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Focused Feasibility Study for the BC Cribs and Trenches Area Waste Sites

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

United States Department of Energy
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TERMS

ALARA	as low as reasonably achievable
amsl	above mean sea level
ARAR	applicable or relevant and appropriate requirement
BCG	biota concentration guide (see DOE-STD-1153-2002)
bgs	below ground surface
CCU	Cold Creek unit
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COC	contaminant of concern
COPC	contaminant of potential concern
CPP	CERCLA past practice
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EIS	environmental impact statement
ELCR	excessive lifetime cancer risk
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
ERDF	Environmental Restoration Disposal Facility
ET	evapotranspiration
FFS	focused feasibility study
FS	feasibility study
HAB	Hanford Advisory Board
HHRA	human health risk assessment
HRR	high resolution resistivity
IAEA	International Atomic Energy Agency
IC	institutional control(s)
Implementation Plan	DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*
ISGR	in situ gaseous reduction
K_d	distribution coefficient
MCL	maximum contaminant level
MESC	maintain existing soil cover
MNA	monitored natural attenuation
NA	not applicable
NEPA	*National Environmental Policy Act of 1969*
NPL	"National Priorities List" (40 CFR 300, Appendix B)
OU	operable unit
PP	proposed plan
PRG	preliminary remediation goal
PRTR	Plutonium Recycle Test Reactor
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
RESRAD	RESidual RADioactivity dose model (ANL 2002)
RI	remedial investigation

RLS	radionuclide logging system
ROD	record of decision
RTD	removal, treatment, and disposal
SLERA	screening-level ecological risk assessment
STOMP	Subsurface Transport Over Multiple Phases
TBP	tributyl phosphate
TMV	toxicity, mobility, or volume through treatment
Tri-Parties	DOE, EPA, and Ecology
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989)
TRU	transuranic (waste materials contaminated with more than 100 nCi/g of transuranic materials having half-lives longer than 20 years)
UPR	unplanned release
URP	Uranium Recovery Process
WIDS	*Waste Information Data System* database

1.0 INTRODUCTION

The Hanford Site, managed by the U.S. Department of Energy (DOE), encompasses approximately 1,517 km^2 (586 mi^2) in the Columbia Basin of south-central Washington State. In 1989, the U.S. Environmental Protection Agency (EPA) placed the 100, 200, 300, and 1100 Areas of the Hanford Site on the 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," Appendix B, "National Priorities List" (NPL) pursuant to the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). The 200 Areas NPL site consists of the 200 West Area and 200 East Area (Figure 1-1), which contain waste management facilities and inactive irradiated fuel reprocessing facilities, and the 200 North Area, formerly used for interim storage and staging of irradiated fuel. Several waste sites in the 600 Area, located near the 200 Areas, also are included in the 200 Areas NPL site. The 200 Areas consist of approximately 700 waste sites organized into 23 waste site groups, called operable units (OU). This focused feasibility study (FFS) addresses waste sites located in the BC Cribs and Trenches Area, located near the center of the Hanford Site on the south edge of the 200 East Area (Figure 1-1).

The BC Cribs and Trenches Area consists of 28 waste sites: 26 cribs and trenches, one siphon tank, and an associated pipeline (Table 1-1). Associated with this area is a large soil-contamination area that will be addressed under separate decision-making pathways. The 28 waste sites comprising the BC Cribs and Trenches Area are CERCLA past-practice (CPP) sites. These waste sites predominantly consist of liquid waste disposal sites associated with former Uranium Recovery Process (URP) and tank waste scavenging operations.

The process for characterization and remediation of waste sites at the Hanford Site is addressed in Ecology et al. 1989, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement). The Tri-Party Agreement establishes major milestones for completing the waste site investigation and decision-making processes by December 31, 2008, and completing waste site remediation by September 30, 2024 (Milestones M-15-00C and M-16-00, respectively) for non-tank farm operable units in the 200 Areas. In 2002, the DOE Richland Operations Office, the EPA, and the Washington State Department of Ecology (Ecology) (the Tri-Parties) renegotiated the 200 Areas waste site cleanup milestones under the Tri-Party Agreement; the results of these negotiations are documented in Tri-Party Agreement change forms M-13-02-01, M-15-02-01, M-16-02-01, and M-20-02-01. The BC Cribs and Trenches Area waste sites lie inside the Central Plateau Industrial/Exclusive Zone boundary identified in DOE/EIS-0222-F, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*. Combining these waste sites into a single FFS is intended to streamline the risk-based decision-making process for a significant geographical area of the 200 Areas NPL site and supports DOE's vision of shrinking the area of land occupied by the Hanford Site.

Submittal of this FFS and the associated proposed plan (PP), DOE/RL-2004-69, *Proposed Plan for the BC Cribs and Trenches Area Waste Sites*, for the BC Cribs and Trenches Area waste sites, most of which are high-risk sites, is intended to facilitate initiation of remedial action(s) to address risk. Addressing these waste sites under a single FFS is a key component of the BC Cribs and Trenches Area initiative, which has been proposed to accelerate the remediation of that geographic area. Elements of the general geographic area not included are the

BC Controlled Area and the Nonradioactive Dangerous Waste Landfill. The overall objective of this initiative is to accelerate all actions necessary to achieve cleanup, such that the area can move to a state of long-term stewardship.

1.1 PURPOSE

The purpose of this FFS is to develop and evaluate alternatives for remediation of the 28 waste sites in the BC Cribs and Trenches Area and to function as a supporting document to the PP. This FFS will refine preliminary potential applicable or relevant and appropriate requirements (ARAR) (Appendix B), remedial action objectives (RAO), and general response actions initially identified in DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (Implementation Plan). The initial remedial alternative development activity provided the basis for developing a focused range of viable alternatives for the BC Cribs and Trenches Area waste sites. The alternatives considered within this FFS include a range of response actions (no further action; removal, treatment, and disposal; containment [capping]; and containment combined with limited "hot spot" removal [partial removal, treatment, and disposal]) that are appropriate to address site-specific conditions. The alternatives are evaluated and compared to the CERCLA criteria. The Tri-Parties will use this FFS as the basis for selecting a remedy to mitigate potential risks to human health and the environment. A preferred remedial alternative(s) will be presented to the public in a PP for review and comment. The EPA then will prepare a CERCLA record of decision (ROD) that will identify the alternative(s) to be implemented by the Tri-Parties.

The 28 waste sites addressed in the FFS are assigned to the 200-TW-1 OU. This geographic-based FFS is expected to accelerate the remedial decision process for the BC Cribs and Trenches Area waste sites over the current remedial investigation (RI)/feasibility study (FS) baseline schedules for the affected OUs.

1.2 SCOPE

Remediation of the waste sites is a source control action that addresses contaminated soil and structures (e.g., the siphon tank and pipelines) associated with cribs and trenches. Other than the requirement for the source control action to be protective of groundwater and surface water, the scope does not include the remediation of groundwater beneath these waste sites.

This FFS focuses on the 28 BC Cribs and Trenches Area waste sites. These waste sites received liquid wastes from 200 Areas reprocessing activities, mainly the uranium recovery process in the U Plant.

1.3 BC CRIBS AND TRENCHES AREA APPROACH

In 1999, the DOE developed the 200 Areas strategy, as described in the Implementation Plan (DOE/RL-98-28). The 200 Areas strategy established an approach for reaching remedial decisions for the non-tank-farm waste sites. Under this approach, the waste sites were grouped

into process-based OUs to streamline characterization. Investigation work plans were prepared beginning in 1999 and were followed by field sampling. As characterization proceeded, other streamlining initiatives, such as combining multiple OUs into a single investigation effort, were implemented within the framework of DOE/RL-98-28. The strategy anticipated further revisions to the waste site groupings for evaluation and/or remediation. In particular, it was considered that remediation might be accomplished most effectively by grouping sites geographically.

Consistent with the 200 Areas strategy and the ongoing effort to accelerate cleanup at the Hanford Site, the DOE partnered with Ecology and EPA to identify new approaches for the 200 Areas cleanup process. One of these approaches is the geographic area closure concept (DOE/RL-2002-68, *Hanford's Groundwater Management Plan: Accelerated Cleanup and Protection*). The geographic-based cleanup goals are (1) to reduce environmental risks and protect underlying groundwater by closing high-risk waste sites and (2) to accelerate remediation of the Hanford Site. In addition, economies of scale could be realized by performing remediation of all sites within a given geographic area as an integrated effort.

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

- The waste disposal sites and pipelines in the area are inactive.
- The waste sites in the area are sufficiently well characterized to apply the analogous site approach in making remedial decisions.
- The majority of the former waste disposal sites are considered high risk, some of which are sources of significant potential technetium groundwater contamination.
- Final decision-making for the 200-PO-1 Groundwater OU would be facilitated by accelerated remediation of the source sites.

Remedial investigation of waste sites located in the BC Cribs and Trenches Area and within the 200-TW-1 OU did not occur until 2003, when the 216-B-26 Trench was characterized. Previous investigation of waste sites in this OU included characterization of the BY Cribs and particularly the 216-B-46 Crib, which was designated as one of representative 200-TW-1 OU waste sites in DOE/RL-2000-38, *200-TW-1 Scavenged Waste Group Operable Unit and 200-TW-2 Tank Waste Group Operable Unit RI/FS Work Plan*. Also, in 2003, the 216-B-58 Trench was characterized. At that time, this waste site was within the 200-LW-1 OU; it has since been transferred to the 200-TW-1 OU.

The BC Cribs and Trenches Area project consists of several coordinated activities with the following decision-making pathways.

- Waste Disposal Sites: Preparation of an FFS and PP, followed by a ROD under CERCLA for the former waste disposal sites in the BC Cribs and Trenches Area. The

public review process for the PP will be initiated in 2005, with a ROD issued later that same year.

- Underground Pipelines: This FFS (and associated PP) also identifies, evaluates, and proposes a remedy for a contaminated subsurface pipeline that will be addressed by the same ROD that addresses the former waste disposal sites. These pipelines include a portion of the pipeline that extends from the BY Tank Farm at the north end of the 200 East Area to the BC Cribs (the scope of this FFS is limited to that portion of the pipeline south of Route 4 South - the remaining portion ultimately will be addressed by the ROD for the remainder of the 200-TW-1 OU waste sites), the liquid waste distribution pipelines extending from the siphon tank to the cribs, and the buried collection of pipes that were used to direct effluent to the various trenches.

- Excess Facilities: This FFS (and associated PP) also identifies, evaluates, and proposes a remedy for the siphon tank (200-E-14) that was used to collect waste liquid until full and then discharge it to the selected crib.

- Groundwater: Preparation of an RI/FS work plan for the 200-PO-1 Groundwater OU, which includes the groundwater underlying the BC Cribs and Trenches Area, is anticipated. After completion of the RI, an RI report, FS, and PP will be prepared, followed by a ROD under CERCLA. The public review process for the PP is likely to be completed in 2008, with a ROD likely issued in 2009.

The first activities that will be completed under the BC Cribs and Trenches Area approach include the remediation of waste sites and selected removal actions for associated pipelines. These activities generally will be coordinated to occur concurrently. After the source terms have been remediated, a final ROD for groundwater can be pursued and associated cleanup actions can be performed. Following cleanup, the area will move to a condition of long-term care, postclosure care, or other condition suitable for long-term stewardship.

All waste sites in the BC Cribs and Trenches Area have been combined into the 200-TW-1 OU.

The supporting key documents that provide detailed characterization data are as follows:

- DOE/RL-2002-42, *Remedial Investigation Report for the 200-TW-1 and 200-TW-2 Operable Units (Includes the 200-PW-5 Operable Unit)*

- DOE/RL-92-70, *Phase 1 Remedial Investigation Report for 200-BP-1 Operable Unit*

- DOE/RL-2003-64, *Feasibility Study for the 200-TW-1 and 200-TW-2 Operable Units.*

1.4 REPORT ORGANIZATION

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

- Chapter 1.0 presents the purpose, scope, and regulatory framework for the FFS, as well as this overview of report organization.
- Chapter 2.0 presents descriptions of the physical setting and natural resources, provides an overview of existing waste site information including characterization data and conceptual site models for representative waste sites, establishes the logic for grouping analogous waste sites and applying the analogous site approach, and summarizes risk evaluations.
- Chapter 3.0 discusses land-use assumptions and develops the overall cleanup objectives and media-specific goals for the waste sites.
- Chapter 4.0 develops remedial alternatives based on DOE/RL-98-28 and site-specific considerations, presents a description of each alternative, and defines the applicability of the alternative to the wastes sites.
- Chapter 5.0 presents a detailed analysis of each of the remedial alternatives against standard CERCLA criteria and *National Environmental Policy Act of 1969* (NEPA) values.
- Chapter 6.0 provides a detailed analysis of the remedial alternatives described in Chapter 5.0.
- Chapter 7.0 provides a comparative analysis of the remedial alternatives, based on the same seven CERCLA criteria used in the detailed analysis.
- Chapter 8.0 summarizes the conclusions of the FFS, including the preferred alternative(s).
- Chapter 9.0 contains all references for the main body of the report; each appendix contains its own reference section.
- Appendix A includes current photographs of the waste sites.
- Appendix B presents an analysis of regulatory requirements and available guidance with respect to the BC Cribs and Trenches Area waste sites.
- Appendix C, presents the human health and ecological risk evaluations, including the methodology, results, and uncertainties.
- Appendix D presents the basis for the cost estimates.
- Appendix E presents the intruder risk evaluations, methodology, and results.

- Appendix F presents the estimated radiation dose to workers if the material in the BC Cribs and Trenches Area were to be excavated, transported, and buried in an engineered burial ground.
- Appendix G presents the methodology and results of the fate and transport modeling associated with select waste sites.
- Appendix H evaluates a range of technologies, using the CERCLA criteria, for applicability in immobilizing the Tc-99 contamination that threatens groundwater.

Table 1-1. BC Cribs and Trenches Area Waste Sites.

Waste Site	Operable Unit	Waste Site Structure Type	Waste Site	Operable Unit	Waste Site Structure Type
200-B-14	200-TW-1	crib	216-B-28	200-TW-1	trench
200-B-15	200-TW-1	crib	216-B-29	200-TW-1	trench
200-B-16	200-TW-1	crib	216-B-30	200-TW-1	trench
200-B-17	200-TW-1	crib	216-B-31	200-TW-1	trench
200-B-18	200-TW-1	crib	216-B-32	200-TW-1	trench
200-B-19	200-TW-1	crib	216-B-33	200-TW-1	trench
200-B-20	200-TW-1	trench	216-B-34	200-TW-1	trench
200-B-21	200-TW-1	trench	216-B-52	200-TW-1	trench
216-B-22	200-TW-1	trench	216-B-53A	200-TW-1	trench
216-B-23	200-TW-1	trench	216-B-53B	200-TW-1	trench
216-B-24	200-TW-1	trench	216-B-54	200-TW-1	trench
216-B-25	200-TW-1	trench	216-B-58	200-TW-1	trench
216-B-26	200-TW-1	trench	200-E-14	200-TW-1	siphon tank
216-B-27	200-TW-1	trench	200-E-114	200-TW-1	pipeline

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601 et seq.

2.0 BACKGROUND INFORMATION

This chapter of the BC Cribs and Trenches Area FFS presents the background and history of the 200-TW-1 OU, including descriptions of the liquid waste generating processes, physical setting, natural resources, cultural resources, socioeconomics, representative sites, the nature and extent of contamination, and a risk evaluation. Information on the four former 200-LW-1 OU waste sites that have been transferred to the 200-TW-1 OU is included.

DOE/RL-98-28; DOE/RL-96-81, *Waste Site Grouping for 200 Areas Soil Investigations Report*; BHI-01356, *Remedial Investigation Data Quality Objectives Summary Report for the 200-TW-1 Scavenged Waste Group and 200-TW-2 Tank Waste Group Operable Units*, and DOE/RL-2000-38 identify the representative sites for the OUs. The representative sites were selected for evaluation in an RI because of the amount of characterization already performed and because the sites generally are considered worst case (upper bound) or typical of the waste characteristics for the OUs.

DOE/RL-2002-42, the RI report for the 200-TW-1, 200-TW-2, and 200-PW-5 OUs, provides characterization data for one of the representative waste sites (216-B-46 Crib). Characterization data for two new 200-TW-1 OU waste sites located in the BC Cribs and Trenches Area are included in this FFS (216-B-26 and 216-B-58 Trenches). An RI report for the 200-LW-1 OU has not been completed. However, DOE/RL-2001-66, *Chemical Laboratory Waste Group Operable Units RI/FS Work Plan, Includes: 200-LW-1 and 200-LW-2 Operable Units*, provides estimates of contaminants at the 216-B-58 Trench. Two boreholes were drilled in the 216-B-58 Trench to support this FFS and the acceleration of remedial actions at the BC Cribs and Trenches Area. This information is included in this FFS.

2.1 OPERABLE UNITS BACKGROUND AND HISTORY

2.1.1 Buildings and Ancillary Facilities

The Hanford Site, established in 1943, was originally designed, built, and operated to produce plutonium for nuclear weapons using production reactors and chemical reprocessing plants. In March 1943, construction began on three reactor facilities (B, D, and F Reactors) in the 100 Areas and three chemical processing facilities (B, T, and U Plants) in the 200 Areas. Operations in the 200 East and 200 West Areas mainly were related to separation of special nuclear materials from spent nuclear fuel (i.e., fuel that has been withdrawn from a nuclear reactor following irradiation). Operations in the 200 Areas relative to the BC Cribs and Trenches Area waste sites consisted of the following facilities.

- B Plant. In the B Plant, the bismuth-phosphate process was used to separate plutonium from irradiated fuel rods. Recovery of cesium, strontium, and other rare earth metals also was performed, using an acid-side oxalate-precipitation process.

- T Plant. In the T Plant, the bismuth phosphate process was used to separate plutonium from irradiated fuel rods.
- C Plant. In the Hot Semiworks Plant, the bismuth-phosphate process was used in plutonium separation.
- U Plant. In the U Plant, the tributyl phosphate (TBP) process was used to recover uranium from bismuth-phosphate process wastes.

The following sections describe the B Plant, T Plant, and U Plant and the associated ancillary buildings and facilities, including a summary of the history of operations, important waste generating processes, and liquid waste disposal practices. The B Plant, T Plant, and U Plant were the primary contaminant sources for the BC Cribs and Trenches Area waste sites. Although the buildings and ancillary facilities associated with the B Plant, T Plant, and U Plant are not within the scope of this FFS, they represent the primary sources of waste disposed to the OU and are, therefore, of interest for this FFS. Figures 2-1a and 2-1b show the processes at the plants and identify the waste sites that received effluents from these processes.

2.1.2 B Plant, T Plant, and U Plant History

B Plant and T Plant were constructed in 1944. B Plant and T Plant consist of several buildings each, including the 221-B Building and 221-T Building (also known as Canyon Buildings because of their shape and appearance) and the 224-B Building and 224-T Building (also known as Concentration Facilities because of the operational procedures performed there). The B and T Plants received and processed irradiated fuel rods from the 100 Area reactors. The fuel rods were subject to several chemical separation and purification steps to produce the desired plutonium product. The plutonium separation and purification operations ceased in 1952 at B Plant and in 1956 at T Plant (DOE/RL-92-05, *B Plant Source Aggregate Area Management Study Report*; DOE/RL-91-61, *T Plant Source Aggregate Area Management Study Report*).

U Plant, constructed in 1944, was based on the design of B Plant and T Plant and initially was used to train personnel for the uranium/plutonium separation operations conducted in B Plant and T Plant. Reportedly, only clean water was used for training purposes, and no waste streams were generated in this early training operation. In 1951, the U Plant was modified to facilitate the URP. This mission, conducted from 1952 to 1958, served two purposes: (1) to recover unprocessed uranium to be irradiated and processed into plutonium, and (2) to reduce the volume of waste generated at B Plant and T Plant. A secondary operation later was added to the URP processes in U Plant to "scavenge" or precipitate out of solution the long-lived fission products in the settling process before the waste was discharged (DOE/RL-91-52, *U Plant Source Aggregate Area Management Study Report*).

Liquid wastes generated at B Plant, T Plant, and U Plant were routed to underground storage tanks in the B, BX, BY, T, TX, and TY Tank Farms through a series of collection and transfer tanks, diversion boxes, vaults, and piping. This allowed the heavier constituents to settle out from solution and form sludge and was known as "cascading." The remaining liquid supernatants were discharged to the soil column in cribs, drains, trenches, and injection/reverse wells (*Waste Information Data System* report [WIDS]).

Cribs and drains were designed to percolate wastewater into the ground without exposing it to the open air. French drains usually were constructed of steel or concrete pipe and were either open or filled with gravel. Cribs were shallow excavations that were either backfilled with permeable material or held open by wooden structures. Cribs usually had an additional layer of an impermeable substance, which allowed the water to flow directly into the backfilled material, or covered space, and percolate into the vadose zone soils. Cribs and drains typically received low-level radioactive waste for disposal. Most were designed to receive liquid until a specific retention volume or radionuclide capacity was met (DOE/RL-91-61, DOE/RL-92-05).

Trenches are shallow, long, narrow, unlined excavations. Trenches received limited quantities of sludge and/or liquid wastes. Trenches often were located in proximity to other trenches. Some trenches have been backfilled and marked as a single group, regardless of whether they all contained the same type of waste (DOE/RL-92-19, *200 East Groundwater Aggregate Area Management Study Report*; DOE/RL-91-61).

2.1.3 Process Information

The chemical separations processes implemented at B Plant, T Plant, and U Plant generated liquid waste streams. The B Plant, T Plant, and U Plant processes that are the primary sources of waste disposed to the 200-TW-1 OU waste sites include the following.

- The bismuth-phosphate separation process generated 221-B Building or 221-T Building waste including dissolved cladding, metal waste, and first- and second-cycle waste streams.
- The URP process generated U Plant waste including TBP waste or column waste, solvent recovery waste, acid recovery waste, off-gas condensates, and uranium trioxide or powdered waste streams.
- The scavenging (fission-product precipitation) process generated the scavenged and in-tank scavenged waste, including the fission-products waste streams.

2.1.3.1 Bismuth-Phosphate Separation Process

Irradiated uranium slugs rich with plutonium were transferred from the 100 Areas to the 200 North Area via shielded rail cars for a 45- to 60-day period of intermediate storage in large tanks containing water. After the necessary period of storage, the slugs were sent via rail car to the 221-B and 221-T Buildings (OUT-1462, *History of Operations (1 January 1944 to 20 March 1945)*). The rods came with an aluminum/aluminum-silicate cladding as a protective jacket. The first step of the separation process was to dissolve this cladding using a sodium hydroxide solution; sodium nitrate and mercury were added to prevent the generation of hydrogen gas and to assist in dissolving the aluminum cladding. The liquid effluent was composed of the sodium hydroxide solution and the dissolved aluminate-sodium nitrate/nitrite. This solution became known as the dissolved-cladding waste stream (HW-10475, *Hanford Engineer Works Technical Manual (T/B Plants)*). This waste stream was sent to Tanks 241-B-110, 241-B-111, 241-B-112, 241-B-201, 241-B-202, 241-B-203, and 241-B-204 and to Tanks 241-T-104, 241-T-105,

241-T-106, 241-T-109, 241-T-110, and 241-T-111. This waste stream often was combined with first-cycle waste.

After the cladding was removed, the fuel rod was rinsed with water and dissolved in a concentrated solution of nitric acid, known as the dissolver solution. Plutonium, uranium, and fission products including Co-60, Sr-90, and Cs-137 isotopes were present in this solution (HW-10475).

The next step of the bismuth-phosphate process involved the separation of the fission products and uranium ions from the plutonium ions. Sodium nitrite solution was added to a batch of dissolver solution to ensure that the plutonium ion would have a valence of 3+ or 4+. Bismuth nitrate, phosphoric acid, and sulfuric acid were added to this solution, causing the plutonium and approximately 10 percent of the fission products to precipitate out of solution as a bismuth-phosphate complex, a white powder (HW-10475).

Once the precipitant was separated from the supernatant, the supernatant was sent to the B, BX, BY, T, TX, and TY Tank Farms. This waste stream was known as the metal wastes stream and contained approximately 100 percent of the uranium and 90 percent of the fission products from the original waste. This waste was so concentrated with radionuclides that storage in the tank farms was the only acceptable waste disposal solution (HW-10475).

2.1.3.2 Uranium Recovery Process

From 1952 to 1958, the URP was implemented at the U Plant to recover the spent uranium from the metal waste and first-cycle waste streams generated in the B Plant and T Plant for reuse in weapons-grade plutonium production. The URP was performed in the following three phases (HW-19140, *Uranium Recovery Technical Manual*):

- Removal of bismuth-phosphate waste from underground storage and preparation of the sludge/slurry solution
- Separation of the uranium from plutonium, fission products, and chemicals
- Conversion of the uranium into uranium trioxide powder.

The metal waste and first-cycle waste stored in the B and T Tank Farms was sent via a network of underground pipes, tanks, and diversion boxes to U Plant, where it was deposited into cascading underground storage tanks. The uranium-rich bismuth-phosphate waste streams often turned into a sludge/supernatant combination because of the basic pH level of the waste solution (pH usually was adjusted and maintained at 10.5 because of the corrosiveness of the waste stored in the tanks). The sludge was dissolved into a liquid solution, to be pumped from the tanks into the 221-U Canyon Building. An aqueous solution was jetted at a high pressure into the sludge to dissolve it into a slurry solution. Water and/or sodium carbonate, ammonium bicarbonate, or sodium bicarbonate solutions were used as alternatives to enhance solubility. The supernatant was recycled and reused in the dissolution process of the sludge.

The sludge/supernatant slurry was pumped to an accumulation tank. The sludge settled and was transferred to an agitated dissolver tank, while the supernatant was recycled. To prepare the

separation feed, a large quantity of nitric acid was added to the sludge. The nitric acid served two purposes. First, it dissolved the uranium-rich sludge into an aqueous phase. Second, it acted as a salting agent, reducing the solubility of the uranyl nitrate in the aqueous phase and increasing its solubility during the first separation via an extraction column. The pH was adjusted in the resulting solution, which was concentrated by evaporation. This concentrated feed solution then was sent to the first-cycle extraction column.

The uranium-rich feed entered the extraction column at mid-point. A countercurrent flow of TBP dissolved in a hydrocarbon solution (usually kerosene or paraffin) extracted the uranium from the feed solution into the TBP/organic solution. The fission products, plutonium, and other inorganic chemicals from the bismuth-phosphate process remained in the aqueous feed solution. A scrub solution, composed of nitric and sulfamic acids along with ferrous ammonium sulfate, also was introduced at the top of the column. The scrub solution was used to scrub the fission products from the extraction column and to ensure that the plutonium remained in solution as a 3^+ ion. The aqueous waste steam was sent to a waste treatment collection tank for further processing. This separation/extraction was a continuous flow process.

The TBP/organic solution, rich with uranium, left the first extraction column and continued to a second extraction column. At this column, the TBP/organic solution entered the bottom of the column and was met by a countercurrent flow of water. Because the organic solution did not contain a salting agent to bind the uranium in solution, the water extracted the uranium from the organic solution into an aqueous phase. The waste organic solution was sent to the solvent recovery operation in U Plant while the aqueous solution, containing the uranium, was sent to the uranium trioxide process in U Plant.

The solvent recovery operation at U Plant used a scrubber column and a sodium sulfate solution to remove any residual fission products, plutonium, and/or inorganic salts including nitrates from the organic solvent. The purified organic/TBP solvent was recycled, and the scrubber solution containing impurities was sent to the waste collection tank in the 241-WR Vault and later was scavenged and sent to cribs and trenches, including the 200-TW-1 OU waste sites (the 216-B-20 to 216-B-34 Trenches and the 216-B-52 Trench) via underground pipelines and diversion boxes (ARH-947, *200 Areas Disposal Sites for Radioactive Liquid Wastes*; WHC-MR-0132, *A History of the 200 Area Tank Farms*).

The aqueous phase containing the uranium was combined with the concentrated uranyl nitrate hexahydrate solution from the Reduction-Oxidation (process) operations and sent to the uranium trioxide plant (UO_3 or 224-U Building) for conversion of the uranyl nitrate solution into uranium trioxide powder. The solutions passed through two evaporators, which evaporated the water/nitric aqueous component and concentrated the solution with uranyl nitrate. The off-gasses were collected and sent to a fractionation operation in U Plant, where the nitric acid was recovered and reused in the dissolver tank for feed preparation or routed to cribs, ditches, and trenches near the U Plant for disposal (ARH-947).

The concentrated uranyl nitrate solution was sent to calcination vessels. These vessels were electrically heated and contained agitators or stirring mechanisms. The vessels were heated for 5 hours. This allowed the uranyl nitrate solution to maintain a temperature of 400 °F.
The off-gasses were again collected and sent to a fractionation operation, where nitric acid was

recovered and reused in the dissolver tank for feed preparation and/or routed to cribs, ditches, and trenches near U Plant for disposal. Once thermo-decomposition was completed, uranium trioxide powder was formed. The powder was removed from the vessels, packaged, and shipped off Site to Oak Ridge, Tennessee, where it was converted to uranium metal. The metal was returned to the 300 Area to be reincorporated into the uranium fuel-rod production (HW-19140).

The aqueous waste streams generated in this TBP/URP process from each of the extraction columns were sent to an aqueous waste collection tank. The waste was pooled until an optimal volume was received and a sample was obtained. Once the waste collection tank reached optimal volume (usually 45,425 L [12,000 gal]), it was condensed and then sent back to the feed accumulation tank for reprocessing, or routed to the neutralization tank. In the neutralization tank, the waste was combined with an equal volume of 50 percent caustic soda (sodium hydroxide) to obtain a pH of 9.5. Because a measurable quantity of ammonia was generated by neutralization, quantities of 50 percent caustic soda (sodium hydroxide) were added to raise the pH to 11.5 (HW-19140).

Waste from the neutralization tank was sent to a concentrator in the 221-U Building, where the volume of the aqueous waste was reduced through evaporation. The concentrate (or remaining sludge/slurry solution) was pumped back to underground storage tanks in the B, BX, BY, T, TX, and TY Tank Farms. The recovered condensate and other recovered condensates (from off-gasses generated during the feed preparation, calcination, solvent recovery, and nitric acid recovery operations) were routed to cribs, trenches, and ditches for disposal via diversion vaults (including the waste sites within the 200-TW-1 OU). Cooling water, steam condensates, nonradioactive wastes, and nonhazardous wastes were routed to U Plant trenches and ditches for disposal into the soil column (HW-19140).

2.1.3.3 Scavenging Process

In 1953, tests to further treat the metal waste and first-cycle waste streams generated at T Plant and B Plant during the bismuth-phosphate campaign proved successful. The scavenging process separated the long-lived fission products, including strontium and cesium, from the waste solutions by precipitation. This process served two purposes: (1) it reduced the volume of waste containing long-lived fission products previously stored within the tank farms, and (2) it allowed the remaining waste liquid effluents (no longer containing the long-lived fission products) to be discharged to the soil column. Waste liquid effluents from the test batches were sent to the 216-T-18 Crib for disposal into the soil column (LA-UR-96-3860, *Hanford Tank Chemical and Radionuclide Inventories: HDW Model*; ARH-947; GE 1958, *Record of Scavenged TBP Waste (Logbook)*).

From 1954 to 1958, the scavenging process was conducted at U Plant after the URP operations. The order of operations often was modified throughout the duration of the scavenging process. Parameters such as pH, addition of other metals to enhance precipitation, and soil retention properties also were continually changing. After URP processing, TBP column wastes were sent to a neutralization tank at U Plant, where the pH was adjusted to 9 ± 1. Chemicals used to scavenge fission products included potassium and sodium derivatives of the metal/ferrocyanide complex ion. The most notable and widely used metals (used to assist precipitation) were iron, nickel, and cobalt. Calcium nitrate and/or strontium nitrate often were added to enhance the

precipitation of the radioactive Sr-90. Phosphate ions also were added to aid the soil retention of Sr-90. Once the TBP waste had been scavenged, the waste was returned to the B, BX, BY, T, TX, and TY Tank Farms to allow the solids (containing the fission products and scavenging chemicals) to settle for approximately one week. The waste liquid effluent was sampled and analyzed from the tanks at various depths. The waste liquid effluent was sent to cribs and/or trenches if the amounts of Cs-137 and Sr-90 were within limits; otherwise, the liquid waste was rerouted to other nearby tanks and settling continued. In extreme cases, scavenging occurred in-tank to further precipitate fission products out of solution. The cribs and trenches receiving the scavenged TBP waste include 200-TW-1 OU waste sites 216-B-14 to 216-B-19 Cribs, 216-B-20 to 216-B-34 Trenches, and the 216-B-52 Trench (HW-19140; DOE/RL-91-52; WIDS; WHC-SD-WM-ER-133, *An Assessment of the Inventories of the Ferrocyanide Watchlist Tanks*; GE 1958).

In 1955, in-tank or in-tank-farm scavenging operations also began. In-tank scavenging was conducted to process the TBP waste, previously generated in U Plant before the implementation of the scavenging operation, that had been returned to the B, BX, BY, T, TX, and TY Tank Farms. The TBP wastes were transferred from the tanks to vaults, including the 244-CR Vault near the Plutonium-Uranium Extraction Plant, where the TBP waste was scavenged and sent back to the original tank farms. The same chemicals were used in the in-tank scavenging that were used in the U Plant. Often, scavenging was performed in batches from tanks in the B, BX, BY, T, TX, and TY Tank Farms, when the liquid effluents did not meet cribbing or trenching limits. The cribs and trenches that received in-tank or in-tank-farm scavenged and/or rescavenged TBP waste include 200-TW-1 OU waste sites 216-B-17 Crib, 216-B-19 Crib, 216-B-20 to 216-B-23 Trenches, 216-B-28 Trench, 216-B-30 to 216-B-34 Trenches, and 216-B-52 Trench (ARH-947). The "in-tank" scavenging operations ended in 1957, and the last of the liquid effluents were discharged in 1958 (HW-31442, *Recovery of Cesium-137 from Uranium Recovery Process Wastes*; HW-33591, *Summary of Liquid Radioactive Wastes Discharged to the Ground – 200 Areas (July 1952 Through June 1954)*; HW-38562, *Radioactive Contaminants in Liquid Wastes Discharged to Ground at Separation Facilities Through June 1955*; HW-42612, *Cobalt-60 in Groundwater and Separation Waste Streams*).

Post-B Plant and T Plant sources of waste disposed of in the 200-TW-1 OU waste sites include the following (DOE/RL-91-61, DOE/RL-92-05):

- Decontamination and equipment refurbishment, including ammonium silica fluoride tests
- Pacific Northwest National Laboratory waste
- Bismuth-phosphate waste treatment experiments
- Dissolved coating wastes from the Plutonium-Uranium Extraction Plant.

2.1.3.4 300 Area Chemical Laboratory Waste

The 216-B-58 Trench, 216-B-53A Trench, 216-B-53B Trench, and 216-B-54 Trench formerly in the 200-LW-1 OU have been included in this FFS, because they are located in the BC Cribs and Trenches Area, which is undergoing accelerated remedial action to address high risk to human and ecological receptors and the groundwater.

From 1962 to 1967, liquid laboratory waste from the 300 Area was sent to the 340 Waste Neutralization Facility via the process sewer. Waste that was above the release limits for the

300 Area Process Ponds was sent by tanker truck to the 216-B-58, 216-B-53B, and 216-B-54 Trenches for disposal. Laboratory process waste was characterized as slightly acidic to alkaline radioactive waste (mainly cesium and strontium) with a low salt and organic content.

The 216-B-53A Trench was active during October and November 1965. The site received waste from a liquid release at the Plutonium Recycle Test Reactor in the 300 Area. The waste was transported to the trench in tanker trucks. The waste contained an estimated 50 to 100 g of plutonium, which possibly could result in soil contaminated with transuranic constituents at levels of concern (100 nCi/g).

2.2 PHYSICAL SETTING

The meteorology, topography, and hydrogeologic frameworks for the BC Cribs and Trenches Area 200-TW-1 OU waste sites are briefly described in the following sections. Additional discussions are provided in DOE/RL-92-19; PNNL-13788, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*; PNNL-13910, *Hanford Site Environmental Report for Calendar Year 2001*; PNNL-6415, *Hanford Site National Environmental Policy Act (NEPA) Characterization*; DOE/RL-2002-42; and DOE/RL-2000-38.

2.2.1 Meteorology

The Hanford Site lies east of the Cascade Mountains and has a semiarid climate caused by the rain shadow effect of the mountains. Climatological data are monitored at the Hanford Meteorological Station and other locations throughout the Hanford Site. From 1945 through 2001, the recorded maximum temperature was 45 °C (113 °F), and the recorded minimum temperature was –30.6 °C (-23 °F) (PNNL-6415). The two extremes occurred during August and February, respectively. The monthly average temperature ranged from a low of –0.24 °C (31.7 °F) in January to a high of 24.6 °C (76.3 °F) in July. The annual average relative humidity is 54 percent (PNNL-6415).

