [2,005 ft]) was backfilled. The ditch was replaced with a new ditch known as the 216-Z-11 Ditch. Documentation is unclear regarding whether the new ditch could have used 203 m (655 ft) of the original 216-Z-1D Ditch excavation near the outlet to the 216-U-10 Pond during some portion of 216-Z-11 Ditch operations.
Vicinity Waste Sites	Z-Ditches waste group
Current Status	Retired, backfilled, stabilized

Potential Remedial Alternatives

X for viable alternatives	**No Action**	**MESC/MNA/IC**	**Removal/Treat/Disposal**	**Barrier**	**Removal, Treatment, and Disposal and Barrier**	**In Situ Treatment, Removal, Treatment, and Disposal, and Barrier**	**Other**
	No	X	X	X	X	X	None

Data Evaluation and Gaps Analysis

Data	**Knowns**	**Data Uncertainties**	**Are supplemental data required to support decision making?**
	In 1959, the 216-Z-1D Ditch was sampled along its entire length starting at the inlet, in 30.5 m (100-ft) intervals, for total alpha and plutonium content in the mud found in the bottom of the ditch. The results from the mud sampling showed an average plutonium concentration of 6×10^5 pCi/g. The highest concentration found was 2.71×10^7 pCi/g of total alpha at 244 m (800 ft) from the entrance to the ditch.		Early agreement that supplemental data are not required.

References/Bibliography:

- *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq.
- *Waste Information Data System* database
- WHC-EP-0707, *216-U-10 Pond and 216-Z-19 Ditch Characterization Studies*.

Proposed activities:

Partial removal, treatment, and disposal of site to remove low-level waste and placement of an isolation and intrusion barrier over remaining area of suspect TRU waste.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*
MESC/MNA/IC = maintain existing soil cover, monitored natural attenuation, and institutional controls.
TRU = Radioactive waste as defined in DOE G 435.1-1, *Implementation Guide for Use with DOE M 435.1-1.*
WIDS = *Waste Information Data System* database.

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Table F-3. Summary Data Sheet, Data-Needs Priority Summary for the 216-Z-19 Ditch (200-CW-5 Operable Unit).

Background	
Site Identification	216-Z-19 Ditch
Site Location	200 West Area, Plutonium Finishing Plant zone
Type of Site	CERCLA past-practice – Ditch
Operating History	The 216-Z-19 Ditch is a backfilled, surface-stabilized site. The ditch is currently co-located within a large Underground Radioactive Material area that also includes the 216-Z-1D and 216-Z-11 Ditches. The 216-Z-19 Ditch operated as a waste disposal/transfer line for various Plutonium Finishing Plant facilities. The ditch received effluent from the 234-5Z Building, the 291-Z Stack, and the 231-Z Buildings. The ditch was fed by three underground process sewer pipelines that entered the head end of the ditch. The ditch was deactivated and backfilled when discharges transferred to the 216-Z-20 Tile Field. Structures associated with this site include the remnants of the 216-Z-1D and the 216-Z-11 Ditches, the 216-U-10 Pond, the storm water and process sewer outfalls from the Plutonium Finishing Plant, and the pipeline from the 231-Z Building. The head end of the ditch reused the first 37 m (120 ft) of land previously containing 216-Z-1D and the 216-Z-11 Ditches. The next 130 m (425 ft) of the 216-Z-19 Ditch mistakenly was excavated through a section of the contaminated (backfilled) 216-Z-1D Ditch. When the mistake was noticed, the ditch was turned west and followed a new route, parallel to the backfilled 216-Z-1D Ditch. The south end of the 216-Z-19 Ditch originally turned east and connected to the 216-Z-11 Ditch culvert that passed under 16th Street to empty into the 216-U-10 Pond. Later, a new culvert was added under 16th Street and the 216-Z-19 Ditch was directed to the new culvert.
Vicinity Waste Sites	Z-Ditches waste group
Current Status	Retired, backfilled, stabilized

Potential Remedial Alternatives

X for viable alternatives	**No Action**	**MESC/MNA/IC**	**Removal/Treat/Disposal**	**Barrier**	**Removal, Treatment, and Disposal and Barrier**	**In Situ Treatment, Removal, Treatment, and Disposal, and Barrier**	**Other**
	No (data indicate significant contamination at site)	X	X	X	X	X	None

Data Evaluation and Gaps Analysis

Data	**Knowns**	**Data Uncertainties**	**Are supplemental data required to support decision making?**
C3810 C3811 C3812 299-W18-193 299-W18-194 C3813 C3814 C3815 C3816 C3817 C3818	In 1979, a series of nine transects with seven sample points each were used at the 216-Z-19 Ditch to characterize the extent of plutonium and americium contamination. The results generally showed that the center of the ditch was the most highly contaminated. The highest Pu-239 concentration found was 97,800 pCi/g in the 0 to 5 cm (0 to 2 in.) depth range. The maximum Am-241 concentration was 29,000 pCi/g.		Early agreement that supplemental data are not required.