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

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

2.2.2 Topography

The Hanford Site is located in the Pasco Basin on the Columbia Plateau. The 200 West and 200 East Areas are located on the Central Plateau near the center of the Hanford Site. The Central Plateau is the common reference used to describe the Cold Creek Bar – a relatively flat,

prominent terrace that trends generally east to west with elevations between 198 m and 230 m (650 to 755 ft) above mean sea level (amsl). The Cold Creek Bar formed during the cataclysmic flooding events of the Missoula floods, which ended approximately 13,000 years ago. The floodwaters deposited a thick sand and gravel bar that constitutes the higher southern portion of the Central Plateau. In the waning stages of the ice age, these floodwaters also eroded a channel north of the 200 Areas in the area currently occupied by Gable Mountain Pond. The northern half of the 200 East Area lies within this ancient flood channel. The southern half of the 200 East Area and most of the 200 West Area are situated on the flood bar. A secondary flood channel running southerly from the main channel bisects the 200 West Area. The surface in the 200 West Area slopes gently to the west.

2.2.3 Geology

The Hanford Site is underlain by basalt of the Columbia River Basalt Group and a sequence of suprabasalt sediments. From oldest to youngest, major geologic units of interest are the Elephant Mountain Basalt Member, the Ringold Formation, the Cold Creek unit (CCU) (formerly Plio-Pleistocene Unit, early Palouse soil, a caliche layer, and pre-Missoula gravels) and the Hanford formation. A generalized stratigraphic column for the 200 East and 200 West Areas is shown in Figure 2-2. 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*). The basalt is overlain by the Ringold Formation over most of the 200 East Area and all of the 200 West Area. The Ringold Formation consists of an interstratified sequence of unconsolidated clay, silt, sand, and granule-to-cobble gravel deposited by the ancestral Columbia River. The fluvial-lacustrine Ringold Formation is informally divided into several units; these are (from oldest to youngest) the fluvial gravel and sand of unit A, the buried soil horizons and lake deposits of the lower mud sequence, the fluvial sand and gravel of unit E, and the lacustrine mud of the upper Ringold.

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

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

In DOE/RL-2002-39, the CCU is divided into five lithofacies. The five lithofacies are differentiated based on grain size, sedimentary structure, sorting, fabric, and mineralogy:

- Fine-grained, laminated to massive
- Fine- to coarse-grained, calcium carbonate cemented
- Coarse-grained, multilithic

- Coarse-grained, angular, basaltic
- Coarse-grained, round basaltic lithofacies.

Description of the five lithofacies, depositional environments, and their association with previous site nomenclature are provided in Table 2-1. Detailed description of each facies of the CCU is presented in DOE/RL-2002-39.

The Hanford formation overlies the CCU in the 200 Areas. Where the Ringold Formation and the CCU are not present in the 200 East Area, the Hanford formation overlies basalt. The Hanford formation consists of unconsolidated gravel, sand, and silts deposited by cataclysmic floodwaters. These deposits consist of gravel-dominated and sand-dominated facies. The gravel-dominated facies consist of cross-stratified, coarse-grained sands and granule-to-boulder gravel. The gravel is uncemented and matrix poor. The sand facies consists of well-stratified fine- to coarse-grained sand and granule gravel. Silt in these facies 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 the 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 Central Plateau. In the waning stages of the ice age, these floodwaters also eroded a channel north of the Central Plateau in the area currently occupied by Gable Mountain Pond. These floodwaters removed all of the Ringold Formation from this area and deposited Hanford formation sediments directly over the basalt.

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

2.2.4 Vadose Zone

The vadose zone is the region between the ground surface and the water table. In the vicinity of the Central Plateau, the vadose zone thickness ranges from 62 m (206 ft) in the 200 West Area to 105 m (345 ft) in the BC Controlled Area south of the 200 East Area fence. Sediments in the vadose zone are the Ringold Formation (the Ringold Unit E and the Upper Ringold), the CCU, and the Hanford formation. Erosion during cataclysmic flooding removed some of the Ringold Formation and CCU. Perched water historically has been documented above the CCU at locations in the 200 West Areas. Because discharge to the surface ceased in the late 1980s, and the water table continues to decline at 0.36 m/yr (1.2 ft/yr), the perched water is infrequently encountered during drilling.

Recharge to the unconfined aquifer in the Central Plateau is from artificial and possibly natural sources. Any natural recharge originates from precipitation. Estimates of recharge from precipitation at the Hanford Site range from 0 to 10 cm/yr (0 to 4 in/yr) and largely depend on

soil texture and the type and density of vegetation. For areas where the ground cover is assumed to remain undisturbed, a recharge rate of 3.5 mm/yr was assumed, which is within the range of values reported for shrub-steppe ground cover (PNL-10285, *Estimated Recharge Rates at the Hanford Site)*. For the disturbed areas above the waste sites (i.e., stabilization cover), a recharge rate of 1.44 cm/yr has been assumed. Artificial recharge occurred when effluents such as cooling water and process waste water were disposed to the ground. PNL-5506, *Hanford Site Water Table Changes 1950 Through 1980, Data Observation and Evaluation*, reports that between 1943 and 1980, 6.33×10^{11} L (1.67×10^{11} gal) of liquid wastes were discharged to the soil column. Most sources of artificial recharge have been halted. The artificial recharge that does continue is limited largely to liquid discharges from sanitary sewer system drainfields; two state-approved land disposal structures; and 140 small-volume uncontaminated miscellaneous streams. A state-approved land disposal site is located 365.8 m (1,200 ft) north of the 200 West Area exclusion fence and receives liquid waste that has been treated at the 200 Areas Effluent Treatment Facility in the 200 East Area (*Waste Information Data Summary Report 600-211 General Summary Report*). While the liquid waste disposal facilities were operating, many localized areas of saturation or near saturation were created in the soil column. With the reduction of artificial recharge in the Central Plateau, these locally saturated soil columns are dewatering. As the soil column dewaters, the moisture flux decreases. Residual moisture in the vadose zone; however, may remain for some time. In the absence of artificial recharge, the potential for recharge from precipitation becomes a primary driving force for contaminant movement in the vadose zone.

2.2.5 Groundwater

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

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

Groundwater in the 200 East Area occurs primarily in the Ringold Formation, CCU, and Hanford formation. The depth to the water table varies from about 58 m (191 ft) to greater than 105 m (345 ft). Groundwater flows to the northwest toward Gable Mountain and to the southeast and east toward the Columbia River. The water table beneath the 200 East Area is declining at a rate of 0.36 m/yr (1.2 ft/yr).

2.3 NATURAL RESOURCES

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

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

2.3.1 Vegetation

The vegetation in the Central Plateau 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 hymnodies*) 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 (*Oenothera missouriensis*) is a rare plant that has been identified on the Central Plateau, but it has not been encountered in disturbed areas of the waste sites.

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 (*Salsola kali*) (PNNL-6415). The area associated with the waste sites addressed in this FFS is highly disturbed (see Appendix A for waste site photographs). 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.

2.3.2 Wildlife

The largest mammal frequenting the area is the mule deer (*Odocoileus hemionus*). While mule deer are much more common along the Columbia River, the few that forage throughout the

Central Plateau make up a distinct group called the Central Population (PNNL-11472, *Hanford Site Environmental Report for Calendar Year 1996*). A large elk herd (*Cervus canadensis*) currently resides on the Fitzner-Eberhardt Arid Lands Ecology Reserve, and a few animals occasionally have been observed south of the Central Plateau.

Other mammals common to the Central Plateau are badgers (*Taxidea taxus*), coyotes (*Canis latrans*), Great Basin pocket mice (*Perognathus parvus*), northern pocket gophers (*Thomomys talpoides*), and deer mice (*Peromyscus maniculatus*). Badgers are known for their digging ability and have been suspected of excavating contaminated soil at 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 Central Plateau. 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 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 on the Central Plateau 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 were not widespread, with only 23 observations of side-blotched lizards at 316 sites surveyed during a 2001 Ecological Compliance Assessment Project survey (DOE/RL-2001-54, Appendix B).

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

2.3.3 Species of Concern

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

Several threatened, endangered, and candidate species are found in and near the Central Plateau. These 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 vicinity of the waste sites 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 BC Cribs and Trenches Area waste sites 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 undisturbed shrub-steppe habitat where possible, because this is important to many species of concern. The undisturbed shrub steppe in the Central Plateau has been designated as Level 3 habitat in DOE/RL-96-32, which requires mitigation of any disturbance (for example through avoidance and minimization) and possibly rectification and compensation. More detailed direction on protecting Level 3 habitats and species of concern is provided in the DOE/RL-96-32 guidance. In addition, site-specific environmental surveys, required before ground disturbance can occur, serve as a final check to ensure that ecological resources are adequately protected.

2.3.4 Cultural Resources

A comprehensive archaeological survey of the Central Plateau found artifacts in conjunction with areas of high topographic relief and nearby sources of permanent water, but few artifacts associated with open, inland flats (PNL-7264, *Archaeological Survey of the 200 East and 200 West Areas, Hanford Site, Washington*).

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

DOE/RL-97-56 was developed to address these requirements and to determine the eligibility of historic properties in accordance with 36 CFR 60, "National Register of Historic Places." The treatment plan evaluated and classified waste sites and structures on the Hanford Site, including those in the Central Plateau, and proposed recommendations for mitigation. Treatment options for mitigation were determined using 36 CFR 60.4, "Criteria for Evaluation." None of the OU waste sites were recommended for individual documentation as contributing properties. Sites beginning with "216" (e.g., 216-B-14 Crib, 216-B-26 Trench) were identified as noncontributing exempt properties (DOE/RL-97-56). Some sites not addressed in DOE/RL-97-56, such as unplanned releases and septic tanks that were not considered to be significant enough to be evaluated, will be evaluated under site-specific preremediation cultural resource reviews.

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

2.3.5 Aesthetics, Visual Resources, and Noise

With the exception of Rattlesnake Mountain, land on the Hanford Site generally is flat with little relief. Rattlesnake Mountain, rising to 1,060 m (3,478 ft) amsl, forms the southwestern boundary of the Hanford Site, and Gable Mountain (238 m [782 ft] amsl) and Gable Butte (331 m [1,085 ft] amsl) 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).

2.3.6 Socioeconomics

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

In 1999, the average number of jobs in the Tri-Cities was 72,200 (PNNL-6415). Of these, the DOE and its prime contractors employed an average of 10,290 people, making the Hanford Site the largest single source of employment in the area. The total wage payroll for the Hanford Site accounted for nearly 21 percent of the total wage income in the area. In addition to the direct employment and payrolls, Hanford Site activities also support a large number of jobs in the local economy through their procurement of equipment, supplies, and business services. Direct procurements and subcontracts represented about 12 percent of the total sales in the Tri-Cities economy during fiscal year 1999. Overall, about 28,250 Tri-Cities jobs, or 32 percent of the non-farm jobs in the economy, are supported directly or indirectly by the Hanford Site payroll, procurements, and contracts.

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

- Energy Northwest
- The agricultural community (including the Lamb Weston food processing plants)
- Iowa Beef Processors, Inc.

- AREVA GROUP (formerly Framatome ANP, and Siemens, Inc. before that)
- Boise Paper Solutions
- Burlington Northern and Santa Fe Railway.

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

Estimates for 2000 placed the population totals for Benton and Franklin Counties at 140,700 and 45,900, respectively (PNNL-6415). When compared to the 1990 census data, the current population totals reflect the continued growth occurring in these two counties. Increased growth is expected in the future.

The 1999 estimates of ethnic categories indicate that in Benton and Franklin Counties, Asians represent a lower proportion, and individuals of Hispanic origin represent a higher proportion of the ethnic distribution than elsewhere in the state of Washington. PNNL-6415 provides maps showing distributions of minority and low-income populations.

2.4 WASTE SITE DESCRIPTIONS

This section describes the 200-TW-1 OU waste sites that have been characterized sufficiently to support the RI/FS process. These waste sites are described in detail to support development of contaminant distribution models and the evaluation of risk and to provide a baseline for implementing the analogous site approach. Waste sites selected for sampling were considered to be bounding or typical in terms of construction type and size, estimated contaminant inventory, effluent volume received, geology, and expected contaminant distribution.

Data from these sites are presented in the 200-TW-1 OU RI report (DOE/RL-2002-42) and the 200-BP-1 OU RI report (DOE/RL-92-70). The following representative sites from the 200-TW-1 and 200-LW-1 OUs were identified in the Implementation Plan (DOE/RL-98-28), the Waste Site Grouping Report (DOE/RL-96-81), and the work plans (DOE/RL-2000-38, DOE/RL-2001-66) as being applicable to the BC Cribs and Trenches Area wastes sites:

- 216-B-46 Crib (for the BC Cribs and Trenches Area 200-TW-1 waste sites)
- 216-B-58 Trench (for the four 200-LW-1 OU waste sites).

Although not initially selected as a representative waste site, the following 200-TW-1 OU waste site, which is in the BC Cribs and Trenches Area, has been characterized sufficiently to allow evaluation of risk and development of a contaminant distribution model:

- 216-B-26 Trench.

Because the 216-B-26 Trench inventory is equivalent or greater than most of the BC Cribs and Trenches Area trenches, it is also treated as a representative site.

Generic information that applies to all of the BC Cribs and Trenches Area waste sites also is provided. Figure 2-3 displays the generic construction of the waste sites that are in the category of cribs, trenches, and tanks.

2.4.1 Representative Sites Information

Representative sites that were sampled are the 216-B-26 Trench and 216-B-58 Trench, which are located in the BC Cribs and Trenches Area, and the 216-B-46 Crib, which is located in the BY Cribs area at the north end of the 200 East Area. This crib is included because it includes a waste disposal structure as do the cribs in the BC Cribs and Trenches Area, and it received the same type of waste. As such, characterization of this waste site supplements the sampling performed in the BC Cribs and Trenches Area.

2.4.1.1 216-B-26 Trench

The 216-B-26 Trench is located in the BC Cribs and Trenches Area south of the 200 East Area. This unlined trench is 154 m (500 ft) long, 3 m (10 ft) wide, and 3.4 m (11 ft) deep. Earthen dams divided the trench into three sections. From 1956 to 1957, the trench received 5,900,000 L (1,600,000 gal.) of scavenged TBP supernate waste from the 221-U Canyon Building. Cesium and strontium content was reduced by precipitation. Radioactive contaminants included 438 Ci of Cs-137, 475 Ci of Sr-90, 28.6 Ci of Tc-99, and 590 kg of uranium (inventory values from DOE/RL-96-81 except the Tc-99 value, which is from BHI-01496, *Groundwater/Vadose Zone Integration Project Hanford Soil Inventory Model*). Chemical contaminants included cyanide, nitrate, sulfate, sodium, and phosphate. After operation was complete, the trench was backfilled with clean soil. In 1969, an additional 0.6 m (2 ft) of cover was added. Further stabilization of the area was conducted in 1982, when an additional 0.6 m (2 ft) of soil was placed over the waste sites.

2.4.1.2 216-B-58 Trench

The 216-B-58 Trench is an inactive liquid waste disposal site located in the BC Cribs and Trenches Area south of the 200 East Area. The trench is 61 m (200 ft) long, 3 m (10 ft) wide and 3 m (10 ft) deep. Earthen dams divided the trench into eight 7.6 m (25 ft) sections. Each section was covered with wooden cover frames covered by Sisalkraft paper[1]. A corrugated 1.2 m (4-ft) diameter steel pipe runs along the bottom of the trench except for the last section at the west end. The trench also includes a wooden cover. From 1965 to 1967, the trench received 413,000 L (109,000 gal) of liquid laboratory waste, brought via tanker truck from the 300 Area. The waste contained 9.1 kg of uranium, 6.7 g of plutonium, 4.4 Ci of Cs-137, 5.6 Ci of Sr-90, and 10 kg of nitrate (inventory values from DOE/RL-96-81). In 1967, the overground piping was removed and the trench was backfilled. In 1982, 0.6 m (2 ft) of clean soil was place over the site.

2.4.1.3 216-B-46 Crib

The 216-B-46 Crib is an inactive liquid waste disposal site located north of the BY Tank Farm and west of Baltimore Avenue; the crib is included in the 216-B-43 through 216-B-50 Crib series commonly referred to as the BY Cribs.

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[1] Sisalkraft (paper) is a trademark of Fortifiber Corporation, Los Angeles, California

From September to December 1955, the crib received approximately 6,700,000 L (1,800,000 gal) of URP bismuth-phosphate waste that had been scavenged (most fission products precipitated out). Once the waste was processed at U Plant, it was sent to the BY Tank Farm to allow settling of the sludge. The remaining waste liquid effluent was discharged to the crib.

The 216-B-46 Crib is constructed of four large-diameter vertical concrete pipes, set below grade in a square pattern with the centers spaced 4.6 m (15 ft) apart in a 9 x 9 x 4.6 m (30 x 30 x 15-ft) deep excavation (DOE/RL-88-30, *Hanford Site Waste Management Units Report*). The crib was fed by a central pipe that branches into a chevron pattern to feed each vertical pipe. The vertical pipes are 1.2 m (4 ft) in diameter and 1.2 m (4 ft) long, placed 2 m (7 ft) below grade and set on a 1.5 m (5-ft) thick bed of gravel (PNL-6456, *Hazard Ranking System Evaluation of CERCLA Inactive Waste Sites at Hanford*). RHO-CD-673, *Handbook 200 Areas Waste Sites*, reports that the feed pipe to the crib was valved out when the specific retention capacity of the soil under the crib was reached. DOE/RL-88-32, *Remedial Investigation/Feasibility Study Work Plan for the 200-BP-1 Operable Unit, Hanford Site, Richland, Washington*, states that the crib received volumes beyond its specific retention capacity. Groundwater below the crib has been impacted (WIDS).

Inorganic compounds in the liquids disposed to the crib included ferrocyanide, nitrate, phosphate, sodium, and sulfate-based compounds. Radionuclides contained in the waste stream sent to these cribs include Cs-137, Sr-90, Ru-106, and plutonium and uranium isotopes (RHO-CD-673; WHC-MR-0227, *Tank Wastes Discharged Directly to the Soil at the Hanford Site*; WHC-EP-0141-2, *Westinghouse Hanford Company Effluent Discharges and Solid Waste Management Report for Calendar Year 1989, 200/600 Area*). The crib also contains organic constituents such as monobutyl phosphates, dibutyl phosphates, and TBPs.

In 1991, the site was interim stabilized with 0.6 m (2 ft) of clean soil. Three characterization boreholes were drilled and geophysically logged, and soil samples were collected and analyzed. Results of this investigation are documented in the Phase 1 RI for the 200-BP-1 OU (DOE/RL-92-70).

2.4.2 Summary of Data Collection Activities

This section summarizes the data collection activities performed for the 216-B-26 and 216-B-58 Trenches, and the 216-B-46 Crib. The RI report (DOE/RL-2002-42) summarized previous characterization efforts for the 216-B-46 Crib. The 216-B-46 Crib was characterized in 1991 and 1992. DOE/RL-92-70, the 200-BP-1 OU RI, summarizes the data collection efforts and results, which are provided herein by reference. The scope of the 200-BP-1 OU RI included drilling, conducting borehole geophysical surveys, and sampling and analysis of soils.

No characterization was conducted in the BC Cribs and Trenches Area to support the 200-TW-1 OU RI. However, in support of the 200-TW-1 FS, boreholes were drilled in the 216-B-26 and 216-B-58 Trenches, and soil sampling was conducted.

2.4.2.1 216-B-26 Trench Characterization

One borehole (C4191) was drilled in the 216-B-26 Trench in accordance with DOE/RL-2003-44, *BC Cribs and Trenches 200-TW-1 Operable Unit Borehole Sampling and Analysis Plan.* The borehole was drilled to the water table at a depth of 104 m (340 ft) below ground surface (bgs). Samples were collected and submitted for laboratory analysis in accordance with DOE/RL-2003-44. The borehole was decommissioned after it had been drilled to total depth in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells." Soil samples were collected for chemical and radiological analysis and determination of physical properties. The sampling approach generally required a greater sample frequency near the bottom of the waste site, which is the area of highest suspected contamination. Analytical results are presented in this document. In addition to the sampling performed per DOE/RL-2003-44, more frequent sampling was conducted to support DOE Office of River Protection programs with particular emphasis on mobile contaminant distribution.

During the summer of 2004, additional geophysical measurements were performed to delineate the extent of the Tc-99 contamination in the vicinity of the 216-B-26 Trench. This characterization focused on measuring soil conductivity to detect the presence of moisture and high ionic strength contaminants. Indication of anomalous high soil conductivity to depths of approximately 46 m (150 ft) was observed.

2.4.2.2 216-B-58 Trench Characterization

Two boreholes (C4174 and C4304) were drilled at the 216-B-58 Trench in December 2003, each to a depth of 30 m (100 ft) bgs. Samples were collected and submitted for laboratory analysis as identified in DOE/RL-2001-66. The original plans for the 216-B-58 Trench borehole were to drill to the water table. However, the regulators agreed to limit the depth of this borehole because the 216-B-26 Trench borehole would provide data to the water table. Only a single borehole was originally planned; however, following geophysical logging of eight drive casings that were installed in the 216-B-58 Trench to locate the region of highest contamination, an anomaly (low concentration of Co-60) was identified at the west end of the trench. Therefore, a second borehole was installed to provide additional information on contaminants at this location. The boreholes were decommissioned after they had been drilled to total depth in accordance with WAC 173-160. Analytical and geophysical logging results are presented in this document.

2.4.2.3 216-B-46 Crib Characterization

Three boreholes (299-E33-299, 299-E33-310, and 299-E33-311) were drilled through the 216-B-46 Crib with a cable tool rig in 1991 and 1992. The boreholes were placed in a triangular array and drilled to depths between 9 m (29.5 ft) and 10.7 m (35 ft) in the crib. The boreholes were decommissioned after being drilled to total depth in accordance with WAC 173-160.

Four samples were collected from each borehole and analyzed for CERCLA Target Compound List and Target Analyte List (both in SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update III-A*) constituents, major anions, bismuth, cyanide (free, complex, and total), and selected radioisotopes. Physical property samples were not collected from this site; however, the data are available from nearby waste sites (e.g., 216-B-43 Crib). Analytical results are presented in DOE/RL-92-70. The subject boreholes

also were logged with the Radionuclide Logging System (RLS) and neutron-moisture tools. In addition, boreholes 299-E33-4 and 299-E33-23, which are located adjacent to the waste site, were logged with the RLS and neutron-moisture tool in 2001.

Characterization of a deep borehole at the nearby 216-B-49 Crib, which received approximately the same effluent and contaminant load, is applied to the 216-B-46 Crib deep vadose soil.

2.5 NATURE AND EXTENT OF CONTAMINATION

This section describes the nature and extent of contamination at representative sites and at analogous sites with sufficient data to support risk evaluation in the 200-TW-1 OU. Contamination, as defined in this section, includes those constituents that are not essential nutrients and that were detected at concentrations above Hanford Site background threshold concentrations at the 90th percentile in DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Inorganics*, and in DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides*. Ecology 94-115, *Natural Background Soil Metals Concentrations in Washington State*, also was used for background concentrations where no site-specific background concentrations were available. Comparison to background threshold concentrations was conducted to eliminate sample detects that represent naturally occurring constituents. Constituents with concentrations above background levels and/or with no available background concentrations also were subjected to a screening process against existing regulatory standards. Nonradiological constituents with concentrations above background were compared to risk-based standards in WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties," and WAC 173-340-747, "Deriving Soil Concentrations for Ground Water Protection," as reported in or calculated per Ecology 94-145, *Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation; CLARC, Version 3.1*. Concentrations exceeding risk-based standards are regarded as evidence of contamination and potential risk, unless information is available that would justify eliminating contaminants from the screening process. Nonradiological constituents remaining after the screening process described above are considered potential contaminants of concern and are evaluated further.

Promulgated soil-based cleanup levels have not been developed for radionuclides. Therefore, radionuclides detected above background are considered potential contaminants of concern in this section and also are evaluated further in the risk evaluation.

Additional details regarding the screening process, including the number of detections, the identification of essential nutrients, and the comparison of concentrations to background risk-based standards, are presented in the RI report for the representative sites and in Appendix C for analogous sites with sufficient data to support risk evaluations.

2.5.1 Nature and Extent of Contamination at the 200-TW-1 Operable Unit Representative Sites

2.5.1.1 216-B-26 Trench

The following constituents were determined to exceed the initial screening criteria (identifying detected chemicals, screening out essential nutrients, comparing concentrations with background levels, and, finally, comparing concentrations with available toxicity values) in the soil column beneath the 216-B-26 Trench:

- tritium
- Co-60
- Ni-63
- Sr-90
- Tc-99
- Sn-126
- Cs-137
- Eu-154/155
- Ra-226/228
- Th-228
- Th-230
- Th-232
- U-233/234
- U-235
- U-238
- Np-237
- Pu-239/240Am-241
- chromium
- manganese
- mercury
- uranium
- vanadium
- cyanide
- chloride
- fluoride
- nitrite
- nitrate
- N in nitrate and nitrite
- phosphate
- bis(2-ethlyhexyl)phthalate
- diethlyphthalate

The majority of contaminants and the highest concentrations were detected from 4.0 to 4.6 m (13 to 15 ft) bgs. Radionuclide contaminants in this zone include Cs-137, Co-60, Pu-239, Pu-239/240, Ra-226, Sr-90, Tc-99, tritium, and total uranium. The maximum concentrations of many of the contaminants were associated with the approximate bottom of the trench at a depth of about 4.0 m (13 ft) bgs. Cesium-137 and Sr-90 were the dominant radionuclides present, with maximum concentrations of 529,000 and 974,000 pCi/g, respectively. The transuranic radionuclides Am-241 and Pu-239/240 were detected at maximum concentrations of 41 pCi/g and 195 pCi/g, respectively, at a depth of approximately 4.3 m (14 ft) bgs. Other contaminants in this zone and their maximum concentrations are shown on Figure 2-4.

Technetium-99, at concentrations up to 92 pCi/g, is the dominant radionuclide present in the zone from 14.9 to 49.7 m (36 to 150 ft) bgs, with the maximum concentration observed at 30 m (100 ft) bgs. A maximum uranium concentration of 56.9 mg/kg was observed at 4.3 m (14 ft) bgs; no uranium was observed below 9.1 m (30 ft). Tritium was detected at a concentration of 42.9 pCi/g at a depth of 30 m (100 ft) bgs. The distribution of these contaminants deeper in the vadose zone is associated with very low contaminant distribution coefficients (K_d), in contrast to Cs-137, Pu-239/240, and Sr-90, which have higher K_ds and remain in vadose zone soils close to the point of release to the environment.

Bismuth was detected in one sample at a concentration of 233 mg/kg at a depth of 3.8 m (12.5 ft) bgs. Bismuth does not have a cleanup level identified through WAC 173-340-745; no background has been established for bismuth. Also, manganese was detected at a concentration of 450 mg/kg at a depth of 9.1 m (30 ft).

Cyanide and nitrate were detected at a concentration of 2.14 mg/kg and 4,090 mg/kg (as nitrate), respectively, at a depth of 30 m (100 ft) bgs. Total organic carbon concentrations of 895 mg/kg and 2,140 mg/kg were detected at depths of approximately 4.3 m (14 ft) and 30 m (100 ft) bgs, respectively. Diethylphthalate was detected to a depth of 30 m (100 ft); the maximum concentration of 0.62 mg/kg was observed at a depth of approximately 16.8 m (55 ft) bgs.

Cesium-137 was detected with the RLS from near the top of the waste zone to a depth of 12.1 m (40 ft) bgs, with significantly elevated levels from 3.7 to 7.6 m (12 to 25 ft) bgs. The RLS data indicate a maximum estimated concentration of 1,700,000 pCi/g at a depth of 3.7 m (12 ft). A true maximum concentration was not determined, because the tool saturated or exceeded the dead time in this zone. Very little cesium was detected in near-surface sediments. Comparison of the RLS data with the soil sampling indicates that a factor of 3.3 should be applied to the RLS data (see Appendix F, Section F1.3.1). Then, translating this factor to the region of highest gamma activity results in the highest contamination levels being 22 times the soil sampling data.

Description of soils by the attendant geologist during borehole drilling indicated interspersed layers of silt within sand down the borehole. Distinct silt layers were observed at depths of 9.4 to 9.8 m (31 to 32 ft), 12.5 m (41 ft), 15.2 to 15.8 m (50 to 52 ft), 17.1 m (56 ft), 18.9 m (62 ft), 21.6 to 21.9 m (71 to 72 ft), 25.9 to 26.7 m (85 to 87.5 ft), 27.4 to 28.9 m (90 to 92 ft), 34.1 m (112 ft), 38.1 to 39.0 m (125 to 128 ft), 39.6 m (130 ft), and 47.5 to 47.8 m (156 to 157 ft) bgs. Many of these regions of silt exhibited some degree of dampness or moisture. At depths greater than 56.7 m (186 ft) bgs, the soil was dry until groundwater was approached.

Analyses performed on "grab samples" collected throughout the borehole drilling activity showed significant presence of mobile contaminants from near surface to groundwater (RPP-20303, *Preliminary Data from 216-B-26 Borehole in BC Cribs Area)*. These analyses focused on the porewater associated with the soil samples, which is reflected by soil moisture values of approximately 10 percent from 9.1 to 12.2 m (30 to 40 ft) bgs, near 4 percent from 15.2 to 24.4 m (50 to 80 ft) bgs, approximately 8 percent from 27.4 to 30 m (90 to 100 ft) bgs, and decreasing to a minimum of approximately 1.5 percent near 94.5 m (310 ft) bgs. Then, as groundwater was approached, soil moisture content increased to approximately 10 percent at 103.6 m (340 ft) bgs. The Tc-99 concentration in porewater was at least 1,000 pCi/L throughout the entire borehole depth and increased to more than 1,000,000 pCi/L near 30.5 m (100 ft) bgs. The concentration of Tc-99 in porewater peaked again to over 1,000,000 pCi/L at a depth of 40.0 m (131 ft) bgs. Nitrate and nitrite concentrations peaked at approximately 27.4 m (90 ft) bgs with values of approximately 150,000 mg/L and 70 mg/L, respectively. Other analytes that exhibited peak porewater concentrations in this depth range are sodium, potassium, magnesium, calcium, strontium, barium, sulfate, and chloride. Uranium-238 concentration peaked at 25,000 pCi/L near 6.9 m (22.5 ft) bgs and again at half that value near 12.5 m (41 ft) bgs.

Geophysical studies focusing on soil conductivity (high resolution resistivity [HRR]) (PNNL-14948, *Plume Delineation in the BC Cribs and Trenches Area*) were performed during the summer of 2004 to delineate the Tc-99 plume identified by previous borehole sampling. Characterization focused on soil conductivity, because the analyses described above also measured the electrical conductivity of the collected soil samples, which revealed elevated conductivity from 27.4 to 42.7 m (90 to 140 ft) bgs. The coincidence of higher nitrate and moisture with Tc-99 allowed the inference to be made that regions of high conductivity could be

a marker for Tc-99. Indeed, such regions of higher conductivity were observed at depths corresponding to the depth of Tc-99 and nitrate observed during previous soil sampling. Furthermore, it is apparent that contamination from adjacent trenches has merged and that deep contamination from the adjacent groupings of trenches has similarly merged. Figure 2-5 depicts the regions of high soil conductivity as determined by a grouping of "scans" in the vicinity of the 216-B-26 Trench. These data show that anomalous high soil conductivity extends considerably beyond the ends of the trench and toward the 216-B-25 and 216-B-27 Trenches that are on either side. Also, the apparent depth of this relatively high conductivity region is centered at approximately 30 to 40 m (100 to 131 ft) bgs. Figure 2-6 displays a "scan" cutting across the 216-B-28 Trench past the 216-B-52 Trench and another scan over the top of the 216-B-52 Trench that extended into the 216-B-29 Series Trenches grouping. Based on the "ground truthing" obtained from the borehole through the 216-B-26 Trench used to relate soil contamination to soil conductivity, it is evident that a near-continuous plume of deep contamination exists beneath this collection of trenches. The apparent preponderance of contamination associated with the 216-B-52 Trench may be related to the relatively large quantity of effluent discharged to that waste site (Table 2-2). Scans over the 216-B-14 Series Cribs (Figure 2-7), where effluent was discharged in amounts similar to those at the 216-B-52 Trench, also showed evidence of a continuous plume of contamination under these waste sites. For each grouping of waste sites characterized by this method, the mobile contaminants appear to have spread laterally at a depth of approximately 40 m (131 ft) bgs. Additional soil conductivity characterization, including more comprehensive "ground truthing," is planned during confirmatory sampling.

Additional HRR characterization was performed during the spring of 2005. HRR scans were performed over each crib, trench, and interconnecting region to develop a comprehensive understanding of the extent of lateral spreading. Figure 2-8 displays an HRR scan over the 216-B-16 and –B-17 Cribs that extends past the ends of the 216-B-20 Series Trenches. Figure 2-9 is a composite of scans performed over all of the waste sites with focus at a depth of 32 m (105 ft). Of particular interest are the strong indications of anomalous high soil conductivity in the vicinity of the cribs and the trenches near the 216-B-52 Trench. Examination of the discharge history for these waste sites shows that the 216-B-14 Crib was the first to receive waste, followed by the 216-B-17, -19, -18, -15, and -16 Cribs. Then, focus shifted to the trenches, beginning with the 216-B-20 Trench, followed by the 216-B-21, -22, -23, -24, -25, -26, -27, -28, -29, -30, -31, -32, -33, -34, and -52 Trenches. It should be noted that the effluent volumes disposed of to most of the cribs and to the 216-B-52 Trench were substantially greater than for the other trenches. The apparently deeper plume of contamination to the west of the 216-B-17 Crib may have resulted from the discharges into adjacent cribs spreading into the existing 216-B-17 Crib plume and pushing it further outward to where it "spilled over" the edge of a soil structure that promoted lateral spreading versus downward migration. Similarly, when waste was finally discharged to the 216-B-52 Trench, it is believed that it spread laterally to merge with waste previously discharged in nearby trenches.

2.5.1.2 216-B-58 Trench

The following constituents were determined to exceed the initial screening criteria in the soil column beneath the 216-B-58 Trench:

- tritium
- Ni-63
- Cs-137
- Co-60
- Sr-90
- Sn-126
- Eu-154
- Eu-155
- Ra-226
- Ra-228
- Th-228
- Th-230
- Th-232
- U-235
- Np-237
- Am-241
- Pu-238
- Pu-239/240
- arsenic
- barium
- selenium
- cyanide
- chloride
- fluoride
- nitrate
- nitrite
- N in nitrate and nitrite
- acetone
- Aroclor-1254[2]
- diethylphthalate
- methylene chloride.

Contamination is present primarily in the shallow portion of the vadose zone beneath the 216-B-58 Trench.

The majority of contaminants and the highest concentrations were detected from 4.1 to 6.1 m (13.5 to 20 ft) bgs. Radionuclide contaminants in this zone include Am-241, Cs-137, Co-60, Pu-239/240, Sr-90, and tritium. The maximum concentrations of many of the contaminants were associated with the soil just below the bottom of the crib at a depth of about 4.6 m (15 ft) bgs. Cesium-137 and Sr-90 were the dominant radionuclides present, with maximum concentrations of 14,600 and 18,400 pCi/g, respectively. Samples from the borehole at the west end of the trench revealed Co-60 concentrations to 1,700 pCi/g. The transuranic constituents Am-241 and Pu-239/240 were observed at the 4.6 m (15.0-ft) level at concentrations of 412 pCi/g and 310 pCi/g, respectively. Tritium was distributed more widely across the vadose zone and was detected to a depth of 16.8 m (55 ft) bgs. The distribution of this contaminant deeper in the vadose zone is associated with its very low contaminant K_d, in contrast to Am-241, Cs-137, and Sr-90, which have higher K_d values and remain in vadose zone soils close to the point of release to the environment. Other contaminants in this zone and their maximum concentrations are shown on Figures 2-10a and 2-10b.

Barium and selenium were the only metals detected that exceeded the initial screening. Barium was detected throughout the vadose zone with a maximum concentration of 150.0 mg/kg at a depth of approximately 8.4 m (27.5 ft) bgs. This concentration is only slightly higher than the background concentration of 132 mg/kg. Selenium was distributed throughout the vadose zone with a maximum concentration of 13.0 mg/kg at a depth of 5.3 m (17.5 ft).

Nitrate concentrations exceeded the screening level at depths corresponding to near the bottom of the trench (40.1 mg/kg as nitrate) and from 8.4 to 10.7 m (27.5 to 35.0 ft) bgs. The only other

[2] Aroclor is an expired trademark.

contaminant observed was diethylphthalate, also observed throughout the vadose zone with a maximum concentration of 0.60 mg/kg at a depth of 8.4 m (27.5 ft) bgs.

At the borehole in the middle of the trench, Cs-137 was detected with the RLS between 2.4 m (8 ft) and 9.4 m (31 ft) bgs, with a maximum estimated concentration of 32,000 pCi/g at a depth of 3.7 m (12 ft) bgs. Cobalt-60 was detected between 2.4 m (8 ft) and 5.5 m (18 ft) bgs, with a maximum of 84 pCi/g at a depth of 3.4 m (11 ft) bgs. At the borehole at the west end of the trench, Cs-137 was detected between 0.9 m (3 ft) and 4.3 m (14 ft) bgs, with a maximum concentration of approximately 943 pCi/g observed at a depth of 3.0 m (10 ft) bgs. Also at the west end of the trench, Co-60 was detected between 2.1 m (7 ft) and 10.4 m (24 ft) bgs, with a maximum concentration of approximately 1,655 pCi/g detected at a depth of 3.3 m (11 ft) bgs. At the borehole in the middle of the trench, neutron moisture logging showed higher moisture concentrations at the 9.1 m (30 ft), 13.7 m (45 ft), 15.2 m (50 ft), 16.1m (53 ft), 20.4 m (67 ft), and near 30.5 m (100 ft) levels bgs. From the west-end borehole, higher moisture concentrations were indicated at the 9.1 m (30 ft), 10.7 m (35 ft), 12.3 m (40 ft), 13.4 m (44 ft), 16.1 m (53 ft), 20.4 m (67 ft), 25.9 m (85 ft), and near 30.5 m (100 ft) levels bgs. The contaminant distribution models for the 216-B-58 Trench are shown in Figures 2-10a and 2-10b.

2.5.1.3 216-B-46 Crib

The following constituents were determined to exceed the initial screening criteria in the soil column beneath the 216-B-46 Crib:

- tritium
- Co-60
- Sr-90
- Tc-99
- Sb-125
- Cs-137
- Pu-238
- Pu-239
- Pu-239/240
- Ra-226
- Th-228
- antimony
- total uranium
- thallium
- cadmium
- cyanide
- benzoic acid
- bis(2-ethylhexyl) phthalate
- di-n-butylphthalate
- methylene chloride.

Contamination is present throughout the vadose zone beneath the 216-B-46 Crib.
For radionuclides, only low levels of Sr-90 (<3 pCi/g) and Ra-226 (< 1 pCi/g) are present from the surface to a depth of 5.5 m (18 ft) bgs.

The majority of contaminants and the highest concentrations were detected from 5.5 m to 14.9 m (18 ft to 49 ft) bgs. Contaminants in this zone include Sb-125, Cs-137, Co-60, Pu-238, Pu-239, Pu-239/240, Ra-226, Sr-90, Tc-99, tritium, and total uranium. The maximum concentrations of many of the contaminants were associated with the approximate bottom of the crib at a depth of about 5.5 m (18 ft) bgs. Cesium-137 and Sr-90 were the dominant radionuclides present, with maximum concentrations of 364,000 and 353,000 pCi/g, respectively. Other contaminants in this zone and their maximum concentrations are shown on Figure 2-11.

Cobalt-60, Ra-226, Tc-99, and total uranium were distributed more widely across the vadose zone and were detected at depths greater than 14.9 m (49 ft) bgs. Technetium-99, at concentrations ranging from 65 to 160 pCi/g, is the dominant radionuclide present in the zone from 14.9 m to 49.7 m (49 ft to 190 ft). The maximum Tc-99 concentration observed was

160 pCi/g at a depth of 23.2 m (76 ft); 140 pCi/g was observed at a depth of 66.4 m (218 ft) bgs. The distribution of these contaminants deep in the vadose zone is associated with very low K_d values, in contrast to Cs-137, Pu-239/240, and Sr-90, which have higher K_d values and remain in vadose zone soils close to the point of release to the environment.

Bismuth, cadmium, and sodium were the only metals detected that exceeded the initial screening. Bismuth was detected in one sample at a concentration of 31.3 mg/kg at a depth of 58 m (190.5 ft) bgs. Sodium was distributed throughout the vadose zone starting at a depth of about 5.5 m (18 ft) and had a maximum concentration of 4,360 mg/kg. Neither constituent has a cleanup level identified through WAC 173-340-745. Sodium was detected above the Hanford Site background; no background has been established for bismuth. Cadmium was detected at a maximum concentration of 2 mg/kg at depths from 0.9 m to 1.8 m (3 ft to 6 ft) bgs, which is only slightly above the background concentration of 1.0 mg/kg. Cadmium was not detected below 3.7 m (12 ft).

Cesium-137 was detected with the RLS from near the top of the waste zone to a depth of 27.4 m (90 ft), with significantly elevated levels from 4.9 m to 17.4 m (16 ft to 57 ft) bgs. The RLS data indicate a maximum estimated concentration of 1,400,000 pCi/g at a depth of 7.6 m (25 ft). A true maximum concentration was not determined because the tool saturated or exceeded the dead time in this zone. Very little cesium was detected in near-surface sediments and at depths greater than 22 m (72 ft) bgs. The data suggest that the deeper contamination may be attributed to the drag down of contamination during drilling. The RLS data from borehole 299-E33-4 indicate that Cs-137 contamination extends laterally from the crib several meters to the west.

2.6 EVALUATION OF THE ANALOGOUS WASTE SITES

DOE/RL-96-81 describes the grouping of 200 Areas waste sites based on process. Sites that received waste associated with a certain process were grouped by waste category (e.g., process condensate). The waste categories then were grouped based on more specific process details (e.g., 200-TW-1 Tank Waste Group OU, 200-LW-1 300 Area Chemical Laboratory Waste Group OU). This streamlining approach is employed to reduce the amount of characterization and evaluation required to support remedial action decision-making. Application of the concept takes into account similarities between waste sites, such as waste stream type, discharge history, and geology, as well as the available characterization data, to assess the nature and extent of contamination. The concept builds on the knowledge gained from the characterization of a few waste sites (representative sites) that are indicative of worst case and typical OU conditions. Selection of representative sites generally is based on waste stream inventory, the volume of effluent discharged, and the knowledge gained from previous characterization efforts performed before the RI.

2.6.1 Assignment of Analogous Sites

This section contains the rationale used to assign potential analogous waste sites to the representative sites and other sufficiently characterized waste sites. Key to the logic is the

comparison of the physical framework between the 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, unplanned release)
- 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.

Analogous waste sites are assigned to representative sites based on the physical framework and expected distribution of contamination after comparison. After assignments are made, preliminary assumptions regarding the potential use of remedial alternatives at both the representative and the analogous site are assessed. Where similar remedial alternatives appear to be applicable at both the representative site and the analogous site, there is a high probability that the sites are truly similar in terms of the physical framework and the possible remedial alternatives that may be employed. Thus, the assignment of an analogous site to a representative site in this section suggests that the potential remedial alternatives selected have a high likelihood of being applicable to both site types. Figure 2-12 shows the process for evaluating the analogous sites against the representative sites for the RI/FS process through the confirmatory and design sampling processes. The rationale for assigning each waste site to a representative site is presented in Table 2-2.

2.6.2 Analogous Site Groupings

Based on the analogous group assignment criteria above, three analogous groups have been developed, with representative waste sites assigned to each group. Table 2-2 provides a list of the representative sites and their associated analogous sites and includes the rationale for assigning an analogous site to an appropriate representative site. The representative sites and analogous waste groups are described in the following sections. Figure 2-13 depicts the assignment of representative sites to analogous sites.

2.6.2.1 216-B-26 Trench Representative Waste Site

The 216-B-26 Trench has been selected as a representative waste site for the following analogous sites:

- 216-B-20 Trench
- 216-B-21 Trench
- 216-B-22 Trench
- 216-B-23 Trench
- 216-B-24 Trench
- 216-B-25 Trench
- 216-B-27 Trench
- 216-B-28 Trench
- 216-B-29 Trench
- 216-B-30 Trench
- 216-B-31 Trench
- 216-B-32 Trench
- 216-B-33 Trench
- 216-B-34 Trench
- 216-B-52 Trench.

All of these sites are located in the same area, are of approximately the same design, and were used for the same purpose (disposal of scavenged waste).

The rationale for assigning 216-B-26 Trench as the representative site for these analogous waste site is as follows.

1. *Waste site configuration and construction*: All of the trenches, including the 216-B-26 Trench, are the same size (152 m long, 3.0 m wide, 2.4 to 3.0 m deep [500 ft long, 10 ft wide, 8 to 10 ft deep]) except the 216-B-52 Trench which is 177 m long, 3.0 m deep, 3.0 m wide (580 ft long, 10 ft deep, 10 ft wide).

2. *Volume of effluent received in relation to the available pore volume*: The 216-B-26 Trench received 5,880,000 L (1,550,000 gal) of liquid waste, which is 44 percent of the estimated available soil pore volume. The analogous waste sites received between 4,860,000 L (1,283,000 gal) and 8,530,000 L (2,252,000 gal) of waste liquid and between 28 percent and 54 percent of estimated available soil pore volume. The 216-B-26 Trench and its analogous trenches were intended to be used as specific retention trenches, whereby the quantity of effluent was limited to a fraction of the nominal soil column porosity, with the objective of minimizing impact to groundwater.

3. *Contaminant inventory*: The 216-B-26 Trench received 438 Ci of Cs-137, 475 Ci of Sr-90 (both decayed to 1989), 590 kg of uranium, 2.5 g of plutonium, 18.0 Ci Tc-99, and 800,000 kg of nitrate. The analogous waste sites received between 10.7 to 684 Ci of Cs-137, 18.1 to 340 Ci of Sr-90, 11.0 to 680 kg of uranium, 0.7 to 77 g of plutonium, 14.1 to 32.9 Ci Tc-99, and 500,000 to 2,100,000 kg of nitrate (inventory values from DOE/RL-96-81 except Tc-99 values from *Soil Inventory Model*, 2004).

4. *Depth of waste discharge*: Waste at the 216-B-26 Trench was discharged at an original depth of 3 m (10 ft). Waste at the analogous sites was discharged at essentially the same depth.

5. *Expected distribution of contaminants*: High concentrations of Cs-137 and Sr-90, 579,000 pCi/g and 974,000 pCi/g, respectively, were observed in a 3.6 to 4.6 m (12-15 ft) band bgs. Very little contamination is expected below a depth of about 10.7 m (35 ft) in any of these sites, and none is expected to have reached groundwater. Characterization of the 216-B-26 Trench indicates that Tc-99 is the only radionuclide detected below this depth at significant concentration (92 pCi/g at 30 m [100 ft]). Nitrate concentration also peaked at this depth. Those sites with greater liquid effluent discharge volumes are expected to exhibit contamination to somewhat greater depth.

6. *Potential for hydrologic and contaminant impacts to groundwater*: Contamination in these sites is expected to eventually reach groundwater. The results of the 216-B-26 Trench modeling indicate that Tc-99 and nitrate are expected to reach the groundwater with concentrations exceeding their maximum contaminant levels (MCL). However, if groundwater is evaluated downgradient 100 m (328 ft), MCLs are not predicted to be exceeded. Impact to groundwater is similarly expected from the analogous waste sites because of the similar waste streams received. However, because the fraction of effluent

volume vs soil porosity is less for all of the analogous trenches except the 216-B-52 Trench, groundwater impact may be delayed relative to the 216-B-26 Trench.

2.6.2.2 216-B-58 Trench Representative Waste Sites

Four sites (the 216-B-53A, 216-B-53B, 216-B-54, and 216-B-58 Trenches), that were originally in the 200-LW-1 OU but are now part of the 200-TW-1 OU, are located in the BC Cribs and Trenches Area south of the 200 East Area. Because these waste sites are in physical proximity to many of the 200-TW-1 OU cribs and trenches and have similar design, they have been included in this FFS to support the accelerated cleanup of the BC Cribs and Trenches Area.

The four trenches from 200-LW-1 OU received liquid waste from the 300 Area. Three trenches (216-B-53B, 216-B-54, and 216-B-58) received liquid laboratory waste from the 340 Neutralization Facility. The 216-B-53A Trench received liquid waste from cleanup of a process tube failure at the Plutonium Recycle Test Reactor. Liquid quantities at all four sites were limited to well within the specific retention capacity of each trench.

Contaminants in the waste at these four sites included uranium, plutonium, Cs-137, Sr-90, and nitrate. Contaminants identified during characterization of the 216-B-58 Trench are identified and discussed in Section 2.5.1.2.

The 216-B-58 Trench has been selected as a representative waste site for the following analogous sites:

- 216-B-53A Trench
- 216-B-53B Trench
- 216-B-54 Trench.

All four sites are located side-by-side in the same area, are of approximately the same design, and were used for the same purpose (disposal of liquid laboratory waste from the 340 Waste Neutralization Facility). The only significant difference is that the 216-B-53A Trench received liquid waste from a process tube failure at the Plutonium Recycle Test Reactor.

The rationale for assigning 216-B-58 Trench as the representative site for these analogous waste site is as follows.

1. *Waste site configuration and construction*: All four trenches are of approximately the same size (18.3 to 61 m long, 3.0 m wide 2.4 to 3.0 m deep [60 to 200 ft long, 10 ft wide, 8 to 10 ft deep]). The 216-B-58 Trench is the largest of these four trenches (61 m long, 3.0 m deep, 3.0 m wide [200 ft long, 10 ft deep, 10 ft wide]).

2. *Volume of effluent received in relation to the available pore volume*: The 216-B-58 Trench received 413,000 L (109,000 gal) of liquid waste, which is 7 percent of the estimated available soil pore volume. The three analogous waste sites received between 15,000 L (4,000 gal) and 999,000 L (264,000 gal) of waste liquid and between 0.4 percent and 34 percent of estimated available soil pore volume.

3. *Contaminant inventory*: The 216-B-58 Trench received 4.4 Ci of Cs-137, 5.6 Ci of Sr-90 (both decayed to 1989), 9.1 kg of uranium, 6.7 g of plutonium, and 10 kg of nitrate. The

analogous waste sites received between 0.05 to 3.7 Ci of Cs-137, 0.05 to 5.1 Ci of Sr-90, 9.1 to 23 kg of uranium, 5 to 100 g of plutonium, and 1 to 100 kg of nitrate (inventory values from DOE/RL-96-81). Between 50 and 100 g of plutonium was received at the 216-B-53A Trench. The 216-B-53A Trench once was believed to possess sufficient plutonium to cause the soil to exceed 100 nCi/g of transuranic constituents. Recent adjustment of the contaminant inventory (49 g Pu rather than 100 g Pu) and comparison with other sampled waste sites has resulted in the conclusion that the 216-B-53A Trench soils will possess considerably lower concentrations than 100 nCi/g of transuranic constituents.

4. *Depth of waste discharge*: Waste at the 216-B-58 Trench was discharged at an original depth of 3 m (10 ft). Waste at the analogous sites was discharged at a depth of 2.4 to3 m (8 to 10 ft).

5. *Expected distribution of contaminants*: Based on DOE/RL-2001-66, very little contamination is expected below a depth of about 10.7 m (35 ft) in any of these sites, and none is expected to have reached groundwater. Characterization of the 216-B-58 Trench indicates that tritium is the only radionuclide detected below this depth (measured at 16.8 m [55 ft]). Nitrate was detected to 16.8 m (55 ft) bgs, and selenium was detected to 30 m (100 ft) bgs.

6. *Potential for hydrologic and contaminant impacts to groundwater*: Based on DOE/RL-2001-66, contamination in these four sites is not expected to reach groundwater. Waste discharges were considerably less than the vadose zone soil column pore volume beneath the footprint of the trench (0.4 to 34 percent).

2.6.2.3 216-B-46 Crib Representative Waste Sites

The 216-B-46 Crib has been selected as a representative waste site for the following analogous sites:

- 216-B-14 Crib
- 216-B-15 Crib
- 216-B-16 Crib
- 216-B-17 Crib
- 216-B-18 Crib
- 216-B-19 Crib.

The following general discussion of the rationale for assigning the 216-B-46 Crib as a bounding site for this group of analogous waste sites includes criteria and evaluations.

1. *Waste site configuration and construction*: The 216-B-46 Crib consists of four concrete culverts buried vertically in a 2.4 m (8 ft) thick bed of gravel, with the centers spaced 3.9 m (15 ft) apart. Construction data indicate that the crib is in a 9.1 x 9.1 x 4.6 m (30 x 30 x 15-ft) deep excavation. The 216-B-14 Series Cribs (B-14, -15, -16, -17, -18, -19) consist of a 3.0 x 3.0 x 0.9-m (10 x 10 x 3-ft) high liquid-dispersion structure of wood, cinder block, and steel seated on a 1.5 m (5 ft) thick bed of gravel. Site dimensions are 12.2 x 12.2 x 4 m (40 x 40 x 13 ft) deep.

2. *Volume of effluent received in relation to the available pore volume*: The 216-B-46 Crib received approximately 6,700,000 L (1,770,000 gal) of scavenged supernatant waste from the 221-U Canyon Building over a 4-month period in 1955, which is 68 percent of the

estimated available soil pore volume. The analogous waste sites received between 3,410,000 L (900,000 gal) and 8,710,000 L (2,299,000 gal) of waste liquid and between 19 percent and 49 percent of estimated available soil pore volume.

3. *Contaminant inventory*: The 216-B-46 Crib received scavenged URP supernatant waste from the 221-U Canyon Building. The waste cascaded through the BY Tank Farm tanks before being discharged to the crib. The waste was originally bismuth-phosphate / lanthanum-fluoride metal waste from the 221-B Canyon Building. The 216-B-46 Crib has significant inventories of Cs-137 (88.9 Ci), plutonium (20 g), uranium (190 kg), Sr-90 (631 Ci), ferrocyanide (4,000 kg), and nitrate (1,200,000 kg).

4. *Inventories and concentrations*: The 216-B-14 Series Cribs received inventories for the following contaminants and ranges of concentrations: Cs-137 (296 to 92 Ci), plutonium (25 to 5 g), uranium (350 to 100 kg), Sr-90 (172 to 68.9 Ci), ferrocyanide (5,000 to 1,800 kg), and nitrate (1,500,000 to 900,000 kg) (inventory values from DOE/RL-96-81).

5. *Depth of waste discharge*: Sample data collected in 1993 confirms that the bottom of the excavation of the 216-B-46 Crib after stabilization (i.e., addition of 0.9 m (3 ft) of clean soil) is about 5.5 m (18 ft) bgs. Maximum contaminant concentrations were detected near the bottom of the crib at a depth of 5.5 m (18 ft bgs) and generally decreased with depth. Table 2-3 provides the depths to the top of the contamination, and thus the thickness of the clean cover, at each of the BC Cribs and Trenches Area waste sites. The 216-B-14 Series Cribs are shallower than the 216-B-46 Crib.

6. *Expected distribution of contaminants*: Most of the contamination detected at the 216-B-46 Crib was within a 9.1 m (30-ft) zone extending from the bottom of the crib at 5.5 to 15 m (18 to 49 ft) bgs. The Cs-137 and Sr-90 concentrations exceed 350,000 pCi/g. With the exception of Tc-99 and nitrate, little contamination was detected greater than 15 m (49 ft) bgs. The maximum Tc-99 concentration below 15 m (49 ft) bgs is 140 pCi/g at a depth of approximately 68.6 m (225 ft) bgs. On an effluent volume per surface area basis, the 216-B-46 Crib received a higher "concentration" (liters per square foot of crib footprint) of effluent than each of the 216-B-14 Series Cribs. Thus, because of the potential for contaminants to be flushed deeper at the 216-B-46 Crib, the expected distribution of contaminants at the 216-B-14 Series Cribs sites may be more concentrated than at the representative site (216-B-46 Crib).

2.6.2.4 Stand-Alone Waste Sites

The 200-E-114 Pipeline and 200-E-14 Siphon Tank are stand-alone waste sites rather than being analogous to any of the sampled waste sites. Both of these waste sites served as conduits for wastes that were disposed of in the trenches and cribs, but neither is known to have leaked and contaminated surrounding soil in the BC Cribs and Trenches Area. If any leakage occurred, it would have been minor compared to the deliberate waste discharges associated with the liquid waste disposal sites. For purposes of discussion and analysis of various remedial alternatives, the 200-E-114 Pipeline is associated with the 216-B-26 Trench; similarly, the 200-E-14 Siphon Tank is associated with the 216-B-46 Crib.

2.7 SUMMARY OF RISK ASSESSMENT

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

1. The Central Plateau Industrial/Exclusive Zone (200 Areas including B Pond [main pond] and S Ponds) will have an industrial scenario for the foreseeable future. The Central Plateau Industrial/Exclusive Zone (Core Zone) is depicted in Figure 2-14.

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

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

4. No drilling for water use or otherwise will be allowed in the Central Plateau Industrial/Exclusive Zone. An intruder scenario will be calculated for assessing the risk to human health and the environment.

5. Waste sites outside the Central Plateau Industrial/Exclusive Zone but within the Central Plateau (e.g., Gable Mountain Pond, BC Controlled Area) will be remediated and closed based on an evaluation of multiple land-use scenarios to optimize land use, institutional control cost, and long-term stewardship.

6. An industrial land-use scenario will set cleanup levels in the Central Plateau Industrial/Exclusive Zone. Other scenarios (e.g., residential, recreational) may be used for comparison purposes to support decision-making, especially for the following:

- The post-institutional controls period (>150 yr)
- Sites near the Central Plateau Industrial/Exclusive Zone perimeter, to analyze opportunities to "shrink the site"
- Early (precedent-setting) closure/remediation decisions.

7. This framework does not address the tank retrieval decision.

This description serves as the basis for the risk assessment activities performed that support this FFS. The human health and ecological risk assessments can be found in DOE/RL-2002-42 and in Appendix C of this document and are summarized in the following subsections.

2.7.1 Human Health Risk Assessment

The human health risk assessment (HHRA) includes the evaluation of nonradiological and radiological constituents from the three representative waste sites. The assessment includes analysis of direct human and ecological exposure using a dose and risk assessment for the shallow zone (0 to 4.6 m [0 to 15 ft] bgs) and analysis of the protection of groundwater, which was based on analysis of deep-zone soil (surface to the groundwater table) samples. Analytical results were screened in accordance with the Tri-Parties' guidance to identify the contaminants of potential concern (COPC). The purpose of the HHRA is to identify and prioritize the COPCs that are estimated to pose an unacceptable risk (or dose) and should be addressed by the FFS. The results of the risk evaluation for the 216-B-46 Crib representative site initially were presented in the RI report (DOE/RL-2002-42) and are repeated in this document, along with the 216-B-26 Trench and 216-B-58 Trench data.

Two of the three sampled sites are in the BC Cribs and Trenches Area (one is in the BY Cribs area), and all are located in the Central Plateau Industrial/Exclusive Zone. All shallow-zone soil COPCs were evaluated under an industrial exposure scenario. A hypothetical Native American subsistence scenario also was evaluated, to provide a basis of comparison (assuming unrestricted land use) to the site-specific industrial exposure scenario. The Tri-Parties have interacted with the Tribes over the past several years to obtain their input on developing a Native American exposure scenario or scenarios, including key parameters for the Central Plateau risk assessment models. The Tribes were involved in the risk assessment framework workshops during the summer of 2002; in October 2002, they were asked to provide written suggestions on specific risk-assessment parameters (exposure assumptions) for tribal-use scenarios (letters without title, DOE-RCA-2002-0584, 2002a; 2002b; 2002c). This request culminated in a workshop in December 2002 that included the Tri-Parties and representatives from the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes and Bands of the Yakama Nation, and the Nez Perce Tribe. The Yakamas and the Nez Perce participated in the workshop, but felt they needed additional time to provide input. The Umatillas asked that the information from Harris and Harper 1997, "A Native American Exposure Scenario," be used to calculate risk estimates for a Native American subsistence scenario. Additional discussion regarding the hypothetical Native American scenario is provided in Appendix C of this report.

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

2.7.1.1 Nonradiological Results

CERCLA prescribes a risk range of 10^{-6} to 10^{-4} for evaluating the need for remedial action for carcinogens and noncarcinogenic constituents that pose a chronic toxic effect to human health. Noncarcinogenic constituents that pose a chronic toxic effect to human health shall not exceed a hazard quotient of 1.0. Risk-based standards based on an industrial scenario are identified in WAC 173-340-745 that equate to a risk of 1.0×10^{-5} for nonradionuclides. These standards are evaluated in the risk assessment. A summary of the HHRA results for nonradiological constituents is presented below.

Shallow Zone[3]

All nonradiological COPCs from the shallow zone were compared to the WAC 173-340-745 Method C direct-contact and the WAC 173-340-750, "Cleanup Standards to Protect Air Quality," Method C ambient air risk-based standards for the industrial-exposure scenario. For the three representative sites, the mean concentrations of all shallow-zone COPCs from each representative waste site were less than their respective direct-contact and ambient-air Method C risk-based standards. A summary of these comparisons is provided in Appendix C. The maximum detected concentrations from the 216-B-58 Trench were used for comparison, because there were insufficient samples to perform a statistical analysis. As presented in Tables 2-4 and 2-5, no constituents exceeded the direct-contact risk-based standards. None of these waste sites exceeded the ambient air risk-based standards (Appendix C).

Deep Zone[4]

All nonradiological COPCs from the deep zone were compared to the WAC 173-340-747 Method B risk-based standards for the groundwater protection pathway. Each of the representative sites experienced some nonradiological contaminants in excess of the groundwater-protection screening levels. Depending on the site, these contaminants include antimony, cadmium, chromium (III), selenium, cyanide, fluoride, nitrate and nitrite (as nitrogen), sulfate, iron, and manganese. These contaminants are considered in this FFS. Tables 3-3 and 3-4 of the RI report (DOE/RL-2002-42) provide the details of this assessment for the 216-B-46 Crib; details for the 216-B-58 and 216-B-26 Trenches are reported in Table 2-6 of this document.

2.7.1.2 Radiological Results

The HHRA for radiological constituents was performed using the RESidual RADioactivity (RESRAD) code Version 6.21 analysis (ANL 2002, *RESRAD for Windows*, Version 6.21). The RESRAD model was used to obtain risk and dose estimates from direct-contact exposure to radiological constituents present in the shallow zone under an industrial-exposure scenario.

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[3] Shallow zone soils are defined as those collected from zero to 4.6 m (0 to15 ft) bgs.

[4] Deep zone soils are defined as those below 4.6 m (15 ft) bgs.

All of the representative sites currently have some amount of clean soil, associated either with clean backfill or with stabilization material, over the contamination.

Radiological constituents in the shallow zone were evaluated using two different methods. The first evaluation method was considered representative of current site conditions, because it accounts for the depth of clean cover (i.e., clean backfill or stabilization material) that is currently over the waste site. The maximum concentration in the 0 to 4.6 m (0 to 15-ft) zone, including the clean cover material, was used to evaluate risk in this method. Radiological constituents were encountered only at depths greater than the clean cover, which accounts for protective shielding effects. Table 2-3 identifies the thickness of the clean material over the waste sites.

The second evaluation method is considered representative of worst-case conditions, because it assumes that there is no clean cover over the representative waste site. The absence of clean cover assumes that the radiological constituents are distributed evenly throughout the shallow zone and that there are no protective effects from shielding. As described in the HHRA, the exposure-point concentrations for each of the radiological constituents were calculated as the lesser of either the maximum value or the 95th percentile upper confidence limit of all results. This method uses either the maximum value or the 95th percentile upper confidence limit for the entire 4.6 m (15-ft) zone.

The RESRAD modeling was performed using both methods for the 216-B-26 and 216-B-58 Trenches, assuming clean soil covers of 3.6 m (12 ft) for the 216-B-26 Trench and 2.4 m (8 ft) for the 216-B-58 Trench. Only the second method (no clean cover) was used for the 216-B-46 Crib, because the dose from the contaminants in the 0 to 4.6 m (0 to 15-ft) bgs zone for these sites was below 15 mrem/yr under this worst case scenario.

The RESRAD model (ANL 2002) was used to obtain screening risk and dose estimates for the groundwater protection pathway for deep zone soils. The screening analysis serves to focus attention on those sites with the potential to contaminate groundwater and to identify the radionuclides of concern.

For comparative purposes, risk and dose estimates were evaluated in context with the following scenario assumptions:

- 50 yr is the estimated time that the DOE will have an on-site presence
- 150 yr is the estimated time identified in the Tri-Parties response to HAB Advice #132 that institutional controls are assumed to be effective (Klein et al. 2002, "Consensus Advice #132: Exposure Scenarios Task Force on the 200 Area").

For this remedial action, the CERCLA risk range of 10^{-4} to 10^{-6} was used to evaluate risks from radionuclides. The RESRAD model calculates a radiation dose using an industrial scenario that is then converted to risk in accordance with EPA guidance (EPA/540/R-99/006, *Radiation Risk Assessment At CERCLA Sites: Q & A* [OSWER Directive No. 9200.4-31P]). A dose of 15 mrem/yr roughly equates to a risk of 10^{-4}. For the groundwater protection pathway, the average annual activity of beta particles and photon radioactivity from manmade radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ of greater than 4 mrem/yr (40 CFR 141.66, "Maximum Contaminant Levels for Radionuclides").

Both of these values are approximately equivalent to an excess lifetime cancer risk (ELCR) of 10^{-4}. The actual ELCR is dependent on which radionuclides are involved.

Shallow Zone – Industrial Scenario – Clean Cover

For those representative sites modeled with a clean cover, none have a total dose rate exceeding the target dose level of 15 mrem/yr at any of the exposure times evaluated. Similarly, the ELCR does not exceed 10^{-5} at any of the exposure times evaluated. The ELCR for all sites is also within the CERCLA target risk range of 10^{-6} to 10^{-4}. The results of this evaluation are provided in Appendix C. Table 2-7 provides the maximum year dose and ELCR for each site.

Shallow Zone – Industrial Scenario – Without Clean Cover

For the industrial scenario without clean cover, two of the representative sites exceeded the 15 mrem/yr dose standard as indicated in Table 2-7.

216-B-26 Trench (Representative Site). The maximum total dose rate at the 216-B-26 Trench is 310,000 mrem/yr at year 0 and decreasing thereafter. The maximum ELCR is 4.3 at year 0. The ELCR under this exposure scenario exceeds the target risk level of 10×10^{-5} until year 1,000. The primary contributors to total dose and risk are Cs-137 and Pu-239. The results of this evaluation are provided in Appendix C.

216-B-58 Trench (Representative Site). The maximum total dose rate at the 216-B-58 Trench is 4,600 mrem/yr at year 0 and decreasing thereafter. The maximum ELCR is 3.0×10^{-2} at year 0. The ELCR under this exposure scenario is never below the target risk level of 1.0×10^{-5}. The primary contributor to total dose and risk is initially Cs-137 and then Th-232 as the cesium decays. The results of this evaluation are provided in Table 2-7.

216-B-46 Crib (Representative Site). The maximum total dose rate at the 216-B-46 Crib is 1.9 mrem/yr at years 0 to 30. After 30 yr, the dose rate decreases. The maximum ELCR is 4.3×10^{-5} for the first 30 yr. The ELCR under this exposure scenario is less than the target risk level of 1.0×10^{-5} only at 1,000 yr. Additionally, the ELCR under this scenario is within or less than the CERCLA target risk range of 1×10^{-6} to 1×10^{-4} for all times analyzed. The primary contributor to total dose and risk is Ra-226. The results of this evaluation are provided in Appendix C.

Deep Zone – Groundwater Protection (STOMP Modeling)

Vadose zone contaminant fate and transport modeling was conducted using Subsurface Transport Over Multiple Phases (STOMP) modeling (PNNL-12034, *STOMP, Subsurface Transport Over Multiple Phases, Version 2.0, User's Guide*). Modeling considered radiological and nonradiological contaminants.

The 216-B-26 Trench modeling (Appendix G) indicates that impact to groundwater, i.e., exceeding the Tc-99 MCL (900 pCi/L measured at the point of entry into the groundwater), would occur in the year 2124, assuming that current conditions, represented conservatively by a recharge rate of 25 mm/yr, prevail. The MCL for nitrate (10 mg/L) is predicted to be exceeded in 2113. When the recharge rate is reduced to 3.5 mm/yr, the dates for MCL exceedance are

2324 and 2252, respectively, for Tc-99 and nitrate. The predicted dates for MCL exceedance are extended for lesser recharge rates. The modeling also considers contaminant concentrations at hypothetical points of compliance located at various nominal distances downgradient from the waste site. Using this approach at a point 100 m (328 ft) downgradient in the groundwater, the Tc-99 MCL would be exceeded in the year 2142 for a 25-mm/yr and in 2600 for a 3.5 mm/yr recharge.

The 216-B-46 Crib modeling reported in the RI indicates that the moderately mobile contaminants (cyanide, Co-60, nitrate, nitrite, sulfate, Tc-99, and uranium isotopes) already observed in the groundwater are expected to continue to impact groundwater. The modeling indicates that certain of the other long-lived less mobile contaminants (e.g., Pu-239) also may reach the groundwater at concentrations exceeding their MCLs in approximately 9,500 yr.

The 216-B-58 Trench was not modeled because of its minimal contaminant concentrations. Comparing 216-B-58 Trench soil concentrations with those from the 216-B-26 Trench leads to the conclusion that nitrate and selenium associated with the 216-B-58 Trench will not impact groundwater.

2.7.2 Ecological Risk Assessment

For the ecological risk assessment (ERA), the eight-step ERA process developed for the Superfund program in EPA/540/R-97/006, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (Interim Final)*, was followed (see Appendix C). The process starts with a screening-level ERA (SLERA), which uses conservative screening values provided by Ecology (WAC-173-340-900, "Tables," Table 749-3) for nonradionuclides and by the Biota Dose Assessment Committee in DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*, for radionuclides. This corresponds to Steps 1 and 2 of the EPA guidance (EPA/540/R-97/006). The SLERA process followed is as described in DOE/RL-2001-54 and is further outlined in Appendix C. The SLERA intentionally is conservative and serves to eliminate analytes and sites from further evaluation that do not pose a risk to the environment despite the SLERA's bias toward overestimating risk. The SLERA is used to determine whether further evaluation (i.e., baseline ERA) or remedial actions are necessary. The results of the screening are presented separately in the following subsections for nonradionuclides and radionuclides.

2.7.2.1 Results of the Screening-Level Ecological Risk Assessment – Nonradionuclides

For each of the representative sites, exposure point concentrations for each nonradionuclide constituent were screened against the wildlife screening values presented in WAC 173-340-900, Table 749-3, to determine if any chemical concentrations exceeded their respective screening values. None of the representative sites exceeded wildlife screening values.

2.7.2.2 Results of the Screening-Level Ecological Risk Assessment – Radionuclides

The 216-B-26 and 216-B-58 Trenches had concentrations of Cs-137 and Sr-90 in the 0 to 4.6 m (0 to 15-ft) bgs zone that exceeded the biota concentration guides (BCG) (DOE-STD-1153-2002) for these constituents. The results of the ecological screening for the representative sites are

presented in DOE/RL-2002-42, except for the 216-B-26 and 216-B-58 Trenches, which are shown in Appendix C.

2.7.2.3 On-Going Ecological Characterization

A phased baseline ecological evaluation is under way in the 200 Areas that will supplement other characterization data for waste sites in the Central Plateau. This evaluation is based on the ecological data quality objectives summary report for the Central Plateau on the Hanford Site, as documented in WMP-20570, *Central Plateau Terrestrial Ecological Risk Assessment Data Quality Objectives Summary Report - Phase 1*. The evaluation will supplement current characterization of the health and condition of the ecosystem across habitats.

2.7.3 Intruder Risk Assessment

Inadvertent intruder scenarios are based on the possibility that an individual unwittingly (through human error or loss of knowledge concerning the location of contaminants) engages in an activity that results in contact with wastes left in place. DOE operations are assumed to continue for at least 50 yr and public entry to the site is expected to be restricted for at least an additional 100 yr by enforcement of active institutional controls. Passive institutional controls may provide extended protection, but no credit is taken for them. For purposes of evaluating risk, an intruder has an assumed ability to obtain access to the waste site areas. Of the three intruder scenarios proposed for evaluation (see Appendix E for additional details on the intruder risk assessment), the third is considered to be the worst-case scenario, because exposure time would be the greatest. Therefore, the third scenario is the primary focus of the analysis presented in this FFS and is assumed to bound scenarios 1 and 2; scenario 1 is considered for acute exposures:

1. Future construction trench worker intruder scenario
2. Future well driller intruder scenario (drill cuttings)
3. Future residential intruder scenario (drill cuttings).

The residential intruder scenario is based on the resident using drill cuttings from a well drilled through the waste site to augment garden plot soil. Table 2-8 summarizes the future residential intruder consequences for the representative waste sites. This table shows that all of these sites are predicted to have unacceptable dose and risk (compared to 15 mrem/yr and an ELCR of greater than 10^{-4}) at 150 yr, but are acceptable before 600 yr.

2.7.4 Representative and Analogous Waste Sites Risk Assessment Synopsis

Table 2-6 summarizes the risks for the 216-B-26 and 216-B-58 Trenches, found in Appendix C of this FFS, and for the 216-B-46 Crib, based on the HHRA and SLERA found in the RI report (DOE/RL-2002-42). Tables 2-4 and 2-5 summarize the timeframes to reach human health and ecological preliminary remediation goals (PRG). PRGs are discussed in Chapter 3.0. The tables support the determination of appropriate alternatives to be evaluated for each representative site and its associated analogous waste sites.

2.7.4.1 Application to the 216-B-26 Trench and Its Analogous Waste Sites

Risks associated with the 216-B-26 Trench are evaluated in this FFS (Appendix C). Significant contamination was located in shallow-zone soils, consisting of primarily Cs-137 and Sr-90 within the 3.7 to 4.9 m (12 to 16 ft) bgs. More than 435 yr would be required for the shallow-zone contamination to decay below PRGs, based on sampling results. When the borehole spectral gamma logging data are correlated with sampling to predict contamination levels at regions not sampled, nearly 600 yr are required to decay below PRGs. As shown in Table 2-6, the following are applicable to vadose zone contamination at the 216-B-26 Trench.

- With respect to radiological contaminants in the 0 to 4.6 m (0 to 15-ft) zone, human health is not protected for the worst case assumption of no existing cover, because the maximum dose is 310,000 mrem/yr under an industrial scenario. This dose is reduced to negligible levels under the existing conditions of a 3.6-m (12-ft) thick layer of backfill and stabilization cover.