References/Bibliography:

- *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq.
- WHC-EP-0707, *216-U-10 Pond and 216-Z-19 Ditch Characterization Studies*.

Proposed activities:

Partial removal, treatment, and disposal of site to remove low-level waste and placement of an isolation and intrusion barrier over remaining area of suspect TRU waste.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*
MESC/MNA/IC = maintain existing soil cover, monitored natural attenuation, and institutional controls.
TRU = Radioactive waste as defined in DOE G 435.1-1, *Implementation Guide for Use with DOE M 435.1-1.*

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Table F-4. Summary Data Sheet, Data-Needs Priority Summary for the 216-Z-20 Tile Field (200-CW-5 Operable Unit). (3 Pages)

Background	
Site Identification	216-Z-20 Tile Field
Site Location	200 West Area; northwest of the U Tank Farm. Parallel to and west of the 216-Z-19 Ditch.
Type of Site	Tile Field
Site Construction	The 216-Z-20 Tile Field is rectangular, 462.99 by 3.05 m (1,519 by 10 ft) at the bottom, and 2.91 m (9.56 ft) deep with a 1:2 side slope. The ditch is divided into North, South 1, and South 2 segments. The tile field structure has varied depths of 2.7 to 8.8 m (9 to 29 ft) below ground surface. Three 15 cm (6-in.) perforated polyvinyl chloride distribution pipes run the length of the tile field to the south end, where the pipes are capped. A set of risers (three in a row across the width of the unit) rose to a height of 0.46 m (1.5 ft) above grade at four locations along the length of the unit. The unit was filled with gravel and backfilled over with soil. Construction information is available in the following historical references: WIDS, H-2-92061, and WHC-EP-0674.
Operating History	The 216-Z-20 Tile Field was built to receive effluent from the Plutonium Finishing Plant facilities and the 231-Z Building It was built to replace the 216-Z-19 Ditch. Construction of the 216-Z-20 Tile Field allowed the radioactively contaminated 216-Z-19 Ditch and 216-U-10 Pond to be decommissioned. The 216-Z-20 Tile Field is a liquid waste site that was used from 1981 to 1995 to receive cooling water, steam condensate, storm sewer, building drains, Hanford Engineering and Development Laboratory Radioactive Acid Digestion Test Unit cooling water, and chemical drains waste from the 234-5Z Building; cooling water stream condensate and laboratory drains from the 231-Z Building and miscellaneous drains waste from 291-Z, 232-Z, and 236-Z Buildings. The unit also received wastes from 2736-Z Building.
Effluent Volume Discharged	3,800,000,000 L (1,003,853,793 gal) (WIDS)
Period of Operation	1981 to 1995
Estimated Discharged Inventory For Representative Site 216-Z-11 Ditch	Inventory information is available in DOE/RL-99-66: Constituent — Inventory Am-241 — 0.492 Ci Plutonium — 8,100 g
Vicinity Waste Sites	Z-Ditches waste group
Characterization Summary	This site received ~4,200 ML of Z Complex chemical sewer waste, Z Complex cooling water, and plutonium recovery waste. The majority of the waste disposed is considered to be chemical sewer and cooling water. The annual volumes can be found in the following documents: RHO-HS-VS-4 RHO-HS-SR-81-3 RHO-HS-SR-82-3-4Q-LIQ-P RHO-HS-SR-83-3-4Q-LIQ-P RHO-HS-SR-84-3-4Q-LIQ-P RHO-HS-SR-85-3-4Q-LIQ-P RHO-HS-SR-86-3-4Q-LIQ-P WHC-EP-0141 WHC-EP-0141-1 WHC-EP-0141-2 WHC-EP-0527 WHC-EP-0527-1 WHC-EP-0527-2 WHC-EP-0527-3 WHC-EP-0527-4 WHC-EP-0527-5. The plutonium recovery waste contribution is estimated using waste-stream concentration and site inventory information regarding Pu-239 and is represented by an asymmetric triangular distribution with a maximum of 500 L (132 gal) (RPP-26744).