- With respect to nonradionuclides, human health is protected, because no contaminant concentrations in this zone exceed WAC 173-340-745 risk-based standards.

- Groundwater may not be protected, because Tc-99 and nitrate are predicted to reach the groundwater above MCLs if evaluated at the vadose zone/groundwater interface, based on comparison to groundwater protection standards. If evaluated 100 m (328 ft) downgradient, MCLs are predicted to not be exceeded.

- With respect to ecological protection, concentrations of Cs-137 and Sr-90 exceed ecological screening criteria.

- With respect to intruders to the waste site past 150 yr, human health is not protected, because the dose and risk values exceed 15 mrem/yr and 1×10^{-4}, respectively, at 150 yr for the resident intruder.

2.7.4.2 Application to the 216-B-58 Trench and Its Analogous Waste Sites

Risks associated with the 216-B-58 Trench are evaluated in this FFS (Appendix C). Significant contamination was located in shallow-zone soils, consisting primarily of Cs-137 and Sr-90 within the 4.1 to 4.9 m (13.5 to 16 ft) bgs. Over 280 yr would be required for the shallow-zone contamination to decay below PRGs. As shown in Table 2-3, the following are applicable to vadose zone contamination at the 216-B-58 Trench.

- With respect to radiological contaminants in the 0 to 4.6 m (0 to 15-ft) zone, human health is not protected for the worst case assumption of no existing cover, because the maximum dose is 4,600 mrem/yr under an industrial scenario. This dose is reduced to negligible levels under the existing conditions of a 3.1-m (10-ft) thick layer of backfill and stabilization cover.

- With respect to nonradionuclides, human health is protected, because no contaminant concentrations in this zone exceed WAC 173-340-745 risk-based standards.

- RESRAD (ANL 2002) modeling indicates that radionuclides would not adversely impact groundwater in the future.

- Groundwater is protected. Although initial screening predicts nitrate and selenium to reach the groundwater above MCLs, comparison of soil concentrations with those observed at the 216-B-26 Trench and STOMP modeling (PNNL-12034) for that trench predicts that MCLs will be met at the 216-B-58 Trench.

- With respect to ecological protection, concentrations of Cs-137 and Sr-90 exceed ecological screening criteria.

- With respect to intruders to the waste site past 150 yr, human health is not protected, because the risk level slightly exceeds 1×10^{-4} at 150 yr for an intruder. Dose at 150 yr is at acceptable levels.

2.7.4.3 Application to the 216-B-46 Crib and Its Analogous Waste Sites

Risks associated with 216-B-46 Crib were evaluated in the RI report. The bottom of the waste site was identified at 5.5 m (18 ft). Only minor contamination was located in the shallow zone. However, because significant concentrations of Cs-137 and Sr-90 are located in the zone from 5.5 to 9.6 m (18 to 31.5 ft), approximately 410 yr would be required for these contaminants to decay below PRGs. As shown in Table 2-6, the following are applicable to vadose zone contamination at the 216-B-46 Crib.

- With respect to radiological contaminants in the 0 to 4.6 m (0 to 15-ft) zone, human health is protected, because dose does not exceed the limit (15 mrem/yr). Also, PRGs are not exceeded in this range.

- With respect to nonradionuclides, human health is protected, because no contaminant concentrations in this zone exceed WAC 173-340-745 risk-based standards.

- Groundwater is not protected, because nitrate, total uranium, Tc-99, and U-238 are predicted to reach the groundwater above MCLs, either through modeling or through comparison to groundwater protection standards.

- Ecological receptors are protected, because contaminant concentrations are below screening levels.

- With respect to intruders to the waste site past 150 yr, human health is not protected, because significant concentrations of contamination would remain in the 5.5 to 9.6 m (18 to 31.5-ft) bgs zone for up to 410 yr.

2.7.5 Principal Threat

2.7.5.1 Principal Threat Guidance

40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," promulgated on March 8, 1990, states that EPA expects to use "treatment to address the principal threats posed by a site, wherever practicable" and "engineering controls, such as containment, for waste that poses a relatively low long-term threat" (40 CFR 300.430(a)(1)(iii), "Remedial Investigation/Feasibility Study and Selection of Remedy," "General," "Introduction," "Expectations." That section also states "EPA expects to use a combination of methods, as appropriate, to achieve protection of human health and the environment. In appropriate site situations, treatment of the principal threats, with priority placed on treating waste that is liquid, highly toxic or highly mobile, will be combined with engineering controls (such as containment) and institutional controls, as appropriate, for treatment residuals and untreated waste."

The EPA Superfund publication "A Guide to Principal Threat and Low Level Threat Wastes," OSWER 9380.3-06FS, (EPA 1991) provides further guidance regarding definition of principal threat material. This guidance specifically defines principal threat wastes as source material and states that no threshold level of toxicity/risk has been established to equate to principal threat. But then it does state "however, where toxicity and mobility of source material combine to pose a potential risk of 10^{-3} or greater, generally treatment alternatives should be evaluated."

2.7.5.2 Principal Threat Criteria

Establishment of definitive criteria is subjective, because no explicit criteria are provided by the EPA, other than to consider treatment "where toxicity and mobility of source material combine to pose a potential risk of 10^{-3} or greater." The EPA provided additional guidance in EPA/540/F-96/018, *The Role of Cost in the Superfund Remedy Selection Process*, OSWER 9200.3-23FS, wherein principal threats are "media containing contaminant concentrations several orders of magnitude above health-based standards." In addition to EPA guidance, the U.S. Nuclear Regulatory Commission provides guidance for categorizing waste according to its potential risk to human health in 10 CFR 61.55, "Licensing Requirements for Land Disposal of Radioactive Waste," "Waste Classification," in defining Class A, B, and C waste. In particular, Class C waste, which presents the greatest risk of these classes, "requires additional measures at the disposal facility to protect against inadvertent intrusion." The U.S. Nuclear Regulatory Commission criteria for waste disposal are instructive, but are not ARARs, because CERCLA does not invoke U.S. Nuclear Regulatory Commission legislation. However, the Class C waste criteria of 10 CFR 61.55, the 10^{-3} risk guidance provided by the EPA (1991) and the EPA guidance in EPA/540/F-96/018 that contaminant concentrations are several orders of magnitude above health-based levels are all considered in defining principal threat criteria. A middle-ground value of 10^{-2} is assigned for the risk-based ELCR associated with principal threat waste.

The following principal threat criteria are established for consideration at the BC Cribs and Trenches Area waste sites:

Criteria:	ELCR is $>10^{-2}$ or Class C waste (per 10 CFR 61.55)
Scenario:	Resident intruder with a small garden using drill cuttings for soil amendment (same scenario adopted for general intruder evaluation) An alternate scenario providing an acute dose is also considered, such as an excavation scenario whereby a worker is working in the contaminated soil for up to 50 h.
Time from present:	Cessation of active institutional controls, i.e., 150 yr from now.

2.7.5.3 Potential Application to BC Cribs and Trenches Area Waste Sites

Per the 40 CFR 300 expectation and criteria described above, waste sites associated with the BC Cribs and Trenches Area are evaluated for consideration as a principal threat. Already, DOE/RL-2002-68 has designated these waste sites as high-risk waste sites because of their predicted cumulative Tc-99 inventory.

2.7.5.3.1 Near-Surface Contaminants

Current concentrations of high-activity radionuclides (Cs-137 and Sr-90, in particular) represent significant potential threat upon exposure. Dose rates encountered during drilling the 216-B-26 Trench borehole (C4191) were 4.5 rem/h at a depth of ~4.0 m (13 ft bgs), which could have resulted in a significant acute exposure if risk had not been recognized. Dose and risk to an excavation worker 150 yr from now are calculated to be 3650 mrem and 2.8 E-03, respectively.

However, the maximum contaminant concentration is believed to be considerably greater than indicated by soil sampling. Using RLS data for the 216-B-26 Trench borehole to extrapolate the soil data to the "hottest" region observed will increase both dose and risk by a factor of about 22[5]. Note that at 150 yr, the ELCR to an inadvertent intruder (resident-with-a-garden scenario) already exceeds the 10^{-2} threshold (see Table 2-8), without employing this factor. Thus, the near-surface concentrations of Cs-137 result in the designation of that waste as being principal threat waste.

Extrapolation of data gathered from the 216-B-26 Trench borehole (C4191) to other waste sites in this area using estimated inventories (*Soil Inventory Model*, 2004) indicates that five of the six cribs and the 216-B-20 Trench have similar risks. It should be noted that this approach does not

[5] Per Appendix F, the ratio of the Cs-137 concentration in the soil sample collected at the 4.0 – 4.7 m (13.0 – 15.5 ft) bgs vs the corresponding value estimated by RLS characterization is 529,000/162,000 ≈ 3.3. Multiplying this ratio times the 4.0 m (13-ft) bgs concentration obtained by RLS characterization (i.e., 3,598,000 pCi/g) yields a Cs-137 concentration of 11,900,000 pCi/g at that depth. Thus, the Cs-137 concentration to be applied to the intruder scenario is approximately 22 times greater than the soil sampling concentration obtained from a slightly greater depth.

consider variability within individual waste sites, which could result in localized portions with very high contaminant concentrations. Assuming that "hot spots" are represented by the 216-B-26 Trench experience, radioactive decay, primarily decay of Cs-137 and Sr-90, will reduce the ELCR to near 10^{-3} in less than 500 yr.

Consideration of the 10 CFR 61.55 waste classification criteria, using the conservative assumption that the waste is uniformly distributed in a 1-m (39.4-in.) thick layer under the footprint of the waste site, would designate all of the cribs and trenches as Class B waste - none meet Class C criteria. For this analysis, the *Soil Inventory Model* database 2004 inventory values were employed, on the belief that they represent updated values.

2.7.5.3.2 Deep Contaminants

Concentrations of Tc-99 and nitrate both are predicted to exceed human health groundwater MCLs. Of particular concern is the Tc-99 contaminant that has a half-life of 2.13 E+05 yr, indicating that natural attenuation is ineffective in mitigating future risk. Soil sampling to date indicates that the main concentration of Tc-99 is approximately 34 m (110 ft) bgs in a plume characterized by substantial lateral spreading. Fate and transport modeling predicts that Tc-99 will continue to move toward groundwater but will not exceed the groundwater MCL for approximately 120 yr under current conditions. If an evapotranspiration (ET) cap is placed over the waste site, the time period before groundwater is affected will be extended another hundred years, but the groundwater still will be adversely affected such that the existing Tc-99 plume in the vadose zone may be considered a principal threat. Risk from the potential groundwater pathway was not calculated.

Because of the extended time before the Tc-99 will impact the groundwater, designation of this contaminant as a principal threat may not be appropriate. The definition of principal threat relative to high contaminant mobility implies a sense of urgency in addressing the threat before it causes damage. There is ample time to develop effective remedial actions to protect human health and the environment.

Comparison of potential Tc-99 concentrations, estimated as described above for the near-surface contaminants, with 10 CFR 61.55 waste classification criteria would place all but one of the cribs in the Class C category. Thus, the deep Tc-99 contamination expected to reside beneath the cribs is designated as principal threat waste. None of the trenches would qualify.

Figure 2-1a. Major Processes (Bismuth/Phosphate and Lanthanum/Fluoride) and Waste Sites of the 200-TW-1 Operable Unit.

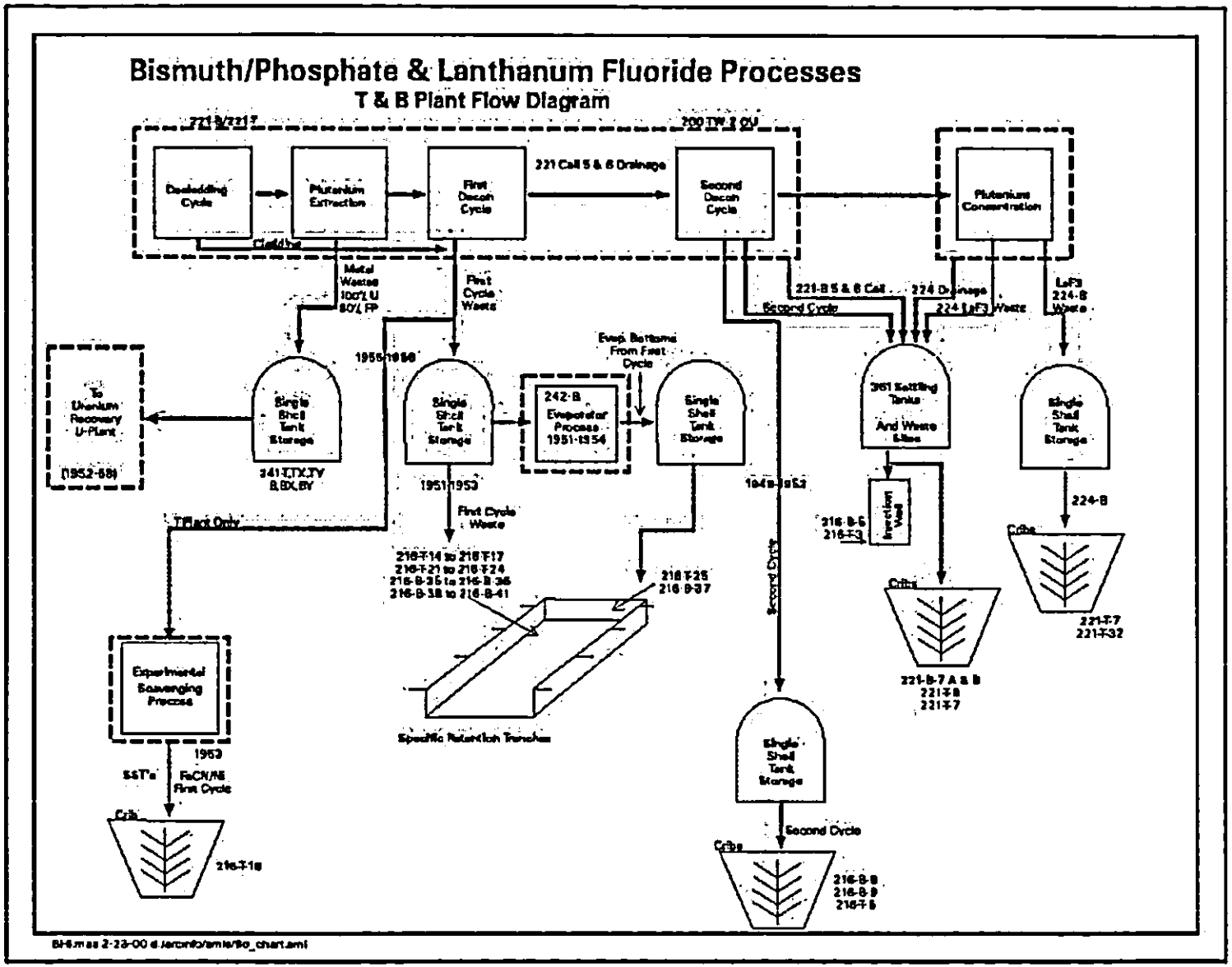

Figure 2-1b. Major Processes (Uranium Recovery and Scavenging) and Waste Sites of the 200-TW-1 Operable Unit.

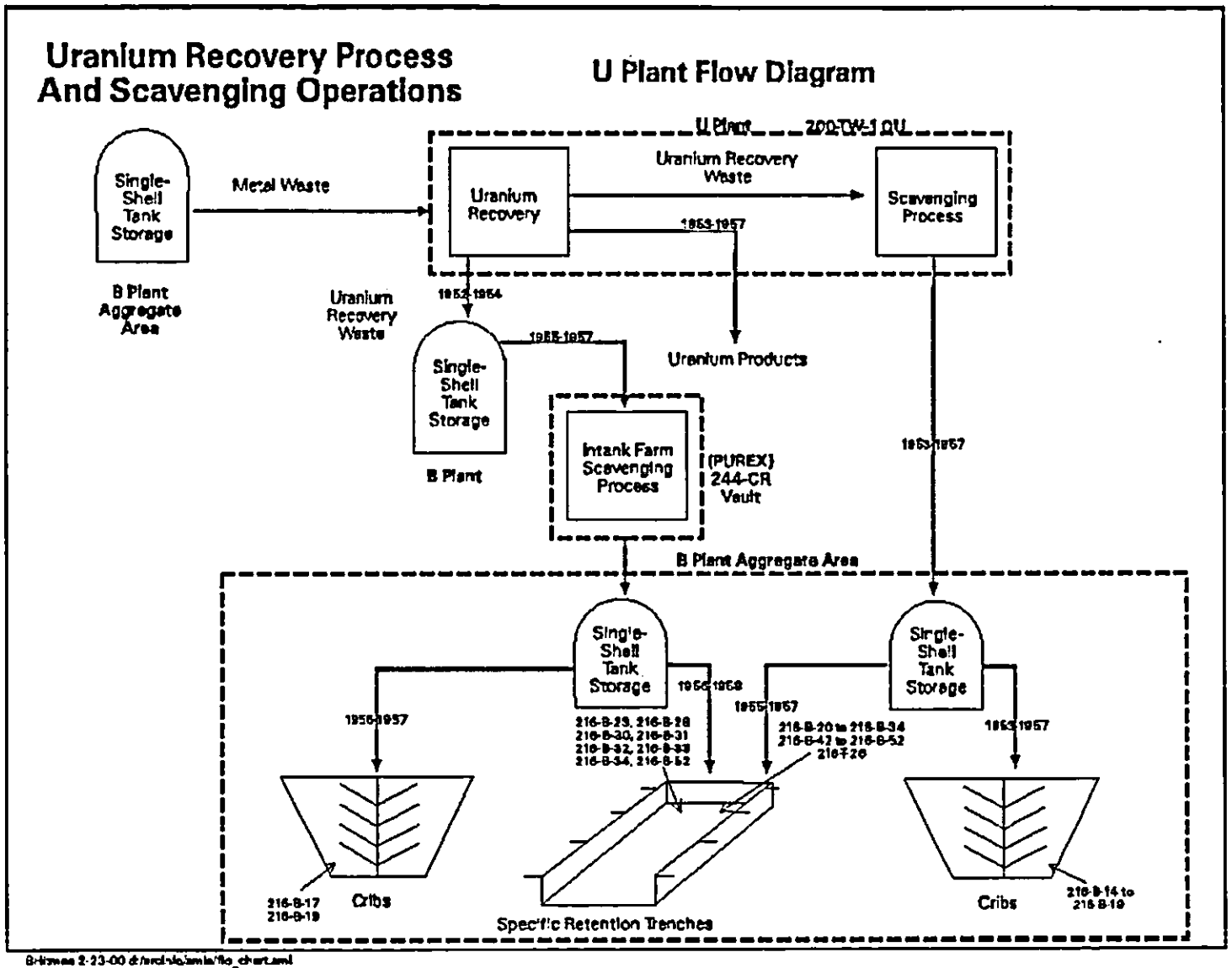

Figure 2-11. 216-B-46 Crib Contaminant Distribution Model of Contaminants of Potential Concern.

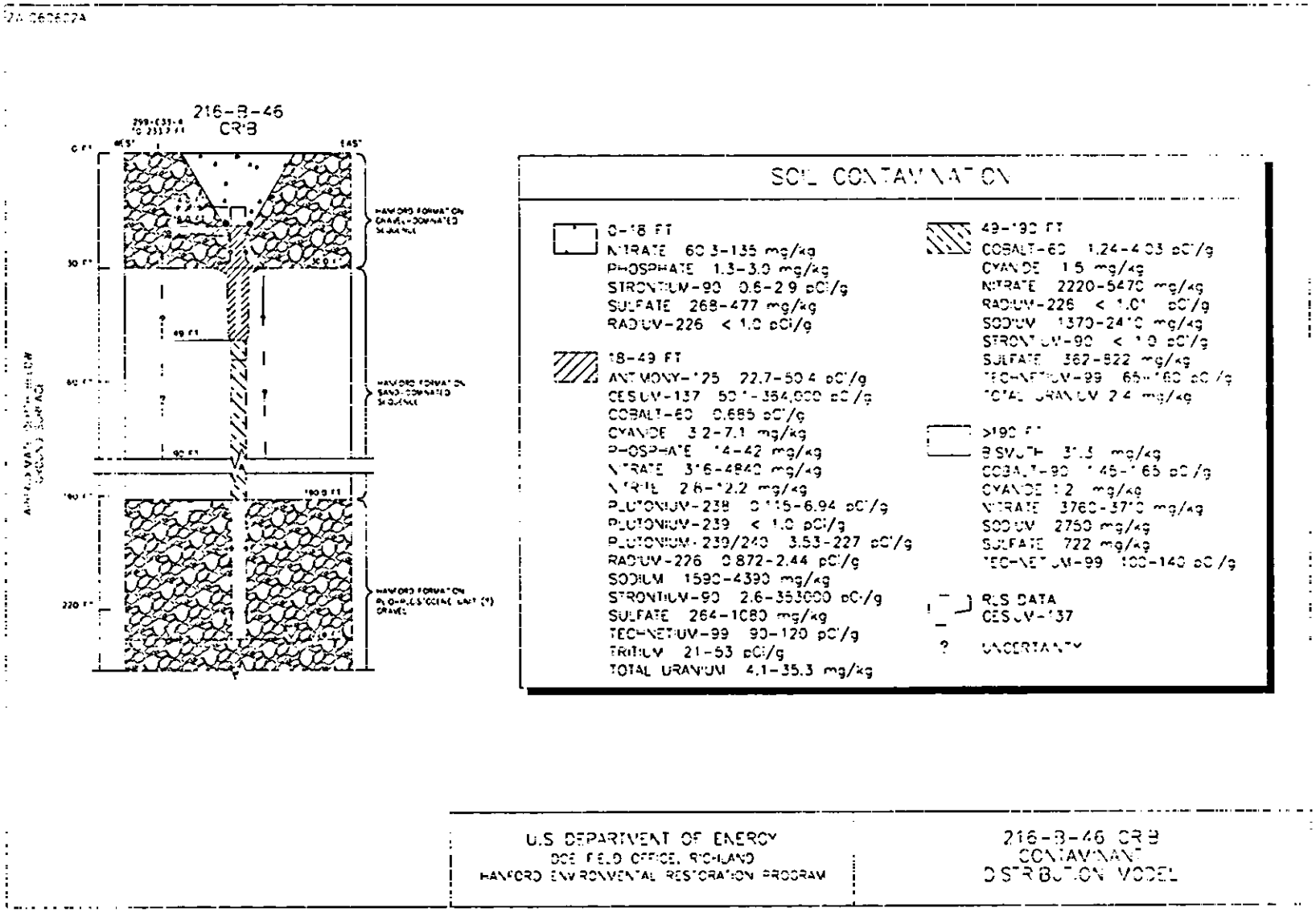

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Figure 2-12. Application of Analogous Site Approach.

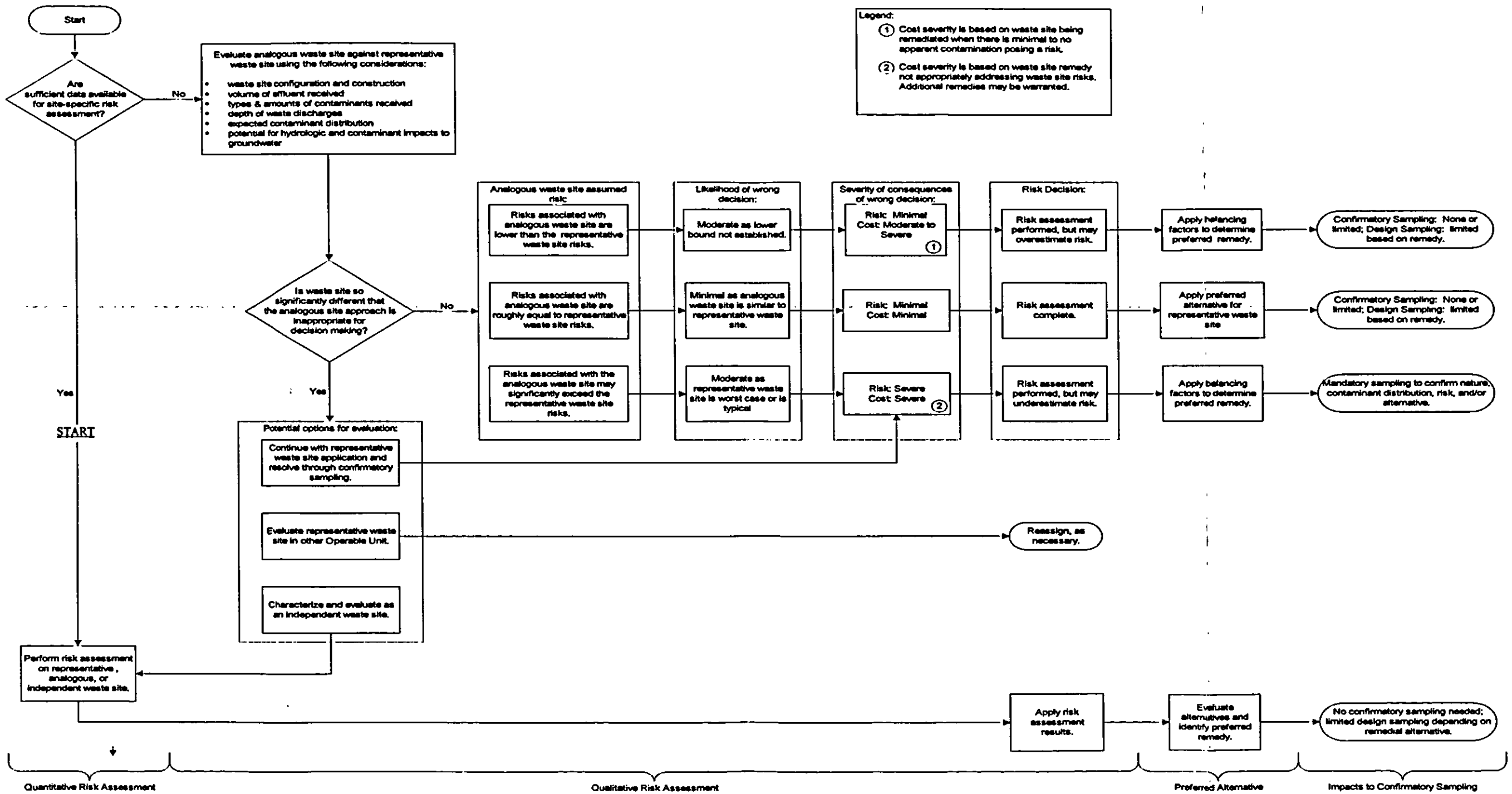

Table 2-1. Lithofacies of the Cold Creek Unit.

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 and 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

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

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Table 2-2. 200-TW-1 Operable Unit Representative Sites and Associated Analogous Waste Sites. (14 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site Discharge History (WIDS)	Contaminant Inventory (DOE/RL-96-81)							Effluent Volume (m^3)	Soil Pore Volume (m^3)	Eff Vol + Pore Vol	Rationale
			Total U (kg)	Total Pu (g)	Tc-99* (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)				
216-B-15	The 216-B-15 Crib is a 3.0 x 3.0 x 0.9 m high (10 x 10 x 3 ft) structure constructed of wood, cinder block, and steel on a bed of gravel. Bottom dimensions of the crib are 12.2 x 12.2 m (40 x 40 ft). The waste site dimensions are 24 x 24 x 4 m deep (80 x 80 x 13 ft deep). The depth to the top of contamination is 4 m (13 ft). Located in the BC Cribs and Trenches Area and within the assembly of 216-B-14 through 216-B-19 Cribs.	Scavenged TBP Waste Stream Tank Farm/B, BX, BY: 1956-1957. The site received scavenged bismuth phosphate waste from URP process waste in the 221-U Building. The waste cascaded through the BY Tank Farm tanks before being discharged to the crib.	100 Less than rep site (179)	5.0 Less than rep site (81.3)	30.8 Similar to rep site (24.0)	92.4 Similar to rep site (222)	87.3 Less than rep site (168)	3,300 Less than rep site (0)	900,000 Less than rep site (1,260,000)	6,320 Similar to rep site	17,670	0.36 Less than rep site	The 216-B-15 Crib is analogous to the 216-B-46 Crib as indicated by process history, contaminant inventory, effluent volume received, and expected nature and vertical extent of contamination: 1. Received the same waste stream as 216-B-46 Crib; therefore, the contaminant types are expected to be very similar. 2. Site construction is similar to 216-B-46 Crib; however, the 216-B-15 Crib is slightly larger than the 216-B-46 Crib. 3. Waste was received from the same source (221-U). 4. Both sites are located in 200 East Area; the geology of the two sites is similar. 5. The vertical extent of contamination is expected to be similar based on evidence from similar sites investigated (e.g., 216-B-43 through 216-B-50 Cribs). 6. Risks are expected to be similar to 216-B-46 Crib; because the top of the contamination is about 4 m (13 ft) bgs, human health and ecological risks are expected in the 0 to 4.6 m (0 to 15-ft) zone. 7. Comparison of contaminant inventories and effluent volume discharges for the 216-B-15 and 216-B-46 Cribs suggests that groundwater may be threatened at the 216-B-15 Crib. Because the ratio of effluent volume to soil pore volume is less for the 216-B-15 Crib, higher inventories of mobile contaminants could remain in the vadose, posing a more significant threat to groundwater than from the 216-B-46 Crib. . 8. Generally received equivalent or less contaminant inventory than 216-B-46 Crib. In general, the 216-B-15 Crib is analogous and roughly equivalent to the 216-B-46 Crib. Remedial actions are needed to address the same risks as those of the 216-B-46 Crib, specifically protection of groundwater and protection against human and ecological intrusion to shallow contaminants at the bottom of the waste site in the 0 to 4.6 m (0 to 15-ft) bgs zone.
216-B-16	The 216-B-16 Crib is a 3.0 x 3.0 x 0.9 m high (10 x 10 x 3 ft) structure constructed of wood, cinder block, and steel on a 1.5 m (5 ft) bed of gravel. Bottom dimensions of the crib are 12.2 x 12.2 m (40 x 40 ft).The waste site dimensions are 24 x 24 x 4 m deep (80 x 80 x 13 ft deep). The depth to the top of contamination is 3 m (10 ft). Located in the BC Cribs and Trenches Area and within the assembly of 216-B-14 through 216-B-19 Cribs.	Scavenged TBP Waste Stream Tank Farm/B, BX, BY: 1956. The site received scavenged bismuth phosphate waste from URP process waste in the 221-U Building. The waste cascaded through the BY Tank Farm tanks before being discharged to the crib. The 216-B-16 Crib received scavenged waste over a short period of time (5 months).	320 More than rep site (158)	10.0 Less than rep site (74.0)	27.3 Similar to rep site (19.7)	296 More than rep site (197)	302 Less than rep site (145)	3,000 Less than rep site (0)	1,100,000 Similar to rep site (1,100,000)	5,600 Less than rep site	17,670	0.32 Less than rep site	The 216-B-16 Crib is analogous to the 216-B-46 Crib as indicated by process history, contaminant inventory, effluent volume received, and expected nature and vertical extent of contamination: 1. Received the same waste stream as 216-B-46 Crib; therefore, the contaminant types are expected to be very similar. 2. Site construction is similar to 216-B-46 Crib; however, the 216-B-16 Crib is slightly larger than the 216-B-46 Crib. 3. Waste was received from the same source (221-U). 4. Both sites are located in 200 East Area; the geology of the two sites is similar. 5. The vertical extent of contamination is expected to be similar based on evidence from similar sites investigated (e.g., 216-B-43 through 216-B-50 Cribs). 6. Risks are expected to be similar to 216-B-46 Crib; because the top of the contamination is about 3 m (10 ft) bgs, human health and ecological risks are expected in the 0 to 4.6 m (0 to 15-ft) zone. 7. Comparison of contaminant inventories and effluent volume discharges for the 216-B-16 and 216-B-46 Cribs suggests that groundwater may be threatened at the 216-B-15 Crib. Because the ratio of effluent volume to soil pore volume is less for the 216-B-16 Crib, higher inventories of mobile contaminants could remain in the vadose, posing a more significant threat to groundwater than from the 216-B-46 Crib. This implies that groundwater protection is needed at this waste site, as it is at 216-B-46 Crib. 8. Generally received equivalent or greater contaminant inventory than the 216-B-46 Crib. The 216-B-16 Crib received higher inventories of uranium and Cs-137, supporting the need for groundwater protection and the likelihood of higher shallow zone and intruder risks than the 216-B-46 Crib. In general, the 216-B-16 Crib is analogous to the 216-B-46 Crib, with potential for higher risk from the Cs-137 in the shallow zone and in the zone at the bottom of the crib structure. Remedial actions are needed to address the same risks as those of the 216-B-26 Trench, specifically protection of groundwater and protection against human and ecological intrusion to shallow contaminants at the bottom of the waste site in the 0 to 4.6 m (0 to 15-ft) bgs zone.

Table 2-2. 200-TW-1 Operable Unit Representative Sites and Associated Analogous Waste Sites. (14 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site Discharge History (WIDS)	Contaminant Inventory (DOE/RL-96-81)							Effluent Volume (m^3)	Soil Pore Volume (m^3)	Eff Vol + Pore Vol	Rationale
			Total U (kg)	Total Pu (g)	Tc-99* (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)				
216-B-17	The 216-B-17 Crib is a 3.0 x 3.0 x 0.9 m high (10 x 10 x 3 ft) structure constructed of wood, cinder block, and steel on a 1.5 m (5 ft) bed of gravel. Bottom dimensions of the crib are 12.2 x 12.2 m (40 x 40 ft). The waste site dimensions are 24 x 24 x 4 m deep (80 x 80 x 13 ft deep). The depth to the top of contamination is 3.4 m (11 ft). Located in the BC Cribs and Trenches Area and within the assembly of 216-B-14 through 216-B-19 Cribs.	Scavenged TBP Waste Stream Tank Farm/B, BX, BY: 1956. The site received in-tank scavenged (first cycle) and scavenged bismuth phosphate waste from URP process waste in the 221-U Building. The waste cascaded through the BY Tank Farm tanks before being discharged to the crib. The 216-B-17 Crib received waste over a short period of time (one month)	350 More than rep site (94.6)	10.0 Less than rep site (45.0)	5.65 Less than rep site (9.8)	100 Similar to rep site (120)	68.9 Less than rep site (82.9)	1,800 Less than rep site (0)	1,100,000 Similar to rep site (561,000)	3,410 Less than rep site	17,670	0.19 Less than rep site	The 216-B-17 Crib is analogous to the 216-B-46 Crib as indicated by process history, contaminant inventory, effluent volume received, and expected nature and vertical extent of contamination: 1. Received the same waste stream as 216-B-46 Crib; therefore, the contaminant types are expected to be very similar. 2. Site construction is similar to 216-B-46 Crib; however, the 216-B-17 Crib is slightly larger than the 216-B-46 Crib. 3. Waste was received from the same source (221-U). 4. Both sites are located in 200 East Area; the geology of the two sites is similar. 5. The vertical extent of contamination is expected to be similar based on evidence from similar sites investigated (e.g., 216-B-43 through 216-B-50 Cribs). 6. Risks are expected to be similar to 216-B-46 Crib; because the top of the contamination is about 3.4 m (11 ft) bgs, human health and ecological risks are expected in the 0 to 4.6 m (0 to 15-ft) zone. 7. Comparison of contaminant inventories and effluent volume discharges for the 216-B-17 and 216-B-46 Cribs suggests that groundwater may be threatened at the 216-B-17 Crib. Because the ratio of effluent volume to soil porosity volume is less for the 216-B-17 Crib, higher inventories of mobile contaminants could remain in the vadose, posing a more significant threat to groundwater than from the 216-B-46 Crib. 8. Generally received equivalent or greater contaminant inventory than 216-B-46 Crib. The 216-B-17 Crib received a higher inventory of uranium, supporting the need for groundwater protection. In general, the 216-B-17 Crib is analogous and roughly equivalent to the 216-B-46 Crib. Remedial actions are needed to address the same risks as those of the 216-B-46 Crib, specifically protection of groundwater and protection against human and ecological intrusion to shallow contaminants at the bottom of the waste site in the 0 to 4.6 m (0 to 15-ft) bgs zone.
216-B-18	The 216-B-18 Crib is a 3.0 x 3.0 x 0.9 m high (10 x 10 x 3 ft) structure constructed of wood, cinder block, and steel on a 1.5 m (5 ft) bed of gravel. Bottom dimensions of the crib are 12.2 x 12.2 m (40 x 40 ft).The waste site dimensions are 24 x 24 x 4 m deep (80 x 80 x 13 ft deep). The depth to the top of contamination is 3.4 m (11 ft). Located in the BC Cribs and Trenches Area and within the assembly of 216-B-14 through 216-B-19 Cribs.	Scavenged TBP Waste Stream Tank Farm/B, BX, BY: over a short period of time (one month) in 1956. The site received scavenged bismuth phosphate waste from URP process waste in the 221-U Building. The waste cascaded through the BY Tank Farm tanks before being discharged to the crib.	240 More than rep site (241)	10.0 Less than rep site (113)	41.5 More than rep site (32.4)	114 More than rep site (299)	81.8 Less than rep site (226)	5,000 More than rep site (0)	1,000,000 Similar to rep site (1,700,000)	8,520 More than rep site	17,670	0.48 Less than rep site	The 216-B-18 Crib is analogous to the 216-B-46 Crib as indicated by process history, contaminant inventory, effluent volume received, and expected nature and vertical extent of contamination: 1. Received the same waste stream as 216-B-46 Crib; therefore, the contaminant types are expected to be very similar. 2. Site construction is similar to 216-B-46 Crib; however, the 216-B-18 Crib is slightly larger than the 216-B-46 Crib. 3. Waste was received from the same source (221-U). 4. Both sites are located in 200 East Area; the geology of the two sites is similar. 5. The vertical extent of contamination is expected to be similar based on evidence from similar sites investigated (e.g., 216-B-43 through 216-B-50 Cribs). 6. Risks are expected to be similar to 216-B-46 Crib; however, because the top of the contamination is about 3.4 m (11 ft) bgs, human health and ecological risks are expected in the 0 to 4.6 m (0 to 15-ft) zone. 7. Comparison of contaminant inventories and effluent volume discharges for the 216-B-18 and 216-B-46 Cribs suggests that groundwater may be threatened at the 216-B-18 Crib. Because the ratio of effluent volume to soil pore volume is less for the 216-B-18 Crib, higher inventories of mobile contaminants could remain in the vadose, posing a more significant threat to groundwater than from the 216-B-46 Crib. 8. Generally received equivalent or greater contaminant inventory than 216-B-46 Crib, with the exception of Sr-90, supporting the need for groundwater protection. In general, the 216-B-18 Crib is analogous and roughly equivalent to the 216-B-46 Crib. Remedial actions are needed to address the same risks as those of the 216-B-46 Crib, specifically protection of groundwater and protection against human and ecological intrusion to shallow contaminants at the bottom of the waste site in the 0 to 4.6 m (0 to 15-ft) bgs zone.

Table 2-2. 200-TW-1 Operable Unit Representative Sites and Associated Analogous Waste Sites. (14 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site Discharge History (WIDS)	Contaminant Inventory (DOE/RL-96-81)							Effluent Volume (m^3)	Soil Pore Volume (m^3)	Eff Vol + Pore Vol	Rationale
			Total U (kg)	Total Pu (g)	Tc-99* (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)				
216-B-19	The 216-B-19 Crib is a 3.0 x 3.0 x 0.9 m high (10 x 10 x 3 ft) structure constructed of wood, cinder block, and steel on a 1.5 m (5 ft) bed of gravel. Bottom dimensions of the crib are 12.2 x 12.2 m (40 x 40 ft). The waste site dimensions are 24 x 24 x 4 m deep (80 x 80 x 13 ft deep). The depth to the top of contamination is 4 m (13 ft). Located in the BC Cribs and Trenches Area and within the assembly of 216-B-14 through 216-B-19 Cribs.	Scavenged TBP Waste Stream Tank Farm/B, BX, BY: 1957. The site received in-tank scavenged (first cycle) and scavenged bismuth phosphate waste from URP process waste in the 221-U Building. The waste cascaded through the BY Tank Farm tanks before being discharged to the crib.	180 Similar to rep site (177)	10.0 Less than rep site (83.9)	31.1 Similar to rep site (20.1)	126 More than rep site (223)	88.3 Less than rep site (159)	3,400 Similar to rep site (0)	1,500,000 Similar to rep site (1,110,000)	6,400 Similar to rep site	17,670	0.36 Less than rep site	The 216-B-19 Crib is analogous to the 216-B-46 Crib as indicated by process history, contaminant inventory, effluent volume received, and expected nature and vertical extent of contamination: 1. Received the same waste stream as 216-B-46 Crib; therefore, the contaminant types are expected to be very similar. 2. Site construction is similar to 216-B-46 Crib; however, the 216-B-19 Crib is slightly larger than the 216-B-46 Crib. 3. Waste was received from the same source (221-U). 4. Both sites are located in 200 East Area; the geology of the two sites is similar. 5. The vertical extent of contamination is expected to be similar based on evidence from similar sites investigated (e.g., 216-B-43 through 216-B-50 Cribs). 6. Risks are expected to be similar to 216-B-46 Crib; because the top of the contamination is about 4 m (13 ft) bgs, human health and ecological risks are expected in the 0 to 4.6 m (0 to 15-ft) zone. 7. Comparison of contaminant inventories and effluent volume discharges for the 216-B-19 and 216-B-46 Cribs suggests that groundwater may be threatened, similar to 216-B-46 Crib. Because the ratio of effluent volume to soil pore volume is less for the 216-B-19 Crib, higher inventories of mobile contaminants could remain in the vadose, posing a more significant threat to groundwater than from the 216-B-46 Crib. 8. Generally received equivalent contaminant inventory compared to 216-B-46 Crib, except less Sr-90. The 216-B-19 Crib received higher inventories of Cs-137 and a similar quantity of nitrate, supporting the need for groundwater protection and the possibility of even higher shallow zone and intruder risks than the 216-B-46 Crib. In general, the 216-B-19 Crib is analogous to the 216-B-46 Crib, with a potential for higher risk from the Cs-137 in the shallow zone and in the zone at the bottom of the crib structure. Remedial actions are needed to address the same risks as those of the 216-B-46 Crib, specifically protection of groundwater and protection against human and ecological intrusion to shallow contaminants at the bottom of the waste site in the 0 to 4.6 m (0 to 15-ft) bgs zone.
200-E-14	The 200-E-14 Siphon Tank is an underground tank designed to accumulate liquid waste from the BY Tank Farm and, when full, rapidly discharge it to selected cribs. Tank dimensions are 8.2 x 3.9 x 2.8 m high (27 x 12.75 x 9.5 ft high). The depth to the top of the tank is 2.1 m (7 ft); however, the tank vent is only 0.6 m (2 ft) below current ground level. Located in the BC Cribs and Trenches Area and within the assembly of 216-B-14 through 216-B-19 Cribs.	Scavenged TBP Waste Stream Tank Farm/BY: 1956-1958. The tank received tank farm and scavenged bismuth phosphate solvent extraction waste from the URP process waste in the 221-U Building. The tank discharged waste to the 216-B-14 through 216-B-19 Cribs	1.5 less than rep site	0.075 less than rep site	-	1.9 less than rep site	2.0 less than rep site	24 less than rep site	7,600 less than rep site	<42 Less than rep site	N/A	N/A	The 200-E-14 Siphon Tank is analogous to the 216-B-46 Crib as indicated by waste stream chemistry and expected distribution of contamination. Radioactive waste from the BY Tank Farm was received by this tank for routing to the 216-B-14 through 216-B-19 Cribs. The volume in the tank is unknown but is less than 3,825 L (1,010 gal) of sludge, based on the low liquid level where flushing action of the tank would stop, and 41,900 L (11,060 gal) of liquid, based on the high liquid level where tank flushing action would commence: 1. Received the same waste stream as 216-B-46 Crib; therefore, the contaminant types are expected to be very similar. 2. Site construction is not similar to 216-B-46 Crib in that it was not designed as an unlined near-surface liquid disposal site; instead it was intended to be an accumulation tank for liquid before its transfer to the cribs. 3. Waste was received from the same source (221-U). 4. Both sites are located in 200 East Area; the geology of the two sites is similar. 5. The vertical extent of contamination is expected to be considerably less, because there is no evidence of tank leakage. 6. Risks are expected to be much less than for 216-B-46 Crib; because the bottom of the tank is approximately4.9 m (16 ft) bgs, human health and ecological risks may exist in the 0 to 4.6 m (0 to 15-ft) zone where leaks may have occurred. 7. Groundwater threat is not expected for this tank, because the tank was designed to transfer effluents to the cribs and not to allow infiltration to the soil column; no leaks have been documented. 8. Generally received lesser contaminant inventory than 216-B-46 Crib. In general, the 200-E-14 Siphon Tank is bounded by the 216-B-46 Crib, with a potential for low risk to human and ecological receptors from near-surface contamination.

Table 2-2. 200-TW-1 Operable Unit Representative Sites and Associated Analogous Waste Sites. (14 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site Discharge History (WIDS)	Contaminant Inventory (DOE/RL-96-81)							Effluent Volume (m^3)	Soil Pore Volume (m^3)	Eff Vol + Pore Vol	Rationale
			Total U (kg)	Total Pu (g)	Tc-99* (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)				
216-B-21	The 216-B-21 Trench is a backfilled unlined ditch. Waste site dimensions are 153 x 3 x 4 m deep (500 x 10 x 13 ft deep). The depth to the top of contamination is 3.7 m (12 ft). Located in the BC Cribs and Trenches Area and within the assembly of 216-B-20 through 216-B-22 Trenches.	Scavenged TBP Waste Stream Tank Farm/B, BX, BY: 1956. The site received scavenged bismuth phosphate waste from URP process waste in the 221-U Building. The waste cascaded through the BY Tank Farm tanks before being discharged to the trench.	680 More than rep site (132)	10.3 Less than rep site (61.7)	22.7 Less than rep site (17.1)	169 More than rep site (164)	318 Less than rep site (123)	- (0)	- (907,000)	4,670 Less than rep site	13,950	0.34 Less than rep site	The 216-B-21 Trench is analogous to the 216-B-26 Trench as indicated by process history, contaminant inventory, effluent volume received, and expected nature and vertical extent of contamination: 1. Received the same waste stream as 216-B-26 Trench; therefore, the contaminant types are expected to be very similar 2. Site construction is identical to the 216-B-26 Trench 3. Waste was received from the same source (221-U) 4. Both sites are located in the BC Cribs and Trenches Area; the geology of the two sites is similar 5. The vertical extent of contamination is expected to be similar based on similar contaminant inventories and fraction of soil porosity column predicted to be consumed by effluent. 6. Risks are expected to be similar to 216-B-26 Trench; because the top of the contamination is about 3.7 m (12 ft) bgs, human health and ecological risks are expected in the 0 to 4.6 m (0 to 15-ft) zone. 7. Comparison of contaminant inventories and effluent volume discharges for the 216-B-26 and 216-B-20 Trenches suggests that groundwater may be threatened, similar to 216-B-26 Trench. Because the ratio of effluent volume to soil pore volume is less for the 216-B-21 Trench, residual mobile contaminants may not be as deep as at the 216-B-26 Trench. 8. Generally received less contaminant inventory than 216-B-26 Trench. In general, the 216-B-21 Trench is analogous to the 216-B-26 Trench, with a potential for lesser risk from the Cs-137 in the shallow zone and in the zone at the bottom of the trench structure, and higher risk from uranium in the deeper vadose soil. Remedial actions are needed to address the same risks as those of the 216-B-26 Trench, specifically protection of groundwater and protection against human and ecological intrusion to shallow contaminants at the bottom of the waste site in the 0 to 4.6 m (0 to 15-ft) bgs zone.
216-B-22	The 216-B-22 Trench is a backfilled unlined ditch. Waste site dimensions are 153 x 3 x 4 m deep (500 x 10 x 13 ft deep). The depth to the top of contamination is 3.7 m (12 ft). Located in the BC Cribs and Trenches Area and within the assembly of 216-B-20 through 216-B-22 Trenches.	Scavenged TBP Waste Stream Tank Farm/B, BX, BY: 1956. The site received scavenged bismuth phosphate waste from URP process waste in the 221-U Building. The waste cascaded through the BY Tank Farm tanks before being discharged to the trench.	320 More than rep site (133)	2.6 Less than rep site (62.7)	23.1 Less than rep site (16.3)	20.5 Less than rep site (166)	176 Less than rep site (122)	2,500 Less than rep site (0)	900,000 Less than rep site (880,000)	4,740 Less than rep site	13,800	0.34 Less than rep site	The 216-B-22 Trench is analogous to the 216-B-26 Trench as indicated by process history, contaminant inventory, effluent volume received, and expected nature and vertical extent of contamination: 1. Received the same waste stream as 216-B-26 Trench; therefore, the contaminant types are expected to be very similar 2. Site construction is identical to 216-B-26 Trench 3. Waste was received from the same source (221-U) 4. Both sites are located in 200 East Area; the geology of the two sites is similar. 5. The vertical extent of contamination is expected to be similar based on similar contaminant inventories and fraction of soil porosity column predicted to be consumed by effluent. 6. Risks are expected to be similar to 216-B-26 Trench; because the top of the contamination is about 3.7 m (12 ft) bgs, human health and ecological risks are expected in the 0 to 4.6 m (0 to 15-ft) zone. 7. Comparison of contaminant inventories and effluent volume discharges for the 216-B-26 and 216-B-22 Trenches suggests that groundwater may be threatened, similar to 216-B-26 Trench. Because the ratio of effluent volume to soil pore volume is less for the 216-B-22 Trench, residual mobile contaminants may not be as deep as at the 216-B-26 Trench. 8. Generally received less contaminant inventory than 216-B-26 Trench. In general, the 216-B-22 Trench is analogous to the 216-B-26 Trench. Remedial actions are needed to address the same risks as those of the 216-B-26 Trench, specifically protection of groundwater and protection against human and ecological intrusion to shallow contaminants at the bottom of the waste site in the 0 to 4.6 m (0 to 15-ft) bgs zone.

Table 2-2. 200-TW-1 Operable Unit Representative Sites and Associated Analogous Waste Sites. (14 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site Discharge History (WIDS)	Contaminant Inventory (DOE/RL-96-81)							Effluent Volume (m^3)	Soil Pore Volume (m^3)	Eff Vol + Pore Vol	Rationale
			Total U (kg)	Total Pu (g)	Tc-99* (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)				
216-B-23	The 216-B-23 Trench is a backfilled unlined ditch. Waste site dimensions are 153 x 3 x 5.4 m deep (500 x 10 x 18 ft deep). Includes 2.4 m (8 ft) of overburden. The depth to the top of contamination is 3.7 m (12 ft). Located in the BC Cribs and Trenches Area and within the assembly of 216-B-23 through 216-B-28 and 216-B-52 Trenches.	Scavenged TBP Waste Stream Tank Farm/B, BX, BY: 1956. The site received scavenged bismuth phosphate waste from URP process waste in the 221-U Building. The waste cascaded through the BY Tank Farm tanks before being discharged to the trench.	160 Similar to rep site (127)	1.8 Less than rep site (59.7)	22.0 Less than rep site (15.5)	50.9 Less than rep site (159)	62.5 Less than rep site (116)	2,400 Less than rep site (0)	1,000,000 Similar to rep site (838,000)	4,520 Less than rep site	13,390	0.34 Less than rep site	The 216-B-23 Trench is analogous to the 216-B-26 Trench as indicated by process history, contaminant inventory, effluent volume received, and expected nature and vertical extent of contamination: 1. Received the same waste stream as 216-B-26 Trench; therefore, the contaminant types are expected to be very similar 2. Site construction is identical to 216-B-26 Trench 3. Waste was received from the same source (221-U) 4. Both sites are located in the BC Cribs and Trenches Area; the geology of the two sites is similar. 5. The vertical extent of contamination is expected to be similar based on similar fraction of soil porosity column predicted to be consumed by effluent. 6. Risks are expected to be similar to 216-B-26 Trench; because the top of the contamination is about 3.7 m (12 ft) bgs, human health and ecological risks are anticipated in the 0 to 4.6 m (0 to 15-ft) zone;. 7. Comparison of contaminant inventories and effluent volume discharges for the 216-B-26 and 216-B-23 Trenches suggests that groundwater may be threatened, similar to 216-B-26 Trench. Because the ratio of effluent volume to soil pore volume is less for the 216-B-23 Trench, residual mobile contaminants may not be as deep as at the 216-B-26 Trench.8. Generally received less contaminant inventory than 216-B-26 Trench. Even so, the need for groundwater protection and the possibility of shallow zone intrusion risks exists. In general, the 216-B-23 Trench is analogous to the 216-B-26 Trench, with a potential for reduced risk in the shallow zone and in the zone at the bottom of the trench structure, and reduced risk in the deeper vadose soil. Remedial actions are needed to address the same risks as those of the 216-B-26 Trench, specifically protection of groundwater and protection against human and ecological intrusion to shallow contaminants at the bottom of the waste site in the 0 to 4.6 m (0 to 15-ft) bgs zone.
216-B-24	The 216-B-24 Trench is a backfilled unlined ditch. Waste site dimensions are 153 x 3 x 5.4 m deep (500 x 10 x 18 ft deep). Includes 2.4 m (8 ft) of overburden. The depth to the top of contamination is 3.7 m (12 ft). Located in the BC Cribs and Trenches Area and within the assembly of 216-B-23 through 216-B-28 and 216-B-52 Trenches.	Scavenged TBP Waste Stream Tank Farm/B, BX, BY: 1956. The site received scavenged bismuth phosphate waste from URP process waste in the 221-U Building. The waste cascaded through the BY Tank Farm tanks before being discharged to the trench.	250 More than rep site (138)	77.0 More than rep site (64.4)	22.9 Less than rep site (18.5)	58.6 Less than rep site (171)	78.1 Less than rep site (130)	2,500 Less than rep site (0)	600,000 Less than rep site (970,000)	4,700 Less than rep site	13,670	0.34 Less than rep site	The 216-B-24 Trench is analogous to the 216-B-26 Trench as indicated by process history, contaminant inventory, effluent volume received, and expected nature and vertical extent of contamination: 1. Received the same waste stream as 216-B-26 Trench; therefore, the contaminant types are expected to be very similar. 2. Site construction is identical to 216-B-46 Crib. 3. Waste was received from the same source (221-U). 4. Both sites are located in the BC Cribs and Trenches Area; the geology of the two sites is similar. 5. The vertical extent of contamination is expected to be similar based on similar fraction of soil porosity column predicted to be consumed by effluent. 6. Risks are expected to be similar to 216-B-26 Trench; because the top of the contamination is about 3.7 m (12 ft) bgs, human health and ecological risks are expected in the 0 to 4.6 m (0 to 15-ft) zone. 7. Comparison of contaminant inventories and effluent volume discharges for the 216-B-26 and 216-B-24 Trenches suggests that groundwater may be threatened, similar to 216-B-26 Trench. Because the ratio of effluent volume to soil pore volume is less for the 216-B-24 Trench, residual mobile contaminants may not be as deep as at the 216-B-26 Trench. 8. Generally received less contaminant inventory than 216-B-26 Trench. In general, the 216-B-24 Trench is analogous to the 216-B26 Trench, with a potential for reduced risk in the shallow zone and in the zone at the bottom of the trench structure, and reduced risk in the deeper vadose soil. Remedial actions are needed to address the same risks as those of the 216-B-26 Trench, specifically protection of groundwater and protection against human and ecological intrusion to shallow contaminants at the bottom of the waste site in the 0 to 4.6 m (0 to 15-ft) bgs zone..

Table 2-2. 200-TW-1 Operable Unit Representative Sites and Associated Analogous Waste Sites. (14 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site Discharge History (WIDS)	Contaminant Inventory (DOE/RL-96-81)							Effluent Volume (m^3)	Soil Pore Volume (m^3)	Eff Vol + Pore Vol	Rationale
			Total U (kg)	Total Pu (g)	Tc-99* (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)				
216-B-25	The 216-B-25 Trench is a backfilled unlined ditch. Waste site dimensions are 153 x 3 x 6.2 m deep (500 x 10 x 20 ft deep). Includes 3 m (10 ft) of overburden. The depth to the top of contamination is 3.7 m (12 ft). Located in the BC Cribs and Trenches Area and within the assembly of 216-B-23 through 216-B-28 and 216-B-52 Trenches.	Scavenged TBP Waste Stream Tank Farm/B, BX, BY: 1956. The site received scavenged bismuth phosphate waste from URP process waste in the 221-U Building. The waste cascaded through the BY Tank Farm tanks before being discharged to the trench.	150 Less than rep site (139)	2.0 Less than rep site (64.9)	18.3 Less than rep site (18.7)	25.5 Less than rep site (172)	88.3 Less than rep site (131)	2,000 Less than rep site (0)	500,000 Less than rep site (978,000)	3,760 Less than rep site	13,260	0.28 Less than rep site	The 216-B-25 Trench is analogous to the 216-B-26 Trench as indicated by process history, contaminant inventory, effluent volume received, and expected nature and vertical extent of contamination: 1. Received the same waste stream as 216-B-26 Trench; therefore, the contaminant types are expected to be very similar. 2. Site construction is identical to 216-B-26 Trench. 3. Waste was received from the same source (221-U). 4. Both sites are located in the BC Cribs and Trenches Area; the geology of the two sites is similar. 5. The vertical extent of contamination is expected to be similar based on similar fraction of soil porosity column predicted to be consumed by effluent. 6. Risks are expected to be similar to 216-B-26 Trench; because the top of the contamination is about 3.7 m (12 ft) bgs, human health and ecological risks are expected in the 0 to 4.6 m (0 to 15-ft) zone. 7. Comparison of contaminant inventories and effluent volume discharges for the 216-B-26 and 216-B-25 Trenches suggests that groundwater may be threatened, similar to 216-B-26 Trench. Because the ratio of effluent volume to soil pore volume is less for the 216-B-25 Trench, residual mobile contaminants may not be as deep as at the 216-B-26 Trench. 8. Generally received less contaminant inventory than 216-B-26 Trench. In general, the 216-B-25 Trench is analogous to the 216-B-26 Trench, with a potential for reduced risk in the shallow zone and in the zone at the bottom of the trench structure, and reduced risk in the deeper vadose soil. Remedial actions are needed to address the same risks as those of the 216-B-26 Trench, specifically protection of groundwater and protection against human and ecological intrusion to shallow contaminants at the bottom of the waste site in the 0 to 4.6 m (0 to 15-ft) bgs zone.
216-B-27	The 216-B-27 Trench is a backfilled unlined ditch. Waste site dimensions are 153 3 x 5.4 m deep (500 x 10 x 18 ft deep). Includes 2.4 m (8 ft) of overburden. The depth to the top of contamination is 3.7 m (12 ft). Located in the BC Cribs and Trenches Area and within the assembly of 216-B-23 through 216-B-28 and 216-B-52 Trenches.	Scavenged TBP Waste Stream Tank Farm/B, BX, BY: 1957. The site received scavenged bismuth phosphate waste from URP process waste in the 221-U Building. The waste cascaded through the BY Tank Farm tanks before being discharged to the trench.	340 More than rep site (125)	0.7 Less than rep site (74.5)	21.5 Less than rep site (16.8)	15.8 Less than rep site (155)	263 Less than rep site (118)	2,300 Less than rep site (0)	600,000 Less than rep site (881,000)	4,420 Less than rep site	13,390	0.33 Less than rep site	The 216-B-27 Trench is analogous to the 216-B-26 Trench as indicated by process history, contaminant inventory, effluent volume received, and expected nature and vertical extent of contamination: 1. Received the same waste stream as 216-B-26 Trench; therefore, the contaminant types are expected to be very similar 2. Site construction is identical to 216-B-26 Trench. 3. Waste was received from the same source (221-U). 4. Both sites are located in 200 East Area; the geology of the two sites is similar. 5. The vertical extent of contamination is expected to be similar based on similar fraction of soil porosity column predicted to be consumed by effluent.. 6. Risks are expected to be similar to 216-B-26 Trench; because the top of the contamination is about 3.7 m (12 ft) bgs, human health and ecological risks are expected in the 0 to 4.6 m (0 to 15-ft) zone. 7. Comparison of contaminant inventories and effluent volume discharges for the 216-B-26 and 216-B-27 Trenches suggests that groundwater may be threatened, similar to 216-B-26 Trench. Because the ratio of effluent volume to soil pore volume is less for the 216-B-27 Trench, residual mobile contaminants may not be as deep as at the 216-B-26 Trench. 8. Generally received equivalent or lesser contaminant inventory than 216-B-26 Trench. In general, the 216-B-27 Trench is analogous to the 216-B-26 Trench. Remedial actions are needed to address the same risks as those of the 216-B-26 Trench, specifically protection of groundwater and protection against human and ecological intrusion to shallow contaminants at the bottom of the waste site in the 0 to 4.6 m (0 to 15-ft) bgs zone.
216-B-28	The 216-B-28 Trench is a backfilled unlined ditch. Waste site dimensions are 153 x 3 x 3 m deep (500 x 10 x 10 ft deep). The depth to the top of contamination is 3.7 m (12 ft). Located in the BC Cribs and Trenches Area and within the assembly of 216-B-23 through 216-B-28 and 216-B-52 Trenches.	Scavenged TBP Waste Stream Tank Farm/B, BX, BY: 1957. The site received scavenged bismuth phosphate waste from URP process waste in the 221-U Building. The waste cascaded through the BY Tank Farm tanks before being discharged to the trench.	300 More than rep site (142)	5.6 Less than rep site (66.7)	24.6 Less than rep site (17.6)	10.7 Less than rep site (177)	49.5 Less than rep site (130)	2,700 Less than rep site (0)	1,000,000 Similar to rep site (946,000)	5,050 Less than rep site	13,530	0.37 Less than rep site	The 216-B-28 Trench is analogous to the 216-B-26 Trench as indicated by process history, contaminant inventory, effluent volume received, and expected nature and vertical extent of contamination: 1. Received the same waste stream as 216-B-26 Trench; therefore, the contaminant types are expected to be very similar. 2. Site construction is identical to 216-B-26 Trench. 3. Waste was received from the same source (221-U). 4. Both sites are located in the BC Cribs and Trenches Area; the geology of the two sites is similar. 5. The vertical extent of contamination is expected to be similar based on similar fraction of soil porosity column predicted to be consumed by effluent. 6. Risks are expected to be similar to 216-B-26 Trench; because the top of the contamination is about 3.7 m (12 ft) bgs, human health and ecological risks are expected in the 0 to 4.6 m (0 to 15-ft) zone. 7. Comparison of contaminant inventories and effluent volume discharges for the 216-B-26 and 216-B-28 Trenches suggests that groundwater may be threatened, similar to 216-B-26 Trench. Because the ratio of effluent volume to soil pore volume is less for the 216-B-28 Trench, residual mobile contaminants may not be as deep as at the 216-B-26 Trench. 8. Generally received lesser contaminant inventory than 216-B-26 Trench, except for nitrate. In general, the 216-B-28 Trench is analogous to the 216-B-26 Trench. Remedial actions are needed to address the same risks as those of the 216-B-26 Trench, specifically protection of groundwater and protection against human and ecological intrusion to shallow contaminants at the bottom of the waste site in the 0 to 4.6 m (0 to 15-ft) bgs zone.

Table 2-2. 200-TW-1 Operable Unit Representative Sites and Associated Analogous Waste Sites. (14 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site Discharge History (WIDS)	Contaminant Inventory (DOE/RL-96-81)							Effluent Volume (m^3)	Soil Pore Volume (m^3)	Eff Vol + Pore Vol	Rationale
			Total U (kg)	Total Pu (g)	Tc-99* (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)				
216-B-29	The 216-B-29 Trench is a backfilled unlined ditch. Waste site dimensions are 153 x 3 x 3 m deep (500 x 10 x 13 ft deep). The depth to the top of contamination is 3.7 m (12 ft). Located in the BC Cribs and Trenches Area and within the assembly of 216-B-28 through 216-B-34 Trenches.	Scavenged TBP Waste Stream Tank Farm/B, BX, BY: 1957. The site received scavenged bismuth phosphate waste from URP process waste in the 221-U Building. The waste cascaded through the BY Tank Farm tanks before being discharged to the trench.	340 More than rep site (140)	1.1 Less than rep site (63.8)	23.6 Less than rep site (18.3)	27.4 Less than rep site (170)	84.8 Less than rep site (249)	2,600 Less than rep site (0)	700,000 Less than rep site (962,000)	4,840 Less than rep site	13,530	0.36 Less than rep site	The 216-B-29 Trench is analogous to the 216-B-26 Trench as indicated by process history, contaminant inventory, effluent volume received, and expected nature and vertical extent of contamination: 1. Received the same waste stream as 216-B-26 Trench; therefore, the contaminant types are expected to be very similar. 2. Site construction is identical to 216-B-26 Trench. 3. Waste was received from the same source (221-U). 4. Both sites are located in the BC Cribs and Trenches Area; the geology of the two sites is similar. 5. The vertical extent of contamination is expected to be similar based on similar fraction of soil porosity column predicted to be consumed by effluent. 6. Risks are expected to be similar to 216-B-26 Trench; because the top of the contamination is about 3.7 m (12 ft) bgs, human health and ecological risks are expected in the 0 to 4.6 m (0 to 15-ft) zone. 7. Comparison of contaminant inventories and effluent volume discharges for the 216-B-26 and 216-B-29 Trenches suggests that groundwater may be threatened, similar to 216-B-26 Trench. Because the ratio of effluent volume to soil pore volume is less for the 216-B-29 Trench, residual mobile contaminants may not be as deep as at the 216-B-26 Trench. 8. Generally received equivalent or lesser contaminant inventory than 216-B-26 Trench. In general, the 216-B-29 Trench is analogous to the 216-B-26 Trench. Remedial actions are needed to address the same risks as those of the 216-B-26 Trench, specifically protection of groundwater and protection against human and ecological intrusion to shallow contaminants at the bottom of the waste site in the 0 to 4.6 m (0 to 15-ft) bgs zone
216-B-30	The 216-B-30 Trench is a backfilled unlined ditch. Waste site dimensions are 153 x 3 x 3 m deep (500 x 10 x 13 ft deep). The depth to the top of contamination is 3.7 m (12 ft). Located in the BC Cribs and Trenches Area and within the assembly of 216-B-28 through 216-B-34 Trenches.	Scavenged TBP Waste Stream Tank Farm/B, BX, BY: 1957. The site received scavenged bismuth phosphate waste from URP process waste in the 221-U Building. The waste cascaded through the BY Tank Farm tanks before being discharged to the trench.	88.0 Less than rep site (133)	2.1 Less than rep site (63.2)	23.3 Less than rep site (15.0)	1,570 More than rep site (168)	265 Less than rep site (119)	2,500 Less than rep site (0)	1,100,000 Similar to rep site (832,000)	4,780 Less than rep site	13,530	0.35 Less than rep site	The 216-B-30 Trench is analogous to the 216-B-26 Trench as indicated by process history, contaminant inventory, effluent volume received, and expected nature and vertical extent of contamination: 1. Received the same waste stream as 216-B-26 Trench; therefore, the contaminant types are expected to be very similar 2. Site construction is identical to the 216-B-46 Crib 3. Waste was received from the same source (221-U) 4. Both sites are located in the BC Cribs and Trenches Area; the geology of the two sites is similar 5. The vertical extent of contamination is expected to be similar based on similar fraction of soil porosity column predicted to be consumed by effluent. 6. Risks are expected to be similar to 216-B-26 Trench; because the top of the contamination is about 3.7 m (12 ft) bgs, human health and ecological risks are expected in the 0 to 4.6 m (0 to 15-ft) zone. 7. Comparison of contaminant inventories and effluent volume discharges for the 216-B-26 and 216-B-30 Trenches suggests that groundwater may be threatened, similar to 216-B-26 Trench. Because the ratio of effluent volume to soil pore volume is less for the 216-B-30 Trench, residual mobile contaminants may not be as deep as at the 216-B-26 Trench. 8. Generally received lesser contaminant inventory than 216-B-26 Trench except for considerably higher inventory of Cs-137, supporting the need for human and ecological intrusion protection. In general, the 216-B-30 Trench is analogous to the 216-B-26 Trench. 26 Trench. Remedial actions are needed to address the same risks as those of the 216-B-26 Trench, specifically protection of groundwater and protection against human and ecological intrusion to shallow contaminants at the bottom of the waste site in the 0 to 4.6 m (0 to 15-ft) bgs zone

Table 2-2. 200-TW-1 Operable Unit Representative Sites and Associated Analogous Waste Sites. (14 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site Discharge History (WIDS)	Contaminant Inventory (DOE/RL-96-81)							Effluent Volume (m^3)	Soil Pore Volume (m^3)	Eff Vol + Pore Vol	Rationale
			Total U (kg)	Total Pu (g)	Tc-99* (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)				
216-B-31	The 216-B-31 Trench is a backfilled unlined ditch. Waste site dimensions are 153 x 3 x 3 m deep (500 x 10 x 13 ft deep). The depth to the top of contamination is 4 m (13 ft). Located in the BC Cribs and Trenches Area and within the assembly of 216-B-28 through 216-B-34 Trenches.	Scavenged TBP Waste Stream Tank Farm/B, BX, BY: 1957. The site received scavenged bismuth phosphate waste from URP process waste in the 221-U Building. The waste cascaded through the BY Tank Farm tanks before being discharged to the trench.	120 Less than rep site (135)	- (64.1)	23.1 Less than rep site (15.2)	10.6 (HNF-1744) Less than rep site (170)	74.5 (HNF-1744) Less than rep site (121)	2,500 Less than rep site (0)	1,100,000 Similar to rep site (821,000)	4,740 Less than rep site	13,530	0.35 Less than rep site	The 216-B-31 Trench is analogous to the 216-B-26 Trench as indicated by process history, contaminant inventory, effluent volume received, and expected nature and vertical extent of contamination: 1. Received the same waste stream as 216-B-26 Trench; therefore, the contaminant types are expected to be very similar. 2. Site construction is identical to the 216-B-26 Trench. 3. Waste was received from the same source (221-U). 4. Both sites are located in the BC Cribs and Trenches Area; the geology of the two sites is similar. 5. The vertical extent of contamination is expected to be similar based on similar fraction of soil porosity column predicted to be consumed by effluent. 6. Risks are expected to be similar to 216-B-26 Trench b; because the top of the contamination is about 4 m (13 ft) bgs, human health and ecological risks are expected in the 0 to 4.6 m (0 to 15-ft) zone. 7. Comparison of contaminant inventories and effluent volume discharges for the 216-B-26 and 216-B-31 Trenches suggests that groundwater may be threatened, similar to 216-B-26 Trench. Because the ratio of effluent volume to soil pore volume is less for the 216-B-31 Trench, residual mobile contaminants may not be as deep as at the 216-B-26 Trench. 8. Generally received lesser contaminant inventory than 216-B-26 Trench except for nitrate. In general, the 216-B-31 Trench is analogous to the 216-B-26 Trench. Remedial actions are needed to address the same risks as those of the 216-B-26 Trench, specifically protection of groundwater and protection against human and ecological intrusion to shallow contaminants at the bottom of the waste site in the 0 to 4.6 m (0 to 15-ft) bgs zone
216-B-32	The 216-B-32 Trench is a backfilled unlined ditch. Waste site dimensions are 153 x 3 x 3 m deep (500 x 10 x 13 ft deep). The depth to the top of contamination is 4 m (13 ft). Located in the BC Cribs and Trenches Area and within the assembly of 216-B-28 through 216-B-34 Trenches.	Scavenged TBP Waste Stream Tank Farm/B, BX, BY: 1957. The site received scavenged bismuth phosphate waste from URP process waste in the 221-U Building. The waste cascaded through the BY Tank Farm tanks before being discharged to the trench.	11.0 Less than rep site (134)	2.6 Less than rep site (64.5)	23.2 Less than rep site (14.2)	58.6 Less than rep site (167)	113 Less than rep site (170)	2,500 Less than rep site (0)	1,000,000 Similar to rep site (799,000)	4,770 Less than rep site	13,530	0.35 Less than rep site	The 216-B-32 Trench is analogous to the 216-B-26 Trench as indicated by process history, contaminant inventory, effluent volume received, and expected nature and vertical extent of contamination: 1. Received the same waste stream as 216-B-26 Trench; therefore, the contaminant types are expected to be very similar. 2. Site construction is similar to the 216-B-26 Trench. 3. Waste was received from the same source (221-U). 4. Both sites are located in the BC Cribs and Trenches Area; the geology of the two sites is similar. 5. The vertical extent of contamination is expected to be similar based on similar fraction of soil porosity column predicted to be consumed by effluent. 6. Risks are expected to be similar to 216-B-26 Trench; because the top of the contamination is about 4.0 m (13 ft) bgs, human health and ecological risks are expected in the 0 to 4.6 m (0 to 15-ft) zone. 7. Comparison of contaminant inventories and effluent volume discharges for the 216-B-26 and 216-B-32 Trenches suggests that groundwater may be threatened, similar to 216-B-26 Trench. Because the ratio of effluent volume to soil pore volume is less for the 216-B-32 Trench, residual mobile contaminants may not be as deep as at the 216-B-26 Trench. 8. Generally received lesser contaminant inventory than 216-B-26 Trench except for nitrate. In general, the 216-B-32 Trench is analogous to the 216-B-26 Trench. Remedial actions are needed to address the same risks as those of the 216-B-26 Trench, specifically protection of groundwater and protection against human and ecological intrusion to shallow contaminants at the bottom of the waste site in the 0 to 4.6 m (0 to 15-ft) bgs zone