Table F-4. Summary Data Sheet, Data-Needs Priority Summary for the 216-Z-20 Tile Field (200-CW-5 Operable Unit). (3 Pages)

Data	
Spectral Gamma Logging System Logs (2003)	The data source for the Spectral Gamma Logging System logs is Stoller Log Data Reports.
299-W18-017 (265 ft) (2003)	Cesium-137 was detected at 8.2 m (27 ft) with a concentration near the MDL (0.2 pCi/g). Cesium-137 also was detected at 46 m (15 ft) on the repeat log with a concentration near the MDL.
299-W18-18 (265 ft) (2003)	Cesium-137 was detected at 6.1 m (20 ft) with a concentration near the MDL (0.2 pCi/g). Cesium-137 also was detected at 2.1 m (7 ft) on the repeat log with a concentration near the MDL. An increase of 6 pCi/g in apparent K-40 concentrations occurs at approximately 21.3 m (70 ft), which represents the transition from the coarse-grained sediments of the Hanford H_1 to the finer-grained sediments of the Hanford H_2. The concentration of natural U-238 is above 2.0 pCi/g near 29.3 m (96 ft), which is anomalously high within the Hanford formation.
299-W18-20 (250 ft) (2003)	Cesium-137 was detected at 4.3, 8.8, 12.5, and 13.7 m (14, 29, 41, and 45 ft) with a concentration near the MDL (0.2 pCi/g). Cesium-137 also was detected at 4 m (13 ft) on the repeat log with a concentration near the MDL. Increases of 5 pCi/g in apparent K-40 concentrations and 0.4 pCi/g in Th-232 and U-238 concentrations occur at approximately 27.1 m (89 ft), which represents the transition from the coarse-grained sediments of the Hanford H_1 to the finer-grained sediments of the Hanford H_2.
Analyses of Borehole Samples from the 216-Z-11 Ditch	The 216-Z-20 Tile Field is analogous to the 216-Z-11 Ditch. Boreholes were drilled in the 216-Z-11 Ditch. The major zone of contamination in the boreholes was detected from about 0.9 to 3.7 m (3 to 12 ft) below ground surface. The maximum soil contaminant concentrations were 40,000 pCi/g for Pu-239/240, 3389 pCi/g for Pu-238, and 3094 pCi/g for Am-241. Contaminant concentrations decreased to less than 1 pCi/g for all contaminants at 6 m (20 ft). (DOE/RL-2003-11, Section 3.2.1.5, page 3-7)
Remedial Investigation (2005-2007)	The 216-Z-20 Tile Field was investigated as being analogous to the 216-Z-11 Ditch in DOE/RL-2003-11.

Table F-4. Summary Data Sheet, Data-Needs Priority Summary for the 216-Z-20 Tile Field (200-CW-5 Operable Unit). (3 Pages)

References/Bibliography:

- BHI-00174, *U Plant Aggregate Area Management Study Technical Baseline Report*
- BHI-01294, *Data Quality Objective Summary Report for the 200-CW-5 U Pond/Z Ditches System Waste Sites*
- DOE/RL-91-52, *U Plant Source Aggregate Area Management Study Report*
- DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*
- DOE/RL-99-66, *Steam Condensate/Cooling Water Waste Group Operable Units RI/FS Work Plan; Includes: 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 Operable Units*
- DOE/RL-2003-11, *Remedial Investigation for the 200-CW-5 U Pond/Z Ditches Cooling Water Group, the 200-CW-2 S Pond and Ditches Cooling Water Group, the 200-CW-4 T Pond and Ditches Cooling Water Group, and the 200-CS-1 Steam Condensate Group Operable Units*
- H-2-92061, *Tile Field to Replace Z-19 Ditch*
- RPP-26744, *Hanford Soil Inventory Model, Rev. 1*
- Stoller Log Data Reports (http://www.hanford.gov/cp/gpp/data/vzcp/vzcp.cfm)
- *Waste Information Data System* database
- RHO-HS-SR-81-3, *Radioactive Liquid Wastes Discharged to Ground in the 200 Areas During 1981*
- RHO-HS-SR-82-3-4Q-LIQ-P, *Radioactive Liquid Wastes Discharged to Ground in the 200 Areas During 1982*
- RHO-HS-SR-83-3-4Q-LIQ-P, *Radioactive Liquid Wastes Discharged to Ground in the 200 Areas During 1983*
- RHO-HS-SR-84-3-4Q-LIQ-P, *Radioactive Liquid Wastes Discharged to Ground in the 200 Areas During 1984*
- RHO-HS-SR-85-3-4Q-LIQ-P, *Radioactive Liquid Wastes Discharged to Ground in the 200 Areas During 1985*
- RHO-HS-SR-86-3-4Q-LIQ-P, *Radioactive Liquid Wastes Discharged to Ground in the 200 Areas During 1986*
- WHC-EP-0141, *Westinghouse Hanford Company Effluent Releases and Solid Waste Management Report for 1987: 200/600/1100 Areas*
- WHC-EP-0141-1, *Westinghouse Hanford Company Effluent Discharges and Solid Waste Management Report for Calendar Year 1988: 200/600 Areas*
- WHC-EP-0141-2, *Westinghouse Hanford Company Effluent Discharges and Solid Waste Management Report for Calendar Year 1989, 200/600 Area*
- WHC-EP-0527, *Environmental Releases for Calendar Year 1990*
- WHC-EP-0527-1, *Environmental Releases for Calendar Year 1991*
- WHC-EP-0527-2, *Environmental Releases for Calendar Year 1992*
- WHC-EP-0527-3, *Environmental Releases for Calendar Year 1993*
- WHC-EP-0527-4, *Environmental Releases for Calendar Year 1994*
- WHC-EP-0527-5, *Environmental Releases for Calendar Year 1995*
- WHC-EP-0674, *Groundwater Impact Assessment Report for the 216-Z-20 Crib, 200 West Area*
- WHC-EP-0707, *216-U-10 Pond and 216-Z-19 Ditch Characterization Studies*