Table 2-2. 200-TW-1 Operable Unit Representative Sites and Associated Analogous Waste Sites. (14 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site Discharge History (WIDS)	Contaminant Inventory (DOE/RL-96-81)							Effluent Volume (m^3)	Soil Pore Volume (m^3)	Eff Vol + Pore Vol	Rationale
			Total U (kg)	Total Pu (g)	Tc-99* (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)				
216-B-33	The 216-B-33 Trench is a backfilled unlined ditch. Waste site dimensions are 153 x 3 x 3 m deep (500 x 10 x 13 ft deep). The depth to the top of contamination is 4 m (13 ft). Located in the BC Cribs and Trenches Area and within the assembly of 216-B-28 through 216-B-34 Trenches.	Scavenged TBP Waste Stream Tank Farm/B, BX, BY: 1957. The site received scavenged bismuth phosphate waste from URP process waste in the 221-U Building. The waste cascaded through the BY Tank Farm tanks before being discharged to the trench.	20 Less than rep site (137)	11.8 Less than rep site (62.7)	23.1 Less than rep site (14.2)	127 More than rep site (167)	18.1 Less than rep site (170)	2,500 Less than rep site (0)	1,700,000 More than rep site (799,000)	4,740 Less than rep site	13,530	0.35 Less than rep site	The 216-B-33 Trench is analogous to the 216-B-26 Trench as indicated by process history, contaminant inventory, effluent volume received, and expected nature and vertical extent of contamination: 1. Received the same waste stream as 216-B-26 Trench; therefore, the contaminant types are expected to be very similar. 2. Site construction is identical to the 216-B-46 Crib. 3. Waste was received from the same source (221-U). 4. Both sites are located in the BC Cribs and Trenches Area; the geology of the two sites is similar. 5. The vertical extent of contamination is expected to be similar based on similar fraction of soil porosity column predicted to be consumed by effluent. 6. Risks are expected to be similar to 216-B-26 Trench; because the top of the contamination is about 4.0 m (13 ft) bgs, human health and ecological risks are expected in the 0 to 4.6 m (0 to 15-ft) zone. 7. Comparison of contaminant inventories and effluent volume discharges for the 216-B-26 and 216-B-33 Trenches suggests that groundwater may be threatened, similar to 216-B-26 Trench. Because the ratio of effluent volume to soil pore volume is less for the 216-B-33 Trench, residual mobile contaminants may not be as deep as at the 216-B-26 Trench. 8. Generally received lesser contaminant inventory of mobile constituents than 216-B-26 Trench except for nitrate. In general, the 216-B-33 Trench is analogous to the 216-B-26 Trench. Remedial actions are needed to address the same risks as those of the 216-B-26 Trench, specifically protection of groundwater and protection against human and ecological intrusion to shallow contaminants at the bottom of the waste site in the 0 to 4.6 m (0 to 15-ft) bgs zone
216-B-34	The 216-B-34 Trench is a backfilled unlined ditch. Waste site dimensions are 153 x 3 x 3 m deep (500 x 10 x 13 ft deep). The depth to the top of contamination is 4 m (13 ft). Located in the BC Cribs and Trenches Area and within the assembly of 216-B-28 through 216-B-34 Trenches.	Scavenged TBP Waste Stream Tank Farm/B, BX, BY: 1957. The site received scavenged bismuth phosphate waste from URP process waste in the 221-U Building. The waste cascaded through the BY Tank Farm tanks before being discharged to the trench.	85.0 Less than rep site (137)	5.7 Less than rep site (64.5)	23.7 Less than rep site (14.5)	7.9 Less than rep site 171)	18.1 Less than rep site (166)	2,600 Less than rep site (0)	1,900,000 More than rep site (818,000)	4,870 Less than rep site	13,530	0.36 Less than rep site	The 216-B-34 Trench is analogous to the 216-B-26 Trench as indicated by process history, contaminant inventory, effluent volume received, and expected nature and vertical extent of contamination: 1. Received the same waste stream as 216-B-26 Trench; therefore, the contaminant types are expected to be very similar. 2. Site construction is identical to the 216-B-26 Trench. 3. Waste was received from the same source (221-U). 4. Both sites are located in the BC Cribs and Trenches Area; the geology of the two sites is similar. 5. The vertical extent of contamination is expected to be similar fraction of soil porosity column predicted to be consumed by effluent. 6. Risks are expected to be similar to 216-B-26 Trench; because the top of the contamination is about 4.0 m (13 ft) bgs, human health and ecological risks are expected in the 0 to 4.6 m (0 to 15-ft) zone; risks to intruders may be associated with high contamination at the bottom of the waste site as evidenced by similar risk at 216-B-26 Trench.. 7. Comparison of contaminant inventories and effluent volume discharges for the 216-B-26 and 216-B-34 Trenches suggests that groundwater may be threatened, similar to 216-B-26 Trench. Because the ratio of effluent volume to soil pore volume is less for the 216-B-34 Trench, residual mobile contaminants may not be as deep as at the 216-B-26 Trench. 8. Generally received lesser contaminant inventory than 216-B-26 Trench except for nitrate. In general, the 216-B-34 Trench is analogous to the 216-B-26 Trench. Remedial actions are needed to address the same risks as those of the 216-B-26 Trench, specifically protection of groundwater and protection against human and ecological intrusion to shallow contaminants at the bottom of the waste site in the 0 to 4.6 m (0 to 15-ft) bgs zone

Table 2-2. 200-TW-1 Operable Unit Representative Sites and Associated Analogous Waste Sites. (14 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site Discharge History (WIDS)	Contaminant Inventory (DOE/RL-96-81)							Effluent Volume (m^3)	Soil Pore Volume (m^3)	Eff Vol + Pore Vol	Rationale
			Total U (kg)	Total Pu (g)	Tc-99* (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)				
216-B-52	The 216-B-52 Trench is a backfilled unlined ditch. Waste site dimensions are 177 x 3 x 3 m deep (580 x 10 x 10 ft deep). The depth to the top of contamination is 3.7 m (12 ft). Located in the BC Cribs and Trenches Area and within the assembly of 216-B-23 through 216-B-28 and 216-B-52 Trenches.	In-Tank Scavenged Waste Stream Tank Farm/B, BX, BY: 1957-1958. The site received scavenged bismuth phosphate waste from URP process waste in the 221-U Building. The waste cascaded through the BY Tank Farm tanks before being discharged to the trench.	30.0 Less than rep site (242)	19.0 Similar to rep site (113)	41.5 More than rep site (26.1)	160 More than rep site (299)	4.92 Less than rep site (387)	5,000 More than rep site (0)	2,100,000 More than rep site (1,460,000)	8,530 More than rep site	15,710	0.54 Similar to rep site	The 216-B-52 Trench is analogous to the 216-B-26 Trench as indicated by process history, contaminant inventory, effluent volume received, and expected nature and vertical extent of contamination: 1. Received the same waste stream as 216-B-26 Trench; therefore, the contaminant types are expected to be very similar 2. Site construction is identical to the 216-B-26 Trench. 3. Waste was received from the same source (221-U). 4. Both sites are located in BC Cribs and Trenches Area; the geology of the two sites is similar. 5. The vertical extent of contamination is expected to be similar based on fraction of soil porosity column predicted to be consumed by effluent. 6. Risks are expected to be similar to 216-B-26 Trench b; however, because the top of the contamination is about 3.7 m (12 ft) bgs, human health and ecological risks are expected in the 0 to 4.6 m (0 to 15-ft) zone. 7. Comparison of contaminant inventories and effluent volume discharges for the 216-B-26 and 216-B-52 Trenches suggests that groundwater may be threatened, similar to 216-B-26 Trench. Because the ratio of effluent volume to soil pore volume is greater for the 216-B-52 Trench, residual mobile contaminants may be deeper than at the 216-B-26 Trench. 8. Generally received lesser contaminant inventory than 216-B-26 Trench except for nitrate and cyanide, supporting the need for groundwater protection. 9. Geophysical characterization (high resolution resistivity) of the 216-B-52 Trench vicinity indicates a continuous plume of deep contamination extending to approximately 40 m (130 ft) bgs that connects with the adjacent trench (216- B-23). This plume also connects with the 216-B-33 Trench that is in the 216-B-29 through 216-B-34 Trench grouping. In general, the 216-B-52 Trench is analogous to the 216-B-26 Trench. Remedial actions are needed to address the same risks as those of the 216-B-26 Trench, specifically protection of groundwater and protection against human and ecological intrusion to shallow contaminants at the bottom of the waste site in the 0 to 4.6 m (0 to 15-ft) bgs zone
200-E-114	The 216-E-114 Pipeline is a steel pipeline. The pipeline extends from the BY and C Tank Farms to the BC Cribs and Trench Area. The pipeline is approximately 4,600 m (15,100 ft) long with a diameter of 6 cm (2.4 in.). The depth to the pipe is assumed to be 2.1 to 3.0 m (7 to 10 ft).	Scavenged TBP Waste Stream Tank Farm/BY and C: 1952-1954. The pipeline transported scavenged bismuth phosphate solvent extraction waste from the URP process waste in the 221-U Building.	-	-	-	-	-	-	-	-	-	-	The 200-E-114 Pipeline is analogous to the 216-B-26 Trench: 9. Received the same waste stream as 216-B-26 Trench; therefore, the contaminant types are expected to be very similar. 10. Site construction is not similar to 216-B-26 Trench in that it was not designed as an unlined near-surface liquid disposal site; instead it was intended to be a transfer pipeline. 11. Waste was received from the same source (221-U). 12. Both sites are located in 200 East Area; the geology of the two sites is similar. 13. The vertical extent of contamination is expected to be considerably less, because there is evidence that only minor pipeline leakage has occurred, and that leakage was outside of the BC Cribs and Trenches Area. In 1997, contamination measuring 2,500 to 5,000 dpm beta/gamma was observed in a 6.1 x 30.5 m (20 x 100 ft) area straddling the pipeline northeast of the B Tank Farm near the point where it turns south. In 2001, another radiological survey found contamination measuring up to 19,000 dpm beta/gamma within a 15.2 m (50 ft) diameter area straddling the pipeline near its junction to the 216-B-51 French Drain. 14. Risks are expected to be much less than for 216-B-26 Trench; because the pipeline depth varies from about 2.1 to 3.0 m (7 to 10 ft) bgs, human health and ecological risks may exist in the 0 to 4.6 m (0 to 15-ft) zone where leaks have occurred. 15. Groundwater threat is not expected for this pipeline because the pipeline was designed to transfer effluents to the cribs and not to allow infiltration to the soil column; only minor historical evidence of leaks has been documented. 16. Generally received lesser contaminant inventory than 216-B-26 Trench. In general, the 200-E-114 Pipeline is bounded by the 216-B-26 Trench, with a potential for low risk to human and ecological receptors from near-surface contamination.

Table 2-2. 200-TW-1 Operable Unit Representative Sites and Associated Analogous Waste Sites. (14 Pages)

Waste Site	Waste Site Configuration, Construction, and Purpose	Site Discharge History (WIDS)	Contaminant Inventory (DOE/RL-96-81)							Effluent Volume (m^3)	Soil Pore Volume (m^3)	Eff Vol + Pore Vol	Rationale
			Total U (kg)	Total Pu (g)	Tc-99* (Ci)	Cs-137 (Ci)	Sr-90 (Ci)	Ferro-cyanide (kg)	Nitrate (kg)				
216-B-53B	The 216-B-53B Trench is 46 m (150 ft) long x 3.0 m (10 ft) wide and 3.0 m (10 ft) deep. It was divided into two sections by an earthen dam at the center that was 1.5 m (5 ft) high and 0.1 m (0.3 ft) wide at its top. The depth to the top of contamination is 3 m (10 ft). Located in the BC Cribs and Trenches Area and within the assembly of 216-B-53A through 216-B-58 Trenches.	300 Area Laboratory Waste Liquid wastes from the 300 Area laboratory facilities were trucked to this trench from 1962 to 1963.	9.1 Similar to rep site (7.6)	5.0 Similar to rep site (14.5)	~0 Similar to rep site (~0)	3.70 Similar to rep site (6.1)	5.06 Similar to rep site (5.2)	-- (0)	1 Less than rep site (900)*	15.1 Less than rep site	4,120	0.004 Similar to rep site	The 216-B-53B Trench is analogous to the 216-B-58 Trench as indicated by process history, contaminant inventory, effluent volume received, and expected nature and vertical extent of contamination: 1. Received the same waste stream as 216-B-58 Trench; therefore, the contaminant types are expected to be very similar. 2. Site construction is similar to 216-B-58 Trench. 3. Both sites are located in 200 East Area in proximity to each other; the geology of the two sites is similar. 4. The vertical extent of contamination is expected to be similar based on effluent volume received. 5. Risks are expected to be similar to 216-B-58 Trench; because the top of the contamination is about 3.1 m (10 ft) bgs, human health and ecological risks are expected in the 0 to 4.6 m (0 to 15-ft) zone. 6. Comparison of effluent volume discharges and contaminant inventories for the 216-B-53B and 216-B-58 Trenches suggests that the contaminant inventory in the vadose zone should be very close to the bottom of the trench, similar to 216-B-58 Trench. Also, the quantity of contaminants having potential to impact groundwater is relatively small, suggesting that the risk to groundwater may be negligible. 7. Generally received equivalent inventory compared to 216-B-58 Trench. In general, the 216-B-53B Trench is analogous to the 216-B-58 Trench, with a potential for risk from contamination in the shallow zone and in the zone at the bottom of the trench structure. Remedial actions are needed to address the same risks as those of the 216-B-58 Trench, specifically protection against human and ecological intrusion to shallow contaminants at the bottom of the waste site in the 0 to 4.6 m (0 to 15-ft) bgs zone.
216-B-54	The 216-B-54 Trench is 60 m (200 ft) long x 3.0 m (10 ft) wide and 3.0 m (10 ft) deep. It was divided into two sections by an earthen dam at the center that was 1.5 m (5 ft) high and 0.1 m (0.3 ft) wide at its top. The depth to the top of contamination is 2 m (7 ft). Located in the BC Cribs and Trenches Area and within the assembly of 216-B-53A through 216-B-58 Trenches.	300 Area Laboratory Waste Liquid wastes from the 300 Area laboratory facilities were trucked to this trench from March to October 1963.	9.1 Similar to rep site (7.7)	5.0 Similar to rep site (14.5)	~0 Similar to rep site (~0)	0.055 Less than rep site (6.1)	0.052 Less than rep site (5.2)	-- (0)	100 More than rep site (1,100)	999 More than rep site	5,470	0.183 More than rep site	The 216-B-54 Trench is analogous to the 216-B-58 Trench as indicated by process history, contaminant inventory, effluent volume received, and expected nature and vertical extent of contamination: 1. Received the same waste stream as 216-B-58 Trench; therefore, the contaminant types are expected to be very similar 2. Site construction is similar to 216-B-58 Trench 3. Both sites are located in 200 East Area in proximity to each other; the geology of the two sites is similar 4. The vertical extent of contamination is expected to be similar based on effluent volume received 5. Risks are expected to be similar to 216-B-58 Trench; because the top of the contamination is about 2.0 m (7 ft) bgs, human health and ecological risks are expected in the 0 to 4.6 m (0 to 15-ft) zone; risks to intruders may be associated with high contamination at the bottom of the waste site as evidenced by similar risk at 216-B-58 Trench 6. Somewhat more relative volume of effluent was sent to the 216-B-54 Trench, suggesting that contaminants in the vadose soil may be somewhat deeper than at 216-B-58 Trench. However, the quantity of contaminants having potential to impact groundwater is relatively small, suggesting that the risk to groundwater may be negligible 7. Generally received less or equivalent or greater contaminant inventory than 216-B-58 Trench. In general, the 216-B-54 Trench is analogous to the 216-B-58 Trench, with a potential for risk from contamination in the shallow zone and in the zone at the bottom of the trench structure. Remedial actions are needed to address the same risks as those of 216-B-58 Trench, specifically protection against intrusion to contaminants at the bottom of the waste site, which could pose a significant direct contact risk to a potential intruder because of the nature of the contaminants.

* BHI-01496, *Groundwater/Vadose Zone Integration Project Hanford Soil Inventory Model.*
DOE/RL-88-32, *Remedial Investigation/Feasibility Study Work Plan for the 200-BP-1 Operable Unit, Hanford Site, Richland, Washington*, Rev. 1.
DOE/RL-92-70, *Phase I Remedial Investigation Report for 200-BP-1 Operable Unit*, Vols. 1 and 2, Rev. 0.
DOE/RL-96-81, *Waste Site Grouping for 200 Areas Soil Investigations*, Rev. 0.
DOE/RL-2000-38, *200-TW-1 Scavenged Waste Group Operable Unit and 200-TW-2 Tank Waste Group Operable Unit RI/FS Work Plan*, Rev. 0.
HNF-1744, *Radionuclide Inventories of Liquid Waste Disposal Sites on the Hanford Site.*
HW-60807, *Unconfined Underground Radioactive Waste and Contamination in the 200 Areas - 1959.*
Waste Information Data System Report, Hanford Site database.
( ) values in parentheses are from *Soil Inventory Model*, 2004.

bgs = below ground surface.
OU = operable unit.
PRTR = Plutonium Recycle Test Reactor.
RI = remedial investigation.
RLS = radionuclide logging system.
TBP = tributyl phosphate.
TRU = contaminated with 100 nCi/g of transuranic materials with half-lives longer than 20 years.
UPR = unplanned release.
URP = Uranium Recovery Process.
WIDS = *Waste Information Data System Report.*

Table 2-3. Estimated Waste Site Clean Cover.

Waste Site	Depth to Top of Contamination (ft)	Waste Site	Depth to Top of Contamination (ft)
200-E-14 Siphon Tank	7 (top of tank)	216-B-26 Trench	11
200-E-114 Pipeline	10	216-B-27 Trench	12
216-B-14 Crib	10	216-B-28 Trench	12
216-B-15 Crib	13	216-B-29 Trench	12
216-B-16 Crib	10	216-B-30 Trench	12
216-B-17 Crib	11	216-B-31 Trench	13
216-B-18 Crib	11	216-B-32 Trench	13
216-B-19 Crib	13	216-B-33 Trench	13
216-B-20 Trench	12	216-B-34 Trench	13
216-B-21 Trench	12	216-B-52 Trench	12
216-B-22 Trench	12	216-B-58 Trench	8
216-B-23 Trench	12	216-B-53A Trench	10
216-B-24 Trench	12	216-B-53B Trench	10
216-B-25 Trench	12	216-B-54 Trench	8

Note: Depth estimated from engineering drawings and, for the 216-B-26 and 216-B-58 Trenches, characterization data.

Table 2-4. Timeframes to Reach Human Health Preliminary Remediation Goals Through Natural Attenuation.

Waste Site	Contaminant and Maximum Concentration (pCi/g) in the 0 to 4.6 m (0 to 15-ft) Zone	Time to Reach Human Health PRGs [a] in the 0 to 4.6 m (0 to 15-ft) Zone (yr)	Maximum Concentration (pCi/g) and Depth (ft bgs) of Short-Lived Radionuclides	Time to Reach PRGs for Short-Lived Radionuclides [b] (yr)	Time to Reach PRGs for Long-Lived Radionuclides [c] (yr)
216-B-46 Crib	Contaminant concentrations meet PRGs in this zone	NA	Cs-137: 280,000 Sr-90: 260,000 Depth: 18 to 49	410	>1000
216-B-26 Trench	Cs-137: 529,000	435	Cs-137: 529,000 Sr-90: 974,000 Depth: 12-20	435	>1000
216-B-58 Trench	Cs-137: 14,600	279	Cs-137: 14,600 Sr-90: 18,400 Depth: 13.5 to 16	280	NA [d]

NOTE: High contamination often is associated with soil just below the bottom of the waste site. Contaminants with the potential to affect groundwater may be distributed throughout deeper soil regions.

[a] Timeframes to reach preliminary remediation goals are based on radioactive decay of short-lived radionuclides (i.e., Cs-137 and Sr-90).
[b] The longest of Cs-137 or Sr-90 decay times based on radioactive decay alone, using Cs-137 PRG of 23.4 pCi/g and Sr-90 PRG of 2,410 pCi/g.
[c] Long-lived radionuclides include, but are not limited to, U-238, Pu-239, and TC-99.
[d] The 216-B-58 Trench has no long-lived radionuclides at concentrations greater than PRGs.
bgs = below ground surface.
NA = not applicable; concentrations already are below preliminary remediation goals.
PRG = preliminary remediation goal.

Table 2-5. Timeframes to Reach Ecological Preliminary Remediation Goals Through Natural Attenuation.

Waste Site	Contaminant	Time to Reach Ecological PRGs (yr)
216-B-46 Crib	No ecological contaminants of concern were identified	NA
216-B-26 Trench	Sr-90, Cs-137	448
216-B-58 Trench	Cs-137 Sr-90	287

NOTES: Timeframes to reach preliminary remediation goals are based on RESRAD modeling (ANL 2002, *RESRAD for Windows*, Version 6.21) and the no-cover scenario.
NA = not applicable; concentrations already are below preliminary remediation goals.
PRG = preliminary remediation goal.

Table 2-6. Representative Waste Site Risk Summary. (2 Pages)

Risk Element	216-B-46 Crib	216-B-26 Trench	216-B-58 Trench
Does the Site meet Human Health Preliminary Remediation Goals – Chemicals?			
Are concentrations less than WAC 173-340-745 risk-based standards?	Yes	Yes	Yes
Does the Site meet Human Health Preliminary Remediation Goals – Radionuclides? Assumes that No Credit is Taken for the Protectiveness of the Existing Cover			
Does the waste site meet human health PRGs for radionuclides?	Yes	No	No
Dose at 0 years (mrem/yr)	1.9	310,000	4,600
Primary radionuclides that contribute dose, 0 years	Ra-226	Cs-137	Co-60, Cs-137, Pu-239
Dose at 150 years (mrem/yr)	1.7	9,800	5.2
Primary radionuclides that contribute dose, 150 years	Ra-226	Cs-137	Pu-239
Dose at 1,000 years (mrem/yr)	0.9	3.5	4.7
Primary radionuclides that contribute dose, 1,000 years	Ra-226	Pu-239	Pu-239
Does the Site Meet Human Health Preliminary Remediation Goals – Radionuclides? Assumes that the Existing Cover Provides Some Protection			
Does the waste site meet human health PRGs for radionuclides?	Yes	No	Yes
Does the Site meet Groundwater Protection Preliminary Remediation Goals – Chemicals?			
Are groundwater protection standards met based on initial screening?	No	No	Yes
Chemicals predicted to reach groundwater above MCL	Nitrate Uranium	Nitrate	None

Table 2-6. Representative Waste Site Risk Summary. (2 Pages)

Risk Element	216-B-46 Crib	216-B-26 Trench	216-B-58 Trench
Does the Site meet Groundwater Protection Preliminary Remediation Goals – Radionuclides?			
Are groundwater protection standards met based on initial screening?	No	No	Yes
Radionuclides predicted to reach groundwater above MCL	Tc-99 U-234	Tc-99	None
Does the Site meet Ecological Preliminary Remediation Goals – Chemicals?			
Are concentrations less than ecological PRGs?	Yes	Yes	Yes
Constituents that exceed PRGs	None	None	None
Does the Site meet Ecological Preliminary Remediation Goals – Radionuclides?			
Are ecological PRGs met?	Yes	No	No
Constituents that exceed PRGs	None	Cs-137, Sr-90	Cs-137 Sr-90

Note - this table presents a summary of the constituents identified as primary risk contributors and the constituents identified as a potential groundwater protection concern as discussed in Section 4.6 of the RI report (DOE/RL-2002-42, *Remedial Investigation Report for the 200-TW-1 and 200-TW-2 Operable Units (Includes the 200-PW-5 Operable Unit).*

WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties."

MCL = maximum contaminant level.
PRG = preliminary remediation goal.

Table 2-7. Maximum Year Doses And Excess Lifetime Cancer Risk.

Site	Clean Cover			Without Clean Cover		
	Maximum Year Dose (mrem/yr)	Excess Lifetime Cancer Risk	Year(s)	Maximum Year Dose (mrem/yr)	Maximum Excess Lifetime Cancer Risk	Year(s)
Representative Sites						
216-B-46	not modeled*			1.9	4.3×10^{-5}	0-30
216-B-58	4.1×10^{-6}	8.6×10^{-11}	1,000	1.3×10^{4}	0.13	0
216-B-26	0	0	NA	3.1×10^{5}	4.3	0

* No radionuclides in the shallow zone exceed background.

NA = not applicable.

Table 2-8. Summary of Baseline Dose and Risk to a Potential Intruder.

Time of exposure (yr from present)	Pipeline Installation Worker[a]		Resident With Garden[b]	
	Dose (mrem/50 h)	Risk (ELCR)	Dose (mrem/yr)	Risk (ELCR)
216-B-46 Crib				
150	87.9	6.5 E-05	137.3	2.2 E-03
200	29.3	2.1 E-05	43.6	7.0 E-04
250	10.6	6.8 E-06	14.0	2.2E-04
300	4.7	2.4 E-06	4.6	7.3 E-05
216-B-26 Trench[c]				
150	3752	2.8 E-03	5599	9.0 E-02
300	126	9.2 E-05	182	2.9 E-03
400	18	1.1 E-05	22.2	3.9 E-04
500	8.3	3.1 E-06	7.5	1.4 E-04
600	d	d	6.4	1.1 E-04
216-B-58 Trench				
150	3.0	2.0 E-06	7.7	1.3 E-04
175	1.9	1.2 E-06	4.5	7.4 E-05
200	1.2	7.0 E-07	2.7	4.5 E-05

[a] Dose assuming current concentrations decay for the indicated time period. Then the dose is calculated for excavation worker in a 15-ft deep trench for 50 h.

[b] Dose and risk are baseline values assuming the current concentrations decay for the indicated time period. then the contaminated soil is removed and used by the resident intruder in a garden plot. Details are provided in Appendix E.

[c] Dose and risk based on soil sample concentrations. Multiply by twenty two (22) to account for higher Cs-137 concentration at the 12-ft depth inferred by borehole spectral gamma logging data.

[d] Dose and risk become dominated by thorium compounds produced from uranium decay. This changes the model parameters of cesium, strontium, and/or plutonium dominance in calculation of dose and risk data. As a result, no values are presented.

ELCR = excess lifetime cancer risk.

3.0 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIATION GOALS

This chapter defines the land use for the BC Cribs and Trenches Area waste sites and the region and defines the RAOs and PRGs. DOE/RL-98-28 (Implementation Plan), DOE/RL-2000-38 (200-TW-1/200-TW-2 OU Work Plan), DOE/RL-2002-42 (200-TW-1/200-TW-2 OU RI report), DOE/RL-2001-66 (which contains information pertinent to the four former 200-LW-1 waste sites included in this FFS), and DOE/RL-88-32 provide initial information on these items for the waste sites. For this FFS, the Implementation Plan information was compared to the data collected during the RI activities, and refinements were made as appropriate for the waste sites.

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

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

3.1 LAND USE

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

3.1.1 Current Land Use

All current land-use activities associated with the 200 Areas and the Central Plateau are industrial in nature. The facilities located in the Central Plateau were built to process irradiated fuel from the plutonium production reactors in the 100 Areas. Most of the facilities directly associated with fuel reprocessing are now inactive and awaiting final disposition. Several waste management facilities operate in the 200 Areas, including permanent waste disposal facilities such as the Environmental Restoration Disposal Facility (ERDF), low-level radioactive waste burial grounds, and a *Resource Conservation and Recovery Act of 1976* (RCRA)-permitted, mixed-waste trench. Construction of tank waste treatment facilities in the 200 Areas began in 2002, and the 200 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 are likely to include institutional controls (e.g., deed restrictions, covenants) as part of the selected remedy. Other Federal agencies, such as the U.S. Department of the Navy, also use the Hanford Site 200 Areas nuclear waste treatment, storage, and disposal 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 that is leased to the State of Washington.

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

According to DOE/EIS-0222-F, 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 treatment, storage, and disposal facilities. The DOE and its contractors, and the U.S. Department of Defense and its contractors, could continue their Federal waste disposal missions; and the Northwest Low-Level Radioactive Waste Compact could continue using the US Ecology site for commercial radioactive waste. Research supporting the dangerous waste, radioactive waste, and mixed-waste treatment, storage, and disposal facilities also would be encouraged within this land-use designation. New uses of radioactive materials such as food irradiation could be developed, and the products could be packaged for commercial distribution under this land-use designation.

3.1.2 Anticipated Future Land Use

The reasonably anticipated future land use for the Central Plateau Industrial/Exclusive Zone is continued industrial (exclusive) activities for the foreseeable future. Eventually, portions of the Central Plateau Industrial/Exclusive Zone may be used for non-DOE-related industrial uses. The DOE worked for several years with cooperating agencies and stakeholders to define land-use goals for the Hanford Site and to 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 EIS (DOE/EIS-0222-F) and the associated ROD (64 FR 61615), which were issued in 1999.

The EIS was written to address the growing need for a comprehensive, long-term approach to planning and development on the Hanford Site because of the DOE's separate missions of environmental restoration, waste management, and science and technology. The EIS 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 EIS, the land-use designation for sites inside the Central Plateau Industrial/Exclusive Zone, as shown in its Figure 2-233-1, is industrial (exclusive) (i.e., those areas suitable and desirable for the treatment, storage, and disposal of hazardous, dangerous, radioactive, and nonradioactive wastes, and related activities.

The current vision for all of the Central Plateau is that it will continue to be used for the treatment, storage, and disposal of hazardous, dangerous, radioactive, and nonradioactive wastes. The EIS and the ROD incorporate this vision in the selected alternative, describe the means by

which new projects will be sited, and focus on using existing infrastructure and developed areas of the Hanford Site for new projects. To support the current vision, the 200 Areas projects will maintain current facilities for continuing missions, remediate soil waste sites and groundwater to support industrial land uses, lease facilities for waste disposal (e.g., US Ecology), and demolish facilities that have no further beneficial use. Based on the EIS and the associated ROD, and consistent with other Hanford Site waste management decisions, this FFS report assumes an industrial land use for all the BC Cribs and Trenches Area waste sites, because they are within the Central Plateau Industrial/Exclusive Zone. Risk assessments for the industrial land use are conducted considering a non-Hanford worker industrial receptor, to bound the industrial land-use exposure possibilities.

Transition from cleanup to potential future land use has been anticipated by DOE/RL-2003-39, *Hanford Long-Term Stewardship Program and Transition: Preparing for Environmental Management Cleanup Completion*. This report anticipates the need for long-term stewardship of portions of the site, as necessary, to ensure protection of human health and the environment. Overall stewardship responsibilities will include monitoring remedy performance and maintaining engineered features to ensure their required performance. Groundwater monitoring will be an integral element of these activities. Also, by inference, some long-term stewardship presence will be required to ensure maintenance/repair/replacement of engineered barriers when required to provide continued groundwater protection. Because of the very long half-lives of some potential contaminants, it was recognized that some portions of the Hanford Site may require long-term stewardship in perpetuity. DOE/RL-2001-41, *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions*, states "In general, if the end state of the selected remedy cannot support unrestricted human use and unlimited human exposure, institutional controls will be required to maintain human health and protection."

3.1.3 Regional Land Use

Communities in the region of the Hanford Site consist of the incorporated cities of Richland, West Richland, Kennewick, and Pasco, as well as surrounding communities within Benton and Franklin Counties. The estimated population of the region in 2000 was 186,600; the population of Benton County was 140,700, and the population of Franklin County was 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).

3.1.4 Groundwater Use

The EIS (DOE/EIS-0222-F) indicates that contamination in the groundwater would restrict its use. Groundwater in the Central Plateau currently is contaminated and is not withdrawn for beneficial uses. This FFS evaluates potential future impacts to groundwater from current vadose zone contaminants at the representative sites, but does not evaluate groundwater remediation or risks. These issues will be addressed through the evaluation of the 200-PO-1 groundwater OU and through other sitewide assessments.

3.2 CONTAMINANTS OF CONCERN

Contaminants that have the potential to contribute significantly to site risk are referred to as COPCs. The COPCs are translated into contaminants of concern (COC) through the risk assessment process. Identification of COPCs is an important process, because it determines the list of contaminants for which further risk evaluations will be developed. Development of COPCs in the data evaluation and risk-assessment process is discussed in EPA/540/1-89/002, *Risk Assessment Guidance for Superfund (RAGS), Volume I -- Human Health Evaluation Manual (Part A) Interim Final.* Those contaminants that are COPCs are determined by risk-based screening or other methods.

The evaluation process that was used to identify the COPCs is presented in Appendix C. Appendix C discusses the detailed risk assessment and provides recommendations as to whether further evaluation of particular contaminants is warranted. That evaluation is summarized in the selection of COCs identified in Tables 3-1 and 3-2.

3.3 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The potential ARARs for the waste sites in this FFS are identified in Appendix B.

3.4 REMEDIAL ACTION OBJECTIVES

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

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

The RAOs provide a basis for evaluating the capability of a specific remedial alternative to achieve compliance with potential ARARs and/or an intended level of risk protection for human health or the environment. The 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 FFS were defined based on the fate and transport of contaminants, projected land uses for the 200 Areas, and the BC Cribs and Trenches Area waste sites conceptual exposure model. The RAOs for this FFS are as follows:

- RAO 1 - Prevent unacceptable risk to human health and ecological receptors from exposure to soils and/or debris as defined by ARARs or risk-based criteria. Prevent or reduce occupational health risks to workers performing remedial actions.

- RAO 2 - Prevent migration of contaminants through the soil column to groundwater so that no further degradation of the groundwater occurs because of leaching from soils.

- RAO 3 - Minimize the general disruption of cultural resources and wildlife habitat and prevent adverse impacts to cultural resources and threatened or endangered species during remediation.

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

RAO 1:

- For the purposes of this FFS (to determine preliminary remediation goals), RAO 1 is assumed to be achieved for radionuclides by prevention or reduction of risks from exposure to waste or contaminated soil that exceeds 500 mrem/yr above background for DOE site workers for a period of 50 years from the present, and 15 mrem/yr above background for a person who receives maximum exposure under an industrial exposure scenario for the period of 50 to 1,000 years after final remediation.

- For carcinogenic chemicals, RAO 1 will be achieved by prevention or reduction of risks from waste or contaminated soil in an industrial scenario such that the CERCLA excess cancer-risk goal of 10^{-6} to 10^{-4} lifetime cancer risk for carcinogens is not exceeded.

- For noncarcinogenic chemicals, RAO 1 is defined as prevention or reduction of risks from direct contact with waste or contaminated soils that exceed a hazard quotient or a hazard index of 1.0.

- For ecological receptors, exposure to wastes or soil contaminated with radionuclides will be prevented or reduced such that dose rates shall not exceed 0.1 rad/day for terrestrial organisms.

- Exposure of ecological receptors to wastes or to soil contaminated with nonradiological constituents will be prevented or reduced so that the hazard quotient and hazard index do not exceed 1.0.

- Existing and anticipated occupational health controls will be employed to protect workers performing remedial actions.

RAO 2 is assumed to be achieved by preventing or reducing migration of contaminants through the soil column to groundwater so that groundwater contaminant concentrations at a point of compliance at the edge of the waste site do not exceed MCLs under 40 CFR 141, "National Primary Drinking Water Regulations," and WAC 173-340-720, "Ground Water Cleanup Standards." Groundwater protection for the BC Cribs and Trenches Area waste sites is assumed

to be protective of the Columbia River. The pathway from the waste sites to the river will be evaluated through the groundwater OUs, with input from the source OUs concerning contributions to the groundwater.

RAO 3 will be achieved by meeting RAOs 1 and 2; by implementing existing Hanford Site standards for protection of cultural resources, wildlife habitat, and industrial workers; and by continuing to enforce existing institutional controls and monitoring requirements.

3.5 PRELIMINARY REMEDIATION GOALS

The PRGs are based on attainment of acceptable levels of human health and ecological risk. Typically, PRGs are identified for individual hazardous substances identified as COCs. If multiple contaminants are present at a site, the suitability of using individual PRGs as the 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 (milligrams per kilogram or milligrams per cubic meter) or activities (picocuries per gram), respectively. Final remedial action goals developed from the PRGs will be specified in a ROD that identifies the selected remedial alternative(s) for the BC Cribs and Trenches Area waste sites.

Residual risks following completion of remediation of the waste sites must meet the 10^{-4} to 10^{-6} CERCLA risk range for radiological and nonradiological chemical constituents and must be below a hazard index of 1.0 for noncarcinogens. Actual soil contaminant concentrations achieving these cleanup objectives would be presented in a cleanup verification package. The cleanup verification package would demonstrate how and where specific criteria have been applied and how the remedy protects receptors from the COCs identified for the waste sites.

3.5.1 Direct Exposure Preliminary Remediation Goals for Nonradioactive Contaminants

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

3.5.1.1 Human Exposure

For human receptors, PRGs for direct exposure to nonradioactive contamination in soils are based on risk-based standards. Risk-based standards for individual hazardous substances are established using applicable Federal and state laws and associated 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 noncarcinogenic substances are set at concentrations that would result in no acute or chronic toxic effects on human health

and the environment; this corresponds to a hazard quotient of less than 1.0. Consistent with this approach, the methodology described for industrial properties under WAC 173-340-745(5), "Soil Cleanup Standards for Industrial Properties," "Method C Industrial Soil Cleanup Levels," is used to calculate the risk-based standards.

Risk-based standards for some contaminants may be less than area background values or practical quantitation limits. Where risk-based standards are less than area background concentrations, practical quantitation limits may be set at concentrations that are equal to the agreed-upon site or area background concentrations. Area background values for select nonradioactive contaminants in soil have been characterized for the Hanford Site (DOE/RL-92-24). 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 3-1 lists the nonradionuclide PRGs for direct human exposure for those COCs.

3.5.1.2 Ecological Exposure

The BC Cribs and Trenches Area waste sites are within the industrial (exclusive) area identified in the EIS (DOE/EIS-0222-F) and designated by the EIS ROD (64 FR 61615). The industrial land-use designation allows for continued waste management operations within the 200 Areas consistent with past NEPA, CERCLA, and RCRA commitments and, among other things, will allow for the development of new waste management facilities. Sites within the Central Plateau Industrial/Exclusive Zone currently have limited habitat that is suitable for the establishment of ecological communities and food webs to support a hierarchy of terrestrial receptors. Maintenance of the industrial-use designation will limit future inhabitation by biota. However, cleanup to industrial land-use standards may not continue to be protective of ecological receptors after loss of institutional controls. A SLERA has been used to develop soil PRGs for the protection of terrestrial wildlife.

Because the waste sites in the BC Cribs and Trenches Area are all within the Central Plateau Industrial/Exclusive Zone, only terrestrial wildlife risks are evaluated. Consistent with this approach, WAC 173-340-7490(3)(b), "Terrestrial Ecological Evaluation Procedures," "Goal," specifies that for industrial or commercial properties, current or potential exposure to soil contamination need only be evaluated for terrestrial wildlife protection. Plants and soil biota need not be considered unless the species is protected under the Federal *Endangered Species Act of 1973*. Currently, no Federally listed threatened or endangered species are known to exist on the waste sites. Surveys conducted before the field activities begin will confirm the presence of any protected species. For sites with institutional controls to prevent excavation of deeper soil, a conditional point of compliance may be set at the biologically active soil zone, which is assumed to extend to a depth of 2.7 m (9 ft) (DOE/RL-98-28). Priority chemicals of ecological concern and their soil screening levels are listed in WAC 173-340-900, Table 749-3. These soil-screening levels were used in conjunction with the risk assessment to develop PRGs for the COCs that are protective of ecological receptors, as indicated in Table 3-1.

3.5.2 Direct Exposure Remediation Goals for Radionuclides

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

3.5.2.1 Human Exposure

For locations within the Central Plateau Industrial/Exclusive Zone, the DOE dose limit of 500 mrem/yr for radiological workers will be in effect for as long as waste management operations continue. For the purpose of evaluating potential exposure, all waste management facilities are assumed to be closed after a period of 50 yr; however, access to the 200 Areas is assumed to be restricted for an additional 100 yr by the enforcement of active institutional controls. Effective passive institutional controls may exist for some uncertain period beyond the cessation of active institutional controls.

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

Numerical values of radionuclide PRGs corresponding to the 15 mrem/yr guidance limits depend on the specific exposure scenario selected for remedial design and site-specific parameters (e.g., the area extent of the waste site). Radionuclide PRGs corresponding to the 15 mrem/yr guidance limit for direct exposure to contaminated soil have been calculated for the industrial scenario as described in Appendix C. The individual PRGs for the identified COCs are calculated using the RESRAD dose assessment model (ANL 2002) and are provided in Table 3-2.

The soluble salts of uranium present noncarcinogenic toxic effects that are evaluated by a hazard quotient, in addition to the incremental cancer risks presented by the radioactive isotopes of uranium. If the hazard quotient exceeds 1.0, the possibility exists for systemic toxic effects. However, the dose from total uranium will exceed the 15 mrem/yr guidance limit at an activity or concentration less than that corresponding to a hazard quotient of 1.0. Therefore, it is expected that cleanup to meet the radioactivity hazard also will be adequate to address the hazard associated with chemical toxicity.

3.5.2.2 Ecological Exposure

The international community has been involved for more than 20 yr in evaluating the effects of ionizing radiation on plants and animals. The International Atomic Energy Agency (IAEA)

issued a study in 1992, IAEA 332, *Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards*, endorsing the 1977 International Commission on Radiological Protection reports, ICRP-26 and ICRP-60, both titled, *Recommendations of the International Commission on Radiological Protection*, and stating that chronic radiation dose rates below 0.1 rad/d will not harm plant and animal populations and that radiation standards for human protection also will protect populations of nonhuman biota. The report implies that dose limits of 0.1 rad/d for animals and 1 rad/d for plants will protect populations, but additional evaluation of effects may be needed if sensitive species are present.

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

In response to the workshop findings, DOE produced DOE/STD-1153-2002, which provides a graded approach to ERA for radionuclides and screening level BCGs. For radiological constituents, no promulgated screening or cleanup levels are available. The potential effects of surface residual contamination on terrestrial receptors are evaluated using the terrestrial radionuclide screening levels presented in DOE-STD-1153-2002, developed by the Biota Dose Assessment Committee. The Biota Dose Assessment Committee has been assisting DOE in developing this technical standard, which provides a graded approach for evaluating radiation doses to biota. The technical standard provides a cost-effective, easy-to-implement methodology that can be used to demonstrate compliance with DOE dose limits and with findings of the IAEA and the National Council on Radiation Protection and Measurements regarding doses below which deleterious effects on populations of aquatic and terrestrial organisms have not been observed. The technical standard also can be used to assess ecological effects of radiological exposure when conducting 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 ERA 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 usually is the simplest, most cost-effective, and least time-consuming process.

The BCGs contained in the technical standard guidance include conservative screening concentrations that are judged to be protective of the most sensitive terrestrial organisms, assuming 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 DOE's established or recommended dose standards for biota protection. Therefore, soil concentrations that are less than the BCGs are not considered to pose a threat to terrestrial receptors.

3.5.3 Remediation Goals for the Protection of Groundwater

Remediation goals for the protection of groundwater must address both contamination reaching the groundwater and contamination remaining in the ground after remediation (i.e., residual contamination). The remediation goals must consider risk-based standards where contamination might have contacted groundwater and standards for residual contamination that might migrate through the vadose zone to groundwater. Residual vadose zone contamination must be below activities or concentrations that could cause groundwater to exceed protective levels, if contaminant migration occurs. To be conservative, PRGs were calculated on the basis that concentrations reaching groundwater would not exceed MCLs. The following subsections present remediation goals for groundwater and for residual contamination in the vadose zone and a discussion of achieving these remediation goals.

3.5.3.1 Nonradionuclide Preliminary Remediation Goals for the Protection of Groundwater

The PRGs for nonradionuclides in the vadose zone that are protective of groundwater are developed from potential ARARs (e.g., MCLs as defined in 40 CFR 141) and published risk-based standards. Consistent with this approach, soil concentrations protective of groundwater are established by evaluating the provisions of WAC 173-340-747, unless it can be demonstrated that a higher contaminant concentration is protective of groundwater (WAC 173-340-747[3][e], "Deriving Soil Concentrations for Ground Water Protection," "Overview of Methods," "Alternative Fate and Transport Models"). Values of soil concentrations protective of groundwater were calculated using formulas from WAC 173-340-747 and inputs from Ecology 94-145. Table 3-1 provides the preliminary remediation goals for nonradionuclides identified as COCs.

3.5.3.2 Radionuclide Preliminary Remediation Goals for the Protection of Groundwater

Title 40 CFR 141 specifies MCLs for radionuclide contaminants in drinking water. Remediation goals for radionuclide contaminants in water, protective of both groundwater and surface water, are based on achieving these MCLs. Remediation goals for radionuclides in water, considered

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

protective of human health, also are considered protective of potential ecological receptors at the groundwater/river interface.

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

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

For radionuclides in the vadose zone, concentrations of residual contaminants are considered protective of groundwater if the residual levels do not result (via migration through the vadose zone) in concentrations that exceed groundwater remediation goals.

4.0 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

Appendix D in the Implementation Plan (DOE/RL-98-28) provided an initial framework to guide the RIs 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, site characterization information was obtained and an RI report was prepared that presented the nature and extent of contamination and the risk at the representative waste sites (DOE/RL-2002-42). Additional risk analysis was performed as part of this FFS for those analogous sites with existing sampling data. This information may affect the identification and screening of remedial technologies. As a result, the Implementation Plan information was reviewed against the results of the SLERA and HHRA, and refinements were made as appropriate for this FFS. A review of technologies was conducted to identify new, emerging technologies or to update information on existing technologies since the writing of the Implementation Plan. If a technology was identified and evaluated in the Implementation Plan and no modifications to this evaluation have been made, then the identified and evaluated technology is only briefly mentioned in this section. The Implementation Plan provides additional detailed information.

4.1 GENERAL RESPONSE ACTIONS

Remedial measures generally are categorized into broad groups called GRAs. The GRAs are intended to satisfy RAOs identified in Chapter 3.0. The GRAs for the representative sites are as follows:

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

These GRAs are intended to cover the range of options necessary to meet the RAOs. Based on the new information collected and evaluated in DOE/RL-2002-42, modifications to these GRAs were not necessary. Detailed descriptions of each GRA are included in the Implementation Plan.

4.2 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This section serves to identify and screen potentially viable technologies for the BC Cribs and Trenches Area waste sites. The initial identification and screening of remedial technologies conducted in Appendix D of the Implementation Plan (Section D5.0 to D5.6 and Table D-1) are modified for this FFS based on the information obtained during the RI. The next two subsections summarize the technology screening conducted: rescreening of the Implementation

Plan remedial technologies that are retained for this BC Cribs and Trenches Area FFS and identifying and screening new technologies identified since the creation of the Implementation Plan. The technologies are discussed by GRA group. Table 4-1 represents a roadmap for technology selection between the Implementation Plan and this FFS.

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

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 BC Cribs and Trenches Area waste sites. Following is a brief screening-level discussion of the technologies and the results of the refinements.

4.2.1.1 No Action

40 CFR 300 requires that a no-action alternative be evaluated as a baseline for comparison with other alternatives. The no-action alternative represents a situation where no restrictions, controls, or active remedial measures are applied to the site. The no-action alternative implies a scenario of walking away from the site and taking no measures to monitor or control contamination. The no-action alternative requires that a site pose no unacceptable threat to human health and the environment. The no-action alternative was retained in the Implementation Plan and is carried forward in this FFS; however, it is not expected to be applicable to any of the waste sites.

4.2.1.2 Institutional Controls

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

Based on the results of the RI activities, no changes have been made to this technology from what appeared in the Implementation Plan. The time period associated with the controls may be subject to discussion relative to that described in the Implementation Plan, however, based on potential on-going remedial action schedules. The institutional controls technologies will be incorporated into remedial alternatives in Chapter 5.0.

4.2.1.3 Containment

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

4.2.1.3.1 Surface Barriers (Capping)

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

DOE/RL-93-33, *Focused Feasibility Study of Engineered Barriers for Waste Management Units in the 200 Areas*, evaluated four conceptual barrier designs for different types of waste sites: the Hanford Barrier, the Modified RCRA Subtitle C Barrier, the Modified RCRA Subtitle D Barrier, and the Standard RCRA Subtitle C Barrier. Based on the results of this evaluation, the Implementation Plan identified three of these engineered barriers as being suitable for use at waste sites in the 200 Areas: the Hanford Barrier, the Modified RCRA Subtitle C Barrier, and the Modified RCRA Subtitle D Barrier. Further discussion of surface barriers is summarized below, because the information supports the RI data and the evaluation of capping alternatives.

Generally, capping consists of constructing surface barriers over contaminated waste sites to control the amount of water that infiltrates into contaminated media, to reduce or eliminate leaching of contamination to groundwater. In addition to their hydrological performance, barriers also may function as physical barriers to prevent intrusion by human and ecological receptors, limit wind and water erosion, and attenuate radiation. The surface barriers proposed in this FFS rely predominantly on the water-holding capacity of a soil, evaporation from the near surface, and plant transpiration to control water movement through the barrier. Precipitation infiltrates at the surface, where it is retained in the soil by absorption and adsorption until ET processes move the water back to the atmosphere. Such designs are particularly suitable for semiarid and arid climates with a low annual amount of precipitation and a relatively high ET potential. When precipitation exceeds ET, water is stored; and when ET exceeds precipitation, water is released. Key design criteria require that the soil layer be of sufficient thickness and quality in terms of water-holding capacity and ability to support native vegetation to accommodate design precipitation events or conditions. Water balance studies at the Hanford Site have shown that vegetation and soil type control the downward movement of precipitation, and for finer grained soils with a healthy plant cover of shrubs and grasses, net recharge is close to zero (Gee et al. 1992, "Variations in Recharge at the Hanford Site").

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

monolayered vegetative cover at the DOE Nevada Test Site and the DOE Alternative Landfill Cover Demonstration Project in New Mexico, managed by the Sandia National Laboratory (Dwyer 2001, "Finding a Better Cover"). The goal of most of these efforts is to provide reliable data on design, cost, construction, and performance for alternative barriers. The intent of the FFS is not to select and design the most applicable ET barrier but to evaluate their performance in general using the CERCLA process. Based on the available data cited above, ET barriers are carried forward for remedial alternative development and evaluation.

Information gained from these studies and programs, including the Hanford Barrier program at the 216-B-57 Crib, will be used to support the remedial design if ET barriers are selected as the preferred remedy. Site-specific conditions establish the level of hydraulic or physical barrier performance required.

A four-year (fiscal years 1995 through 1998) treatability test was successfully completed on a prototype of the Hanford Barrier constructed in fiscal year 1994 over the 216-B-57 Crib. The primary purpose of the test was to document surface barrier constructability, construction costs, and physical and hydrologic performance in support of remedial decision making and remediation at similar waste sites 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.*

The principal surface barrier performance parameters evaluated during the treatability test included water balance within the barrier under ambient and extreme precipitation conditions; surface wind and water erosion; stability of the barrier foundation, surface, and riprap side slope; surface vegetation dynamics; and animal intrusion. Using irrigation techniques, extreme precipitation conditions were simulated by applying water up to three times normal, including 1,000-year storms. Treatability test objectives were achieved or exceeded by the four years of testing. Results demonstrate that the barrier is easily constructed with standard construction equipment, performance criteria have been met or exceeded, and the Hanford Barrier and associated design components are highly effective. Subsequent to the treatability test, monitoring activities have continued at the barrier. Results of the monitoring activities are reported in annual letter reports; the most recent is CP-18187, *200-BP-1 Prototype Hanford Barrier Annual Monitoring Report for Fiscal Year 2003.* Water balance, barrier stability, vegetation, and animal intrusion monitoring continue at the barrier. Results have shown essentially no drainage through upper barrier silt layers and no measurable amounts of drainage through the asphalt layer/functional barrier system. Drainage does occur at the side slopes. Barrier sideslopes and surface have remained stable. The barrier maintains a healthy coverage of native plants. The vegetation has been shown to effectively remove water. The barrier showed minimal small mammal burrowing activity with no impact on barrier performance during the monitoring period.

The ET barriers can be divided into two categories: capillary barriers and monolithic barriers. The barriers retained in the Implementation Plan (i.e., the Hanford Barrier, the Modified RCRA Subtitle C Barrier, and the Modified RCRA Subtitle D Barrier) are capillary barriers, which consist of a fine-grained soil layer overlying a relatively coarse-grained soil layer. Monolithic barriers rely on a relatively thick single layer of fine-textured soil. The distinct textural interface in capillary ET barriers between the fine and coarse soil layers creates a capillary break, which functionally increases the water-holding capacity of the fine-grained soil over that associated

with unimpeded vertical drainage. Water will not flow into the coarse layer until the water content approaches saturation in the fine-grained soil layer. If the textural interface is sloped, water will move laterally in the fine-soil layer above the interface, which provides an additional mechanism for water removal.

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

Advantages of capillary barriers are reduced soil thickness, greater design control for retaining water within the effective root zone, and the ability to move water laterally out of the barrier. If lateral drainage along the textural interface is desired, special design considerations must be addressed, such as the ability of the soil to conduct water laterally (unsaturated flow) over the length of the sloped interface, and the final routing and disposition of the drainage. Furthermore, capillary barriers produce relatively low moisture conditions in the lower coarse layer, which may serve to limit biointrusion and maximize root retention in the ET zone. If the capillary break is compromised, the performance of the barrier diminishes.

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

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

Considering the level of supporting documentation, and Hanford Site-specific field data that demonstrate that capillary barriers perform well (DOE/RL-99-11; PNNL-13033, *Recharge Data Package for the Immobilized Low-Activity Waste 2001 Performance Assessment*), a generic ET barrier employing intrusion-deterrent features is considered to be an appropriate process option for the waste sites in this FFS. This process option forms the basis for evaluating capping alternatives at soil waste sites not contaminated with transuranic constituents. The standard RCRA, asphalt, concrete, and cement-type barriers were rejected in the Implementation Plan (DOE/RL-98-28) because of their limited effectiveness and duration in an arid climate; they are similarly rejected in this FFS. Both the monolithic and capillary barriers have been shown to be equivalent to or to exceed the performance of the standard RCRA Subtitle C Barrier design, and both have been approved or planned for use in several western states (DOE/RL-93-33).

If capping is identified as the preferred alternative, finalization of site-specific designs will occur as part of the remedial design process and will consider the RAOs and requirements defined in the ROD, regulatory design and performance standards, material availability, cost-effectiveness, current surface barrier technology information, and site-specific hydrologic and physical performance requirements to ensure waste containment. Different waste sites likely will have varying barrier performance requirements, and more than one barrier design (e.g., monolithic and capillary barrier) may be deployed to address waste site capping needs. The cap will be sized to cover not just the physical boundaries of the waste site, but the lateral extent of contamination spread, to prevent recharge from intersecting it.

Although test data have shown ET barriers to provide considerable benefit, it has also been determined that they possess limited capability, particularly for mobile contaminants located deep in vadose zone soil. Overall barrier performance is characterized by a reduction in the rate that contaminants move toward groundwater and is achieved by reducing the driving force, i.e., infiltration of water into the contaminants, to push them deeper. Recent analysis has shown that even when such infiltration is eliminated entirely, residual gradients are sufficient to enhance diffusion from wetter soil toward drier soil. Also, edge effects associated with the barrier perimeter can result in ambient moisture "curling" underneath the barrier to intercept the waste unless the barrier has sufficient lateral extension. Fate and transport studies of the 216-B-26 Trench vicinity (Appendix G) have shown that overall barrier performance will both slow the downward transport of mobile contaminants toward the ground water and reduce the overall quantity entering the ground water. In some cases, the barrier will provide sufficient protection such that drinking water standards are predicted to be protected; if the barrier fails to adequately protect groundwater, either a waiver or some further remedial action may be necessary.

4.2.1.3.2 Slurry Walls and Grout Walls

Slurry walls and grout walls were retained in the Implementation Plan. Slurry walls and grout walls often are used to contain contaminated groundwater but have application in the vadose zone to limit (1) the horizontal movement of moisture into contaminated materials or (2) the vertical migration of contaminants. Vertical barriers are a supplemental element in the design of surface caps to effectively improve containment performance in deeper zones; both slurry walls and grout walls are suitable technologies for this application. 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 and for potential future use following the collection and evaluation of additional data to confirm that the appropriate remedial action has been specified for the analogous waste sites.

Vertical migration of contaminants can be addressed through the use of directional drilling techniques. Angled grout walls can be formed beneath a waste, and new innovative materials can assist with limiting radionuclide mobility through chemical reactions. This type of barrier is limited (more so than slurry walls) by difficulties in verifying barrier continuity and identifying grouting materials suitable for use. Their potential use to form grout walls beneath contamination at the BC Cribs and Trenches Area waste sites is rejected because of the depth of the mobile contaminants (greater than 30 m [100 ft]) bgs at these sites.

4.2.1.4 Removal, Treatment, and Disposal

The Implementation Plan identified excavation of contaminated soils, with treatment as needed to meet disposal criteria, and transportation and disposal to the appropriate disposal facility, as an applicable technology for the waste sites. Excavation of materials generally is accomplished using standard earthmoving equipment, such as excavators, 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 capping. Most of the sites in the BC Cribs and Trenches Area contain the majority of their contamination in the depth range of 4.6 to 6.1 m (12 to 20 ft). Excavation to 15 m (50 ft), while possible, is more difficult at depths greater than 7.6 m (25 ft), which is a normal reach for conventional excavation equipment. While excavation to greater depths is possible, additional engineering controls, such as shoring or more gradual side slopes, would be needed. Terracing would be required to reach greater depths. Risks to workers increase with the depth of excavation, as well.

The levels of contamination in many of the waste sites in the BC Cribs and Trenches Area pose a significant dose threat to workers. The levels of Cs-137 and Sr-90 and potentially other radionuclides may result in excavation and disposal activities being identified as nuclear activities. In addition, the levels may result in implementing semi-remote-handled removal techniques. Whether remote handled or contact handled, special safety controls will be required to address the contaminant concentrations. Shielded excavation equipment for these wastes will be required to reduce worker dose, and the blending of less contaminated soils with the more highly contaminated soils will be required to meet as low as reasonably achievable (ALARA) and on-site disposal facility requirements. 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. This approach also would limit the potential for wind dispersal

of contaminants. During periods of high wind, excavation would be stopped and fixative would be applied to exposed contaminated soil. These time-consuming activities limit worker risk but 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. However, Hanford Site experience with excavation of highly contaminated soil has been successfully demonstrated without containment. Potential future animal intrusion/ 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 like fruit flies represent a further pathway to spread contamination. These are documented pathways at the Hanford Site.

Shoring may be needed at cut intervals to reach these depths safely. Large excavations would significantly increase the time that workers are associated with the highly contaminated zones, resulting in increased doses. Also, large excavations to these depths would put a large amount of contaminated material at risk for spread associated with airborne pathways. Safety costs associated with these techniques would be greatly increased.

The on-site disposal option for soils is the ERDF. The waste acceptance criteria for the ERDF 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 the ERDF, then a suitable offsite disposal facility will be used. However, all contaminated soils from the BC Cribs and Trenches Area waste sites are expected to be acceptable to the ERDF, although downblending of highly contaminated, high dose-rate soil would be required.

4.2.1.5 Ex Situ Treatment

Ex situ treatment processes retained in the Implementation Plan (DOE/RL-98-28) include thermal desorption, vapor extraction, mechanical separation, soil washing, ex situ vitrification, and solidification/stabilization. However, all of these technologies except solidification/stabilization are rejected for this FFS because of limited effectiveness and applicability to contaminant types and distribution in the BC Cribs and Trenches Area waste sites. 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 RI report (DOE/RL-2002-42) and the results of the risk assessment, the waste sites primarily are contaminated with radionuclides, nitrate, and metals; remediation for hydrocarbons or organics is not necessary. These technologies are ineffective for radionuclides and inorganic compounds and, therefore, were rejected for this FFS.

The primary separation technique for solid media using mechanical separation is sieving to segregate material according to size, but other physical properties also may be used as a basis for segregation (e.g., local discoloration of soil). This technology is not deemed necessary to dispose of waste at the sites in this FFS. The main disadvantage of this technology is that increased waste handling carries the potential of increased worker risk and the production of fugitive dust. This process has been used as a component of removal and disposal actions on the

Hanford Site. Experience in the 300 Area burial grounds has shown that certain problems with sieving solid debris may be encountered, specifically clogging of the sieving device.

Soil washing has limited effectiveness on many radionuclides, with the risk of higher exposures to workers and potentially high costs associated with the soil washing, especially if chemicals are needed to remove contaminants. Also, the liquid associated with the soil washing process may require special handling before disposal. Based on the results of the RI, treatment is not required to meet ERDF or Waste Isolation Pilot Plant waste acceptance criteria.

Ex situ vitrification is costly and is deemed unnecessary to dispose of waste at the ERDF or the Waste Isolation Pilot Plant.

Ex situ soil mixing is retained to allow consideration of establishing a facility to blend highly contaminated soil with less contaminated soil to achieve a blend that satisfies the ERDF waste acceptance criteria. Most waste sites are predicted to contain some fraction of soil that is sufficiently contaminated to require down blending at a rate of up to 7:1 or more. Because it may not be practicable to perform such blending in situ (i.e., within the crib or trench excavation), the soil may have to be removed and transferred to a specific blending facility for processing. Although this process represents increased waste handling, the potential of increased worker risk, and the production of fugitive dust, application of appropriate controls can satisfy the required worker and environmental safety requirements.

4.2.1.6 In Situ Treatment – (Vitrification, Grout Injection, Soil Mixing, Dynamic Compaction, and Natural Attenuation)

These technologies were retained in the Implementation Plan to mitigate contaminant mobility or to treat organics in situ.

Vitrification is rejected because of the physical size of the waste sites and the implementation problems associated with this technology. Vitrification of near-surface contaminants (i.e., those within 6 m (20 ft) of the surface) could reduce their mobility, but these contaminants are already essentially immobile (that's why they remain "fixed" in the soil near their point of discharge). Furthermore, vitrification is not likely to reduce intruder risk appreciably, because intrusion scenarios would still encounter the waste. Even though a vitrified waste form would be less soluble than the untreated waste and less amenable to uptake, the uniformity of vitrification within a variable matrix undoubtedly would leave some fraction of the waste in an essentially untreated form. Vitrification of deep more-mobile contaminants such as Tc-99 is not practicable, because sampling of the 216-B-26 Trench has shown that the bulk of the contamination is at least 30 m (100 ft) bgs. In situ vitrification also is not retained for use at the settling tank because of the high cost and implementation problems.

Grout injection, commonly referred to as jet grouting or in situ grouting, is a process that entails injecting a slurry-like mixture of cements, chemical polymers, or petroleum-based waxes into contaminated media. Grouts are specially formulated to encapsulate contaminants, isolating them from the surrounding environment.

As summarized in INEEL/EXT-01-00281, *Evaluation of Soil and Buried Transuranic Waste Retrieval Technologies for Operable Unit 7-13/14*, in situ grouting has been approved by

regulating agencies and implemented at several small-scale sites, although in situ grouting has not been applied to large-scale sites with many radiological and chemical hazards, such as the BC Cribs and Trenches Area waste sites. Grout injection, as a stand-alone action, is rejected for this FFS because of the size of the waste sites and its unproven effectiveness on large-scale sites having radiological and chemical hazards.

The grouting technology is applicable to remedial alternatives to fill voids in pipelines (e.g., 200-E-114 Pipeline and pipelines connecting the siphon tank to the cribs), to fill voids in cribs, and to fill voids in tanks that will remain in place after contamination is removed.

Dynamic compaction is used to increase the soil density, compact the buried solid waste, and/or reduce void spaces by dropping a heavy weight onto the ground surface. The compaction process can reduce the hydraulic conductivity of subsurface soils and, correspondingly, the mobility of contaminants. Because the compactive energy attenuates with depth, dynamic compaction is limited to shallow applications typically less than 3 m (10 ft). Dynamic compaction is rejected in this FFS as a standalone action, because the chemicals and radionuclides at these sites are typically at a depth where compaction would not be effective. Dynamic compaction is retained in the FFS as a potential element of capping to reduce or eliminate potential void spaces; this technology frequently is used to prepare a waste site for cap construction.

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

In situ soil mixing to mix highly contaminated soil with less contaminated soil to achieve a blend that satisfies the ERDF waste acceptance criteria is retained. Although some waste sites are predicted to contain some fraction of soil that is sufficiently contaminated as to require down blending at a rate of up to 7:1, most waste sites are predicted to require maximum blending that is somewhat less. Although difficult and time consuming, it is feasible to perform such blending in situ (i.e., within the crib or trench excavation). While this process represents increased waste handling, the potential of increased worker risk, and the production of fugitive dust, application of appropriate controls can satisfy the required worker and environmental safety requirements. In situ soil blending to achieve the ERDF waste acceptance criteria has been demonstrated by excavation of the 116-N-1 Crib in the Hanford Site 100 Area.

Natural attenuation is retained for this FFS, because it is a natural component of all of the potential alternatives. Natural attenuation is most effective on sites with nonradionuclides that readily degrade in the environment and on sites with radionuclides that have short half-lives, such as Cs-137 and Sr-90; however, it is a slow process at sites that have radionuclides with long half-lives (e.g., plutonium, uranium and Tc-99) or nonradionuclides that do not degrade naturally in the environment. It may be the only feasible and cost-effective technology for sites that have deep contamination, because other technologies (e.g., retrieval, in situ treatment) are difficult to implement, ineffective, and cost prohibitive.

4.2.2 Identification and Screening of New or Additional Remedial Technologies

In addition to the technologies identified in the Implementation Plan, retrieval technologies for sludge removal from tanks have been identified as applicable. These technologies are briefly discussed and screened below.

HNF-6354, *Tank 241-Z-361 Sludge Retrieval and Treatment Alternatives*, evaluated four alternatives for retrieving tank wastes at the Hanford Site. Alternatives applicable to retrieving the possible sludge in the 200-E-14 Siphon Tank are a sludge retrieval vehicle, power fluidics, sluicing to an interim receiver tank, and mechanical retrieval.

4.2.2.1 Sludge Retrieval Vehicle

A sludge retrieval vehicle is a hydraulic, motorized, track-driven device that acts as the platform for a high-pressure-water dislodging device and a hydraulic scavenging pump to remove sludge from inside tanks. The vehicle is tethered by an umbilical system that consists of the pump's discharge line, the high-pressure water line, and various hydraulic lines. The vehicle is sized to pass through a tank's manhole. An umbilical management and hoisting system can be located on the surface. An operator viewing the vehicle through a closed-circuit television camera located in one of the tank's smaller risers remotely controls the vehicle.

This vehicle is similar to that demonstrated in past Hanford demonstration test programs and has been demonstrated in radioactive tanks using an on-board pump and dislodger. The Oak Ridge National Laboratory has successfully deployed a similar vehicle in a 15 m (50-ft) diameter radioactive waste tank. The Oak Ridge National Laboratory vehicle uses a confined sluicer and jet pump to remove waste from the tank. The vehicle can be modeled after commercially available hardware that is used routinely in private industry to clean out large hydrocarbon tanks. One vendor (Environmental Specialties Group) has 600 units in use with over 30,000 hours of operating time in total.

4.2.2.2 Power Fluidics

Power fluidics is the technology of moving and controlling large-scale fluid flows of process fluids including sludge, using devices with no mechanical moving parts that operate on fluid phenomena such as the Bernoulli effect, entrainment, vortex, and surface tension. Such devices have been used with good reliability in the United Kingdom for the past 20 years in 400 systems of pumps, mixers, and samplers. They are particularly well suited to sludge pumping because of the absence of moving parts in the primary pumping equipment.

A successful application of a pulse jet system at the Bethel Valley Evaporator Service Tanks at Oak Ridge, in which approximately 20,000 gal of sludge were removed, is presented in Schwart and Billingsley 1998, "Technology and Teamwork Equal Empty Tanks."

4.2.2.3 Sluicing to an Interim Receiver Tank

Another retrieval method is sluicing to an interim receiver tank. This concept would include removal of sludge from tanks by sluicing with a suitable nozzle mounted from the top of the

tank, employing a submersible pump lowered to the bottom of the tank through one of the existing manholes, and having an interim storage tank on the surface that would act as a sluicing source tank. This tank would have to incorporate a sluicing pump and an agitator to mix the slurry feed to facilitate transfer to a cementation process.

This concept requires waste slurry handling on the surface, including pumping of contaminated supernatant back into the tank and decanting the slurry on the surface. The amount of new water introduced to the waste slurry would be equal to or greater than that for the sludge retrieval method.

Direct pumping, for example with a pneumatic diaphragm pump or a septic tank-type suction pump adapted for radiological service, is another method of sluicing.

4.2.2.4 Mechanical Retrieval

Finally, mechanical retrieval of sludge from the Hanford Site tanks would include a robotic tracked vehicle equipped with a plow blade that would dislodge the waste sludge and introduce it to a mechanical conveyor, which then would transfer the waste to the surface. The potential advantage of this option is that little water would be added to the sludge. A significant amount of water would have to be used to decontaminate the conveyor upon completion of the retrieval process. This concept would require a relatively complex mechanical conveyor to move the sludge on the surface. The conveyor would become highly contaminated and might prove difficult to decontaminate.

4.2.2.5 Alternative Chosen

DOE/RL-2003-52, *Tank 241-Z-361 Engineering Evaluation / Cost Analysis*, recommends a commercially available fluidics system for sludge removal from the 241-Z-361 Settling Tank. If examination of the 200-E-14 Siphon Tank reveals significant sludge, this tank will be added to the scope of the engineering evaluation/cost analysis for sludge removal.

4.2.3 In Situ Treatment - Technetium-99 Immobilization

Appendix H provides an evaluation of a variety of technologies having potential to immobilize the deep [30 to 39.6 m (100 to 130 ft) bgs] Tc-99 contamination:

- In situ gaseous reduction
- In situ technetium bioreduction
- Vadose zone permeable reactive barrier
- Saturated zone in situ redox manipulation permeable reactive barrier
- Saturated zone bioreduction permeable reactive barrier
- In situ grouting
- Soil desiccation.

4.2.3.1 In Situ Gaseous Reduction

In Situ Gaseous Reduction (ISGR) is a vadose zone remediation technology that uses a hydrogen sulfide/nitrogen gas mixture to chemically reduce contaminants and sediment-associated iron. For contaminants such as chromate, uranium, and technetium, the reduced species are significantly less mobile than the oxidized species. With the reduction of sediment-associated iron, the ISGR technology creates a reducing zone within the subsurface that will continue to reduce contaminants or other oxidants (e.g., oxygen) that migrate into the treatment zone until the reducing capacity becomes depleted. The mobile pertechnetate ion [$Tc(VII)O_4^-$] would be reduced to the +4 valence, which forms immobile compounds. The capacity of the reducing zone is a function of the reducible iron content in the sediment.

The ISGR technology is rejected for further consideration because immobilization of the pertechnetate ion is subject to continued reducing conditions in the vadose soil and because considerable development work is necessary.

4.2.3.2 In Situ Technetium Bioreduction

Microbial reactions have been shown to mediate reduction of pertechnetate, which is highly mobile, to $Tc(IV)O_2$, which is immobile, via two mechanisms:

- Direct coupling of technetium reduction to oxidation of H_2 or organic compounds
  - Lloyd and Macaskie 1996, "A Novel Phosphorimager-Based Technique for Monitoring the Microbial Reduction of Technetium"
  - Lloyd et al. 1997, "Reduction and Removal of Heptavalent Technetium from Solution by *Escherichia coli*"
  - Lloyd et al. 1999, "Reduction of Technetium by *Desufovibrio desulfuricans*: Biocatalyst Characterization and Use in a Flowthrough Bioreactor"
  - Wildung et al. 2000, "Effect of Electron Donor and Solution Chemistry on Products of Dissimilatory Reduction of Technetium by *Shewanella putrafaciens*"
- Microbial reduction of naturally-occurring Fe(III) compounds to produce reactive Fe(II) (i.e., biogenic Fe(II)) that can reduce technetium
  - Cui and Eriksen 1996, "Reduction of Pertechnetate in Solution by Heterogeneous Electron Transfer from Fe(II)-Containing Geological Material"
  - Lloyd et al. 2000, "Direct and Fe(II) Mediated Reduction of Technetium by Fe(II)-Reducing Bacteria"
  - Fredrickson et al. 2004, "Reduction of TcO_4^- by Sediment-Associated Biogenic Fe(II)".

For either mechanism, the process of pertechnetate reduction is initiated through stimulating the activity of microorganisms with an added microbial substrate. Glucose, lactate, and hydrogen have been used to successfully stimulate pertechnetate reduction in laboratory treatments, but other substrates may work equally well. Because microorganisms are the catalyst of the overall reaction, the rate of reaction is proportional to the population of active microbes and their intrinsic rate for the mediating reaction under the prevailing subsurface conditions.

In situ pertechnetate bioreduction technology is rejected for further consideration because immobilization of the pertechnetate ion is subject to continued reducing conditions in the vadose zone soil and because considerable development work is necessary. Furthermore, it is not known if sufficient indigenous microorganisms exist to support the reduction process.

4.2.3.3 Vadose Zone Permeable Reactive Barrier

This activity would establish a zone of reactive material in the path of the pertechnetate that would reduce it to an immobile form. In groundwater, the thickness of permeable reactive barriers is determined based on the groundwater flow rate, the related contaminant and oxygen mass flux rates, and the reaction rates within the barrier. In the vadose zone, the flux of contamination would be much smaller than the flux of oxygen because, while soil moisture is the carrier for contamination, soil gas is the carrier for the oxygen. Thus, the design of a vadose zone barrier is closely linked to the expected transport of Tc-99 over time. Given the uncertainties in Tc-99 transport over time, the likely scenario for applying either bioreduction or ISGR would be to use volumetric treatment or at least to treat a portion (e.g., the bottom portion) of the contaminated zone and reapply the treatment in this zone as needed to maintain reduced conditions for the immobilized Tc-99 and to immobilize Tc-99 that migrates into this zone.

Because this alternative is not significantly different than the volumetric applications of bioreduction and ISGR, it was not carried forward for evaluation.

4.2.3.4 Saturated Zone In Situ Redox Manipulation Permeable Reactive Barrier

This activity would establish a zone of reactive material in the saturated zone that would intercept the pertechnetate and reduce it to an immobile form. A potential application for in situ redox manipulation is to reduce sediment associated Fe(III) in aquifer sediments beneath the BC Cribs and Trenches Area to create a permeable reactive barrier. Application of in situ redox manipulation to create a permeable reactive barrier at the BC Cribs and Trenches Area would be fundamentally the same as the process previously implemented in the 100 D Area at the Hanford Site to treat chromate-contaminated groundwater. Although oxidation of Fe(II)/Mn(II) and Tc(IV) in the saturated zone is a concern as with the vadose zone application of ISGR, the oxidation rate would be expected to be considerably slower than in the vadose zone due to a lower flux of oxygen into the treated zone. The thickness of the permeable reactive barrier would be determined based on the groundwater flow rate, the related contaminant and oxygen mass flux rates, and the reaction rates within the barrier.

Saturated-zone in situ redox manipulation permeable-reactive-barrier technology is rejected because the Tc-99 contamination is far removed from the saturated zone in both time and space. It would not be effective to employ this technology until contaminant entry into the saturated zone is imminent.