Proposed activities:

In accordance with proposed Alternative 5A, remove, treat, and dispose of low-level waste at the 2126-Z-20 Tile Field portion of the Z-Ditches.

H_1 = Hanford formation gravel-dominated facies.
H_2 = Hanford formation sand-dominated facies.
MDL = minimum detection level.
WIDS = *Waste Information Data System* database.

Table F-5. Summary Data Sheet, Data-Needs Summary for UPR-200-W-110 (200-CW-5 Operable Unit).

Background	
Site Identification	UPR-200-W-110
Site Location	This site is east of and parallel to the north end of the 216-Z-19 and 216-Z-11 Ditches in the 200 West Area.
Type of Site	Unplanned release/trench
Site Construction	The trench is 129.5 m (425 ft) long, 30.5 m (100 ft) wide, and 4.6 (15 ft) deep. It has been backfilled within an "Underground Radioactive Material" zone. The area was surface stabilized in 1982. The area is marked with concrete posts and an intermittent light chain.
Operating History	Disposal trench used only once in 1971.
Effluent Volume Discharged	Unknown
Duration	1971 (occurrence date)
Inventory Information	Unknown, but bounded by the inventory information for the 216-Z-1D Ditch.
Vicinity Waste Sites	216-Z-1 Ditch, 216-Z-11 Ditch, and 216-Z-19 Ditch
Characterization Summary	Characterization boreholes were drilled in 1982 to assess the hydrology, geology, and radioactive contaminants at the 216-Z-1, 216-Z-11 and 216-Z-19 Ditches; the 216-Z-20 Tile Field; and the UPR-200-W-110 site. Approximately 200 samples were collected and analyzed for radiological contaminants. At the time of stabilization (1982), the boundaries of the spoil trench were delineated based on sediment conditions encountered during drilling of shallow boreholes, radiological measurements of sediment samples collected during drilling operations, and vegetation growing in and around the spoil trench area. Nine boreholes were drilled at the site to investigate the sediment conditions and to collect sediment samples for radiological analyses. Five boreholes encountered sediments with normal moisture conditions (damp) that were penetrated at a slow to moderate rate (during drilling). Four other boreholes were drier and the penetration rate during drilling was faster. These sediments were judged to be disturbed by human intrusion. During radiological analyses, five boreholes contained detectable contaminated sediments. Positive radionuclide values were not detected from sediments in the remaining four boreholes. Vegetation growing in and around the site was inspected to aid in determining the spoil trench boundaries. At the time of the study (RHO-HS-VS-4), the spoil trench was about 10 years old and was not expected to have a less developed plant community than the surrounding area.
Data	
Field survey using x-ray spectroscopy (1982)	Sample-to-detector analysis.
299-W18-233	Data indicated Pu-239 at 3 to 5 nCi/g in the spoils deposition area at 3.8 m (12.5 ft) below ground surface.
References/Bibliography	
• RHO-HS-VS-4, *Earth Science Investigation of the 216-Z-20 Crib; The UN-216-W-20 Soil Trench & the Storm Sewer Pond* • RPP-26744, *Hanford Soil Inventory Model, Rev. 1* • *Waste Information Data System* database.	
Proposed activities:	
In accordance with proposed Alternative 5A, remove, treat, and dispose of low-level waste at the UPR-200-W-110 portion of the Z-Ditches.	

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BHI-01294, 1999, *Data Quality Objective Summary Report for the 200-CW-5 U Pond/Z Ditches System Waste Sites*, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

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DOE G 435.1-1, 1999, *Implementation Guide for Use with DOE M 435.1-1*, U.S. Department of Energy, Washington, D.C.

DOE/RL-91-52, 1992, *U Plant Source Aggregate Area Management Study Report*, Rev. 0, 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-99-66, 2004, *Steam Condensate/Cooling Water Waste Group Operable Units RI/FS Work Plan; Includes: 200-CW-5, 200-CW-2, 200-CW-4, and 200-SC-1 Operable Units*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

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WHC-EP-0674, 1993, *Groundwater Impact Assessment Report for the 216-Z-20 Crib, 200 West Area*, Westinghouse Hanford Company, Richland, Washington.

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