4.2.3.5 Saturated Zone Bioreduction Permeable Reactive Barrier

This activity would use microorganisms to establish a zone of reactive material in the saturated zone that would intercept the pertechnetate and reduce it to an immobile form. A potential application for bioreduction is to biologically reduce sediment-associated Fe(III) in aquifer sediments beneath the BC Cribs and Trenches Area to create a permeable reactive barrier. Because it has been demonstrated that biogenic Fe(II) in Hanford (Ringold) subsurface sediment can serve as a facile reductant of Tc(VII) (Fredrickson et al. 2004), this concept could be exploited to reduce Tc-99 in situ in the aquifer in the event that pertechnetate reaches the saturated zone. Although oxidation of Fe(II)/Mn(II) and Tc(IV) in the saturated zone is a concern as with the vadose zone application of bioreduction, the oxidation rate would be expected to be considerably slower than in the vadose zone because of a lower flux of oxygen into the treated zone.

The fundamental application of bioreduction as a saturated zone permeable reactive barrier is the same as described for vadose zone bioreduction, except that the target materials for reduction are only the sediment-associated iron and manganese, and a wider variety of substrates would be suitable to induce bioreduction. Use of soluble substrates such as glucose or lactate would negate the need for the two-step process required in the vadose zone, because these substrates would remove oxygen and stimulate iron and manganese reduction. The thickness of the permeable reactive barrier would be determined based on the groundwater flow rate, the related contaminant and oxygen mass flux rates, and the reaction rates within the barrier.

Saturated zone bioreduction permeable reactive barrier technology is rejected because the Tc-99 contamination is far removed from the saturated zone in both time and space. It would not be effective to employ this technology until contaminant entry into the saturated zone is imminent.

4.2.3.6 Soil Desiccation

This activity would remove soil moisture associated with the pertechnetate, thereby reducing the driving force for its transport toward groundwater. The viability of using subsurface air flow and extraction to remove water from the vadose zone has been demonstrated at the mock tank site in the 200 East Area (PNNL-13820, *Summary of Hanford Subsurface Air Flow and Extraction (SAFE) Activities for Fiscal Year 2002*). In these tests subsurface air flow across a distance of about 20 m (65.6 ft) withdrew about 3785.4 L (1,000 gal) of water in a 3-wk period. The concept for applying soil desiccation at the BC Cribs and Trenches Area site is to use a combination of air injection and extraction to sufficiently dry the subsurface that the migration potential of Tc-99 is significantly reduced. The migration of Tc-99 in the vadose zone is related to the soil moisture content and the flux of water from the ground surface. Drying the soil either above or within the contamination would reduce the potential for migration, create conditions that attenuate the impact of water recharge because more recharge would be necessary before continued downward migration could occur, and provide a means to periodically remove moisture if it begins to build up in the subsurface over time.

The soil desiccation option is retained for further evaluation because it does not introduce additional liquid that could drive existing contamination deeper, nor does it depend on reduction of Tc-99 to achieve immobilization. Also, implementation appears to be feasible. Used in

conjunction with a cap, it appears to offer potential supplemental benefit. It could be effective in minimizing the impact of any infiltration through (or outside of) a cap, in changing subsurface conditions to reduce the driving force for downward contaminant migration, and in periodically reducing the subsurface moisture content. Further study and evaluation is recommended to (1) determine an effective subsurface air-flow design to provide a relatively uniform extraction of soil moisture from targeted areas, (2) assess the expected contaminant concentrations in extracted water, and (3) model or conduct experimentation to identify the amount of water that should be removed and the best subsurface location for water removal.

4.3 SUMMARY OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS RETAINED FOR BC CRIBS AND TRENCHES AREA ALTERNATIVE DEVELOPMENT

Based on the screening presented in Section 4.2, the following remedial technologies and process options (specific technology implementation methodology) were retained for development of the BC Cribs and Trenches Area-specific remedial alternatives (see Table 4-1 also):

- No action
- Land use restrictions – technology
  - Deed restrictions – process option
- Access controls – technology
  - Signs/fences – process option
  - Entry control – process option
- Monitoring – technology
  - Groundwater – process option
  - Vadose zone – process option
  - Air – process option
- Surface barriers – technology
  - Existing soil cover – process option
- Surface barrier/cap – technology
  - ET barriers – process option
  - Standard RCRA Barriers – process option
  - Asphalt, concrete, or cement-type cap – process option
- Vertical barriers – technology
  - Slurry walls – process option
  - Grout curtains – process option
- In situ grouting – technology (fill tanks and pipeline voids)

- Excavation – technology (including sludge removal)
  - Conventional – process option
  - High contamination – process option
  - Sludge retrieval – process option
- Landfill disposal – technology
  - Onsite and offsite landfill disposal – process option
- In situ treatment – technology
  - Natural attenuation – process option
  - Soil Desiccation – process option
- Ex situ treatment – technology
  - Soil mixing - process option.

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

General Response Action	Technology Type	Process Option	Retained in Implementation Plan	Retained in Focused Feasibility Study for BC Cribs and Trenches Area Waste Sites
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 Evapotranspiration Barriers	Surface Barriers	Hanford Barrier	Yes	Yes
		Modified RCRA and other Evapotranspiration Caps	Yes	Yes
		Standard RCRA Caps	No	No
		Asphalt, concrete, or cement-type cap	No	No
	Vertical Barriers	Slurry Walls	Yes	Yes
		Grout Curtains	Yes	Yes
Removal	Excavation	Conventional	Yes	Yes
		High contamination	No	Yes
		Sludge Retrieval	No	Yes
Disposal	Landfill Disposal	Onsite Landfill	Yes	Yes
		Offsite Landfill/Repository	Yes	Yes
Ex Situ Treatment	Thermal Treatment	Thermal Desorption	Yes	No
		Vitrification	Yes	No
	Physical/Chemical Treatment	Vapor Extraction	Yes	No
		Soil Washing	Yes	No

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

General Response Action	Technology Type	Process Option	Retained in Implementation Plan	Retained in Focused Feasibility Study for BC Cribs and Trenches Area Waste Sites
		Mechanical Separation	Yes	No
		Solidification/ Stabilization	Yes	No
		Soil Mixing	Yes	Yes
In Situ Treatment	Thermal Treatment	Vitrification	Yes	No
	Chemical/Physical Treatment	Vapor Extraction	Yes	No
		Grout Injection (pipelines and tanks)	Yes	Yes
		Shallow Soil Mixing	Yes	Yes
		Deep Soil Mixing	Yes	No
		Dynamic Compaction (component of capping)	Yes	Yes
		Soil Desiccation	No	Yes
		Bioreduction of Pertechnetate	No	No
		Gaseous Reduction of Pertechnetate	No	No
	Natural Attenuation	Natural Attenuation	Yes	Yes

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

5.0 REMEDIAL ACTION ALTERNATIVES

The EPA guidance for conducting feasibility studies 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 contaminants of concern. 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 waste sites in the BC Cribs and Trenches Area. The applicability of these alternatives to the individual waste sites also is considered.

5.1 DEVELOPMENT OF ALTERNATIVES

Significant efforts and evaluations have contributed to defining applicable technologies and process options that address the BC Cribs and Trenches Area representative and analogous waste sites. Appendix D of the Implementation Plan (DOE/RL-98-28) provides initial information on identification and screening of remedial technologies for 200 Areas waste sites. The Implementation Plan, in conjunction with Chapter 4.0 of this FFS, represents a Phase I FS and thus forms the basis for the development of remedial alternatives. The Implementation Plan also preliminarily develops remedial alternatives based on the results of the technology screening and the GRAs identified for the waste sites. Remedial alternatives identified in the Implementation Plan for the BC Cribs and Trenches Area waste sites include the following:

- No action
- Monitored natural attenuation/institutional controls
- Removal, treatment, and disposal (onsite disposal and geologic repository)
- Containment using surface barriers
- In situ grouting or stabilization
- In situ vitrification
- In situ soil mixing
- Ex situ soil mixing.

Table 5-1 illustrates the process of identifying technology types, combining process options, and presenting the elements of each alternative. The no-action alternative is a requirement under CERCLA. The monitored natural attenuation/institutional controls alternative is retained and further developed in this FFS for sites where existing remedial actions are in place or where contamination is expected to reach RAOs within a reasonable institutional controls period. The removal, treatment, and disposal alternative and the containment (capping) using surface barriers alternative also are retained and further developed in this FFS. The in situ grouting or stabilization and in situ vitrification alternatives, as stand-alone alternatives, are screened out of this FFS because of (1) implementation problems associated with the depth of contamination at the waste sites, (2) effectiveness issues with ensuring a complete stabilization of contaminated materials, and (3) high cost in relation to other alternatives. However, these technologies are retained for inclusion as elements of other remedial actions. One additional alternative is developed in this FFS that was not identified in the Implementation Plan (Alternative 5). This

alternative is a combination alternative that includes partial removal, treatment, and disposal with subsequent capping. 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. As such, these compounds must be removed, physically immobilized, contained, or chemically converted to a less mobile or less toxic form to meet the RAOs. Development of alternatives recognized that the regulatory agencies have a statutory preference for treatment and removal alternatives rather than containment remedies.

5.2 DESCRIPTION OF ALTERNATIVES

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

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

5.2.1 Alternative 1 – No Action

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

Based on the waste site evaluations and the results of the risk assessment, none of the representative sites meet the RAOs using the no-action alternative. The no-action alternative is carried forward in this FFS for comparison purposes.

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

This alternative takes advantage of existing soil covers and the nature of the contaminants (such as the natural attenuation of Cs-137 and Sr-90, which have relatively short half-lives), in combination with institutional controls, to provide protection of human health and the environment. Monitoring is also an element of this alternative. For most of the waste sites in

these OUs, an existing soil cap is present that is associated with the actual construction of the waste site (i.e., the waste site was constructed at depth and clean backfill was placed in the excavation to the surface) and with surveillance and maintenance activities, where additional soil was added to stabilize the waste sites. Under this alternative, these existing soil covers would be maintained and/or augmented as needed to provide protection from intrusion by human and/or biological receptors. Selective herbicides may be applied to prevent establishment of deep-rooted plants. Institutional controls, including legal and physical barriers, also would be used to prevent human access to the site. The existing soil covers and/or caps would break the pathway between human and ecological receptors and the contaminants. WAC 173-340-745(7), "Soil Cleanup Standards for Industrial Properties," "Point of Compliance," identifies the points of compliance for different pathways as follows.

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

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

Based on literature searches regarding the root and burrowing depths of vegetation and animals present on the Hanford Site, a sufficient soil thickness to prevent biological intrusion generally would be 2.4 to 3.0 m (8 to 10 ft). Many of the BC Cribs and Trenches Area waste sites have a soil cover (i.e., surface stabilization, backfill) over the contaminated zone of 3 m (10 ft) or more.

Institutional controls involve the use of physical barriers (fences) and access restrictions (deed restrictions) to reduce or eliminate exposure to contaminants of concern. Institutional controls also can include groundwater, vadose zone, surface soil, biotic, and/or air monitoring. Institutional controls for this alternative include periodic surveillance of the waste sites for evidence of contamination and biologic intrusion; vegetation emplacement, 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.

For sites having a clean soil cover of less than 4.6 m (15 ft), more stringent institutional controls (e.g., physical and legal barriers) would need to be implemented to address potential risks from direct human and ecological contact with the contaminants. Water- and land-use restrictions also would be used to prevent exposure.

Contaminants remaining beneath the clean soil cover would be allowed to naturally attenuate until remediation goals are met. Natural attenuation relies on natural processes to lower contaminant concentrations until cleanup levels are met. Monitored natural attenuation 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 Directive No. 9200.4-17P), to verify that contaminants are attenuating as expected. Attenuation monitoring activities could include monitoring of the vadose zone using geophysical logging methods or groundwater monitoring to verify that natural attenuation processes are effective.

The existing network of groundwater monitoring wells is unsatisfactory in the BC Cribs and Trenches Area, necessitating the need for additional monitoring wells. 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 as required to meet PRGs and waste acceptance criteria, and disposed of to an appropriate facility. A generalized cross-section of this activity is shown in Figure 5-1. The disposal facility chosen depends on the type of waste to be disposed of. The waste generated under this alternative would be disposed of at the ERDF. Although historical estimates indicate the potential for the 216-B-53A Trench to contain transuranic constituents above levels of concern, recent adjustments to inventory make this unlikely.

Soil and associated structures (such as cribs) with contaminant concentrations above the PRGs would be removed using conventional excavation techniques where appropriate, or specialized excavation techniques where contamination levels require added protection (these specialized techniques are discussed in greater detail in Chapter 4.0). Precautions would be used to minimize the generation of onsite fugitive dust. The depth, and therefore the volume, of soil removed largely depend on the categories of PRGs that are exceeded. For example, if human health direct-contact or ecological PRGs are exceeded, removals generally would be conducted to a maximum of 4.6 m (15 ft) in line with the points of compliance identified in WAC 173-340-745 and WAC 173-340-7490. Conversely, if groundwater protection were required, soils would be removed to meet groundwater protection PRGs, as shown in Table 5-2. Below-grade structures extending below 4.6 m (15 ft) would be removed, if practicable, or stabilized in place.

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. Data are collected to assess the extent of contamination and to make "real-time" decisions in the field. Targeted removals could be considered under this alternative if contamination were localized in only a portion of a waste site.

Based on existing information, soil and/or debris removed from the waste sites do not require ex situ treatment to meet ERDF waste acceptance criteria (BHI-00139, *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 would be blended with less contaminated soil to achieve ALARA goals and to reduce worker risks at all points in the removal and disposal process. Contaminated soil, structures, and well casings would 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 were 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 was determined to be clean (verified as clean by meeting the PRGs). Following remediation, the site would be recontoured, resurfaced, and/or revegetated to establish natural site conditions. Maintenance of the site would be required until the vegetation was sufficiently established to prevent intrusion by noxious, non-native plants such as cheatgrass or Russian Thistle.

5.2.4 Alternative 4 – Capping

The capping alternative consists of constructing surface barriers over contaminated waste sites to control the amount of water that infiltrates contaminated media, to reduce or eliminate leaching of contamination to groundwater. In addition to their hydrological performance, barriers also can function as physical barriers to prevent intrusion by human and ecological receptors, limit wind and water erosion, and attenuate radiation. Additional elements to the capping alternative include institutional controls, discussed earlier, and monitored natural attenuation, where contamination undergoes natural processes in a reasonable amount of time. This is particularly important for waste sites that have elevated contamination levels that pose a threat to groundwater or to potential intruders past the institutional controls period. For example, many of the waste site bottoms are located above 4.6 m (15 ft), with the soil above the waste site being clean backfill. Thus, elevated concentrations of radionuclides (mainly Cs-137 and Sr-90) are expected to extend down from the bottom of the waste site for a few feet. Also, mobile contaminants such as Tc-99 and nitrate are found at depth in the waste sites. This combination of contaminants presents a zone of exposure to future intruders to the waste sites and a potential threat to the groundwater. Therefore, the capping alternative would have to consider layers or other actions that would prevent, or at least warn, potential intruders of the hazard.

The preferred capping technology for the BC Cribs and Trenches Area waste sites is an ET barrier, as shown in Figure 5-2. However, if significant intruder threat accompanied the groundwater threat, this cap would need to include features to address that risk. In that case, the ET cap might look like the Modified RCRA Subtitle C Barrier depicted in Figure 5-3. The ET surface barriers rely on the water-holding capacity of the soil, evaporation from the near-surface, and plant transpiration to control water movement through the barrier. The most appropriate barrier would be determined during design. A mix of simple ET barriers and the Modified RCRA Subtitle C Barriers is used as the basis for evaluating this alternative; this does not preclude the use of other ET designs (e.g., monolithic barrier). Both monolithic and capillary barriers have been shown to be equivalent to or to exceed the performance of the standard RCRA Subtitle C Barrier design, and both have been approved or planned for use in several western

states (EPA 2003, *Remediation Technology Descriptions*, "Alternative Landfill Cover Project Profiles"; and DOE/RL-93-33). If capping is identified as the preferred alternative, finalization of site-specific designs will occur as part of the remedial design process and will consider the RAOs and requirements defined in the ROD, regulatory design and performance standards, material availability, cost effectiveness, current surface barrier technology information, and site-specific hydrologic and physical performance requirements to ensure waste containment. Different waste sites likely will have varying barrier performance requirements, and more than one barrier design (e.g., monolithic and capillary barrier) may be deployed to address waste site capping needs.

When groundwater protection is required, the cap will limit the infiltration of precipitation. When the prevention of ecological and human intrusion is a performance requirement, then the physical barrier components to the cap become more important. The capping alternative includes provisions for groundwater monitoring for those waste sites with contamination predicted to threaten groundwater maximum concentration levels.

Performance monitoring of the Hanford Barrier, installed at the 216-B-57 Crib in 1994, has shown essentially no water percolation through the barrier (CP-18187). The effectiveness of the cap is related to the design, which must be specific to the conditions at the waste site, and to continued monitoring activities. Fate and transport modeling for the BC Cribs and Trenches Area (see Appendix G) has shown that reducing the infiltration rate to 0.1 mm/yr by use of a cap would extend the time before the MCL is exceeded at the vadose zone/groundwater interface from 108 yr to 201 yr. Additional modeling will be needed to design an appropriate cap to achieve the most effective protection of groundwater.

Use of a capping alternative would require an assessment of the lateral extent of contamination during the confirmatory and/or remedial design sampling phases to properly size the cap to ensure containment. The site-specific extent of contamination can be assessed using a variety of approaches including, but not limited to, process knowledge, previous site investigations, geophysical logging, and/or soil sampling. Some degree of oversizing of the barrier beyond the footprint of the waste zone (referred to as overlap) is expected and is dependent on the barrier design used and the depth of contamination. For the purposes of this FFS, an overlap of 22.9 m (75 ft) is assumed based on recent geophysical characterization of the 216-B-26 Trench vicinity. The type and availability of barrier construction materials also is a design consideration. The results of the most recent investigation (D&D-25575, *Silt Borrow Source Field Investigation Report*) will be considered during remedial design for selection of the barrier construction materials.

Caps require surveillance and maintenance throughout their life to ensure continued protection. To ensure that the cap is performing as designed, performance monitoring will be conducted. The performance monitoring for this alternative will be twofold. The first component is groundwater monitoring. The second component is vadose zone monitoring, if practical. This FFS assumes fairly robust performance monitoring during the first 5 years after construction, followed by more focused monitoring in subsequent years. For barriers that use naturally stable geologic materials, the key factor establishing life expectancy is projected wind-erosion rates, which will be minimized by maintaining the vegetation cover, adding gravel to the upper portion of the surface layer, or by using other armoring methods.

5.2.5 Alternative 5 – Partial Removal, Treatment, and Disposal with Capping

Figure 5-4 depicts a generalized remedial action that combines excavation of near-surface contamination with capping. This alternative would remove high-activity, near-surface contaminants from affected waste sites that may require significant soil mixing to achieve ERDF waste acceptance criteria. If the near-surface contamination is present as localized "hot spots" rather than being uniformly distributed along the trench footprint, the mixing would be employed only as necessary. Excavation would be to the maximum depths listed in Table 5-3, which are approximately 1 m (3 ft) below the depth corresponding to the maximum activity. Following excavation, the waste site would be backfilled with clean borrow soil and capped as discussed above, except that the cap would not require intrusion-deterrent features. These activities would remove a majority of the near-surface contaminant load. The removal, treatment, disposal, and capping activities would be the same as or similar to those described in Chapter 4.0 and in the preceding subsections except that removal activities would be focused at reducing the mass of contaminants associated with the bottom of the waste site, which would, in turn, reduce the potential intruder risk. The disposal options would be the same. The required cap would be less rigorous than if these contaminants were left in place, because the inadvertent intruder risk is significantly reduced. For example, a monofill soil barrier may be appropriate. The actual design of the barrier would be determined through the detailed design activities. Table 5-3 lists the contamination zone for each representative site. If contaminants are not in the 0 to 4.6 m (0 to 15-ft) zone, then the resulting risk reduction to humans and ecological receptors from direct contact to shallow-zone contamination would be zero. The point of compliance for direct exposure is the 0 to 4.6 m (0 to 15-ft) zone, so contaminants deeper than this only would reduce the risk to intruders. Contaminants that impact the groundwater are located much deeper in the vadose zone than 6.1 m (20 ft). Therefore, the removal of contaminants from the 0 to 6.1 m (0 to 20-ft) zone would not significantly change the risk to groundwater. The capping activity provided in this alternative would address protection of groundwater from the remaining contaminants in the vadose zone. Institutional controls would be an additional requirement for this alternative, because contamination above PRGs is left on site.

5.3 200-E-14 SIPHON TANK SLUDGE REMOVAL

Sludge removal from the 200-E-14 Siphon Tank is included in Alternatives 3 and 5, given the potential nature and volume of sludge material in this tank. The potential for sludge/residual waste liquid in this tank could represent significant risk to human intruders with the top of the tank (and potential access to tank contents) being within 2.1 m (7 ft) of the surface. However, further analysis during the confirmatory sampling activities may result in other options for the sludge. These options will be evaluated following the confirmatory sampling activities at the tanks.

5.3.1 Sludge Removal at the 200-E-14 Siphon Tank

If sludge removal from the 200-E-14 Siphon Tank is recommended, it will be addressed as described below.

Alternatives for this tank were evaluated by reviewing two previous studies. The first study, HNF-6354, was reviewed to assess applicable sludge-removal options. Based on the review, all the options studied in HNF-6354 could apply to the tank. The follow-up report, DOE/RL-2003-52, looked at three options: in situ vitrification; in situ stabilization; and ex situ retrieval, treatment, and storage. All options present challenges. However, because of the amount and nature of material in the tanks (as predicted by BHI-01018, Rev. 2, *Environmental Restoration Contractor Management Plan for Inactive Miscellaneous Underground Storage Tanks*, removal and ex situ treatment of the sludge is assumed. As currently envisioned, removal and disposal of the sludge will be implemented by excavating to the top of the tanks to access the manhole covers. The sludge then can be mixed and retrieved from the manholes into an applicable container (e.g., high-integrity containers with dewatering capabilities). These high-integrity containers will be shielded as needed. If necessary, shielding also can be placed over the tank and manhole to reduce personnel exposure during sludge-removal operations.

Water removed during dewatering of the sludge in the high-integrity containers can be returned to the tank to assist in sluicing sludge from the tank. The water removed during dewatering can be treated, if required for disposal, and then disposed of on site. During sludge-removal operations, high-efficiency particulate air -filtered exhausters can be attached to a riser to control airflow through the manholes, into the tank, and out the risers, thereby reducing potential airborne contamination at the work areas. The tank contents would be sampled before they were removed to determine sludge handling, packaging, treatment, and disposal options.

5.4 PRINCIPAL-THREAT WASTE

Principal-threat considerations associated with the BC Cribs and Trenches Area waste sites were described in Chapter 2.0. In this section, particular focus is directed toward application of specific remedial actions that have the potential to remediate principal threats. Both near-surface high concentrations of Cs-137 and deep contaminants, particularly Tc-99, are considered principal-threat wastes.

Potential remedial alternatives to treat the near-surface waste include excavation (and treatment to satisfy waste disposal requirements), in situ treatment to immobilize it, and natural attenuation.

Excavation represents the most complete remedy, in that the source material would be removed and unavailable to potential human or environmental exposure, except at its disposal site. The relatively near-surface positioning of the highest contamination material would facilitate its excavation. However, because of the high activity of this waste, excavation and disposal would be accompanied by substantial down blending of the waste (up to a factor of approximately 7 and perhaps higher for localized regions) to meet ERDF waste acceptance criteria, resulting in significant magnification of the time and cost to effect the excavation, and potential increased worker exposure. Excavation of those waste sites that are predicted to contain the highest concentrations of Cs-137 and thus represent the highest near-term threat to human health is the focus of Alternative 5 (see Section 5.2.5). Excavation is retained as a potential alternative to address the near-surface principal threat waste.

In situ immobilization via vitrification or grouting would leave the waste in place but place it in a form that is less amenable to human and/or environmental uptake. Both techniques would achieve some measure of contaminant immobilization relative to the pathways leading to uptake and exposure. Consequently, overall risk to an inadvertent intruder would be reduced. This risk reduction results primarily from reduced contaminant uptake; risk associated with direct exposure would be essentially unchanged. It is not likely that complete immobilization would be achieved because of waste/matrix heterogeneity, but overall benefit would be realized. Waste vitrification would be expected to offer greater relative immobilization relative to grouting. As described in Section 4.2.1.6, grout injection and vitrification are rejected for this FFS because of the size of the waste sites and the unproven effectiveness of grout injection and vitrification on large-scale sites having radiological and chemical hazards.

Jet grouting is a technique that has been used primarily to stabilize soil, to facilitate subsequent construction activities or to limit soil permeability. This technique is characterized by injection of binder into the soil at high pressure and velocity to break up the soil particles and mix them with the binder to achieve a homogeneous mixture that then solidifies. Contaminants associated with the soil particles are captured and rendered less mobile by virtue of the binder, which typically is a water/cement/bentonite mix when impermeabilization of the soil is desired. The capability to achieve a homogeneous product is particularly attractive from the perspective of reducing the overall mobility of the contamination. Jet grouting has been demonstrated at depths exceeding 18.3 m (60 ft), which is several times the depth associated with the high Cs-137 and Sr-90 concentrations expected at the trenches and cribs in this area. Furthermore, because the region of high contamination is on the order of 1.2 to 2.4 m (4 to 8 ft) thick in addition to being within 6 m (20 ft) of the surface, achievement of thorough mixing and immobilization would be facilitated. Finally, those same features would facilitate overall effectiveness evaluation. However, because of the extensive area represented by these waste sites, jet grouting is rejected in this FFS.

Options addressing the principal threat waste represented by Tc-99 are removing the Tc-99, immobilizing it in situ to prevent its transport to the groundwater, or treating the groundwater after the Tc-99 has reached it to remove the threat. Groundwater remediation represents the last line of defense.

Excavation to remove the Tc-99 is feasible but would be very costly relative to capping. Near the surface of the excavation, high concentrations of Cs-137 and Sr-90 are located that would require deliberate ALARA procedures to achieve acceptable worker dose. Once that material was removed, excavation to the depth of the Tc-99 would be relatively straightforward except for the magnitude of the excavation. Cost probably would be prohibitive because of the necessity to excavate several dozen acres to greater than 40 m (130 ft). Considering that no imminent threat exists, and considering the magnitude of the potential excavation, this remedy is not practical.

In situ treatment of Tc-99 has been the goal of recent studies aimed at reducing the highly mobile pertechnetate ion to a less mobile valence state. Bioremediation has been shown to achieve such reduction either by direct interaction with the pertechnetate ion or by indirect interaction with iron that generally exists in the soil, which in turn reduces the pertechnetate ion. Also, hydrogen sulfide injection into the soil is capable of reducing the pertechnetate ion to immobilize it. However, each of these technologies is dependent on maintaining reducing conditions in the vadose zone. Otherwise, eventual reoxidation would be expected to remobilize the Tc-99.

In situ soil desiccation, as described in Section 4.2.3.7, does appear to warrant further consideration, with the potential to restore the vadose zone moisture to pre-effluent discharge levels. Although this technology currently is not implementable, it is believed that it deserves further attention.

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

Technology Type	Process Option	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
No action	No action	X				
Land-use restrictions	Deed restrictions		X		X	X
Access controls	Signs/fences		X		X	X
	Entry control		X		X	X
Monitoring	Groundwater		X		X	X
	Vadose zone				X	X
	Air		X		X	X
Surface barriers	Existing soil cover		X			
	Evapotranspiration barriers				X	X
	Engineered arid climate barriers				X	
In situ physical treatment	Grouting				X[a]	X[a]
Ex situ physical treatment	Soil mixing			X		X
Removal	Conventional excavation			X		X
	Excavation in high-contamination areas			X		X
	Sludge removal		X	X	X	X
Landfill disposal	Onsite landfill			X		X
	Offsite landfill/repository					
Monitored natural attenuation	Monitored natural attenuation	X	X		X	X

[a]For filling pipelines or tanks or for stabilizing cribs or other structures to prepare for placement of a cap.

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

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

Representative Site	Depth of Overburden (ft bgs)	Depth of Contaminated Soil (ft bgs)	Total Depth of Excavation (ft bgs)
216-B-46 Crib	18	220	220
216-B-26 Trench	12	150	150
216-B-58 Trench	10	24	24

bgs = below ground surface.

Table 5-3. Depth of Excavation for Alternative 5 - Partial Removal and Capping.

Representative Site	Depth of Clean Overburden (ft bgs)	Potential Greatest Radionuclide Peak (ft bgs)	Total Depth of Excavation (ft bgs)
216-B-46 Crib (extrapolated to the 216-B-14 Series Cribs)	11	15	20
216-B-26 Trench	11	12	15

bgs = below ground surface.

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6.0 DETAILED ANALYSIS OF ALTERNATIVES

This chapter presents the detailed analysis of the remedial alternatives described in Chapter 5.0 for the BC Cribs and Trenches Area waste sites included in this FFS. The waste sites evaluated in this FFS have characteristics (e.g., size, waste type, extent of contamination, location) that influence the analysis of the CERCLA evaluation criteria. Analogous waste sites were assigned to sampled sites in Chapter 2.0. These assignments are based on the physical framework and expected distribution of contamination using available information and process knowledge. The assignments in Chapter 2.0 also include the relationship between the sampled site and similar analogous sites. For example, an analogous site that is very similar to the sampled site is assumed to have risks and contaminant distribution similar to those of that site. Therefore, the detailed analysis for the sampled site is assumed to be appropriate for the analogous site. If the analogous site is assumed to be either less contaminated (and therefore less risky) or more contaminated (and therefore more risky) than the sampled site, then the analogous site is evaluated considering site-specific differences from the sampled site. The detailed analysis of alternatives for the sampled site also will include an evaluation of these site-specific differences and their influence on alternative selection for the analogous sites.

The detailed analysis is presented by alternative. The evaluation of the sampled sites is included within the discussion of each alternative. Tables 6-1 through 6-4 provide a summary of the detailed analyses for the sampled sites and all analogous sites.

Figure 6-1 guides the application of alternatives to the sampled sites using overall protection of human health and the environment as its decision basis. The starting point of this tool is an evaluation of risk for each individual sampled site based on contaminants of concern, their mobility in the Hanford Site environment, and their location in the vadose zone with respect to ground surface.

The identified alternatives reflect the nature of the contaminants at each site and the assumed land use. Currently, the land use for the 200 Areas is industrial in nature, associated with the management of waste. This land use can be reasonably predicted to be the same for the next 50 yr, given DOE's current commitment to vitrify waste in the tank farms. Industrial use is assumed after that period. Loss of active institutional control is evaluated after 150 yr. The COCs are persistent beyond 150 yr at all the representative sites. Risks to intruders were calculated for the sampled sites in Appendix E.

6.1 DESCRIPTION OF EVALUATION CRITERIA

The EPA has developed nine CERCLA evaluation criteria, defined in 40 CFR 300.430(e)(9)(iii), "Remedial Investigation/Feasibility Study and Selection of Remedy," "Feasibility Study," "Detailed Analysis of Alternatives," "Nine Criteria for Evaluation," to address the statutory requirements and the technical and policy considerations important for selecting remedial alternatives. These criteria serve as the basis for conducting detailed and comparative analyses and for the subsequent selection of appropriate remedial actions.

The nine CERCLA evaluation criteria are as follows:

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

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

The next five criteria (long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost) are balancing criteria on which the remedy selection is based. The CERCLA guidance for conducting an FS lists appropriate questions to be answered when evaluating an alternative against the balancing criteria (EPA/540/G-89/004, *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final*, OSWER 9355.3-01). The detailed analysis process in this chapter addresses these questions, providing a consistent basis for the evaluation of each alternative.

The final two criteria, state and community acceptance, are modifying criteria. The criterion of state acceptance will be addressed in the PP (DOE/RL-2004-69), a document prepared by the Tri-Parties. The PP 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 PP for public review and comment. The preferred alternative could change in response to public comments or new information.

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 both *Secretarial Policy on National Environmental Policy Act* (DOE 1994) and DOE O 451.1B, *National Environmental Policy Act Compliance Program*. Potential effects on NEPA values also are discussed in this chapter.

6.1.1 Overall Protection of Human Health and the Environment

This criterion determines whether adequate protection of human health and the environment, including preservation of natural systems and biological diversity, is achieved through implementation of the remedial alternative. Protection includes reducing risk to acceptable levels, either by reducing contaminant concentrations or by eliminating potential routes for exposure, and minimizing exposure threats introduced by actions during remediation. Environmental protection includes avoiding or minimizing impacts to natural, cultural, and

historical resources. This criterion also evaluates the potential for human health risks, the extent of those risks, and whether a net environmental benefit will result from implementing the remedial alternative.

This first criterion is a threshold requirement and is the primary objective of the remedial action program. As indicated in EPA guidance, this criterion and the criteria for compliance with the ARARs, long-term effectiveness and permanence and short-term effectiveness, overlap (EPA/540/G-89/004). This FFS used the CERCLA risk range of 1×10^{-4} to 1×10^{-6} for human health as the indication of protectiveness. Alternatives were measured against this standard to determine if the alternative meets this criterion. Protection of groundwater was measured against groundwater protection standards derived from the MCLs identified in 40 CFR 141 and on fate and transport modeling, reported herein and in DOE/RL-2002-42. The ecological compliance was evaluated using screening levels in WAC 173-340-900, Table 749-3, and DOE/STD-1153-2002.

6.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

The ARARs are any appropriate standards, criteria, or limitations under any Federal environmental law or more stringent state requirement that must be either met or waived for any hazardous substance, pollutant, or contaminant that will remain on site during or after completion of a remedial action. The ARAR identification process is based on CERCLA guidance (EPA/540/G-89/006, *CERCLA Compliance with Other Laws Manual: Interim Final*, and EPA/540/G-89/004. Potential Federal and state chemical-, location-, and action-specific ARARs associated with remediation of the BC Cribs and Trenches Area waste sites are presented in Appendix B, and each alternative is assessed for compliance against these ARARs. When an ARAR is not met, the basis for justifying a waiver must be presented.

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 technical components of the alternative.

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

6.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

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

This criterion focuses on the following factors for each alternative:

- The treatment processes used and the materials treated
- Whether recycling, reuse, and/or waste minimization are part of 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 off-gas emissions
- Physical, biological, and cultural impacts that might result from the construction and implementation of the remedial action, and whether the impacts can be controlled or mitigated
- The amount of time for the RAOs to be met.

Short-term human health impacts are closely related to the duration of exposure to hazardous waste and the risks associated with waste removal. The greater the exposure time, the greater the risk. Guidelines will be followed during implementation of the remedial action to minimize worker risks and maintain exposures 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 (e.g., failures)
- Administrative feasibility
  - Ability to coordinate activities with other offices and agencies
  - Potential for regulatory constraints to develop (e.g., as a result of uncovering buried cultural resources or encountering endangered species)
- Availability of services and materials
  - Availability of adequate onsite or offsite treatment storage capacity, and disposal services, if necessary
  - Availability of necessary equipment, specialists, and provisions to ensure obtaining any additional resources, if necessary.

6.1.7 Cost

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

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

6.1.8 State Acceptance

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

6.2 DETAILED ANALYSIS OF ALTERNATIVES

This section presents the detailed analysis of the alternatives under an industrial (exclusive) land-use scenario. This section also presents the NEPA evaluation.

Detailed evaluations were performed on all sampled sites and other sites where sufficient data were available. Data obtained at the sampled sites were used to evaluate similar (analogous) sites. Furthermore, for costing purposes, all sites within the BC Cribs and Trenches Area are grouped in logical units for remedial actions.

The remainder of this chapter evaluates the alternatives on a sampled site basis.

The 216-B-26 Trench is the representative site for the following analogous waste sites:

- The 216-B-20 through 216-B-22 Trenches
- The 216-B-23 through 216-B-34 Trenches
- The 216-B-52 Trench
- The 200-E-114 Pipeline.

The 216-B-58 Trench is the representative site for the following analogous waste sites:

- The 216-B-53A Trench
- The 216-B-53B Trench
- The 216-B-54 Trench

The 216-B-46 Crib is the representative site for the following analogous waste sites:[2]

- The 216-B-14 through 216-B-19 Cribs
- The 200-E-14 Siphon Tank.

Tables 6-1 through 6-4 provide a summary of the detailed analysis for all of the waste sites in the BC Cribs and Trenches Area.

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[2] Note that the 216-B-46 Crib, which is the representative site for some of the BC Cribs and Trenches Area analogous waste sites, is not, itself, located in the BC Cribs and Trenches Area.

6.2.1 Detailed Analysis of Alternative 1: No Action

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

6.2.1.1 Overall Protection of Human Health and the Environment

For the BC Cribs and Trenches Area waste sites, the no-action alternative would fail to provide overall protection of human health and the environment, because contaminants at concentrations above the PRGs would remain on site with no measures performed to prevent intrusion to the contaminants or to monitor their migration. Because of these circumstances, this alternative fails to meet this criterion under CERCLA for all three waste site groups. A possible exception is the 200-E-114 Pipeline, if no soil contamination is found and no residual liquid exists within the piping.

6.2.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

Because no action would be taken to control the exposure pathways, this alternative would not meet the ARARs for any of the three waste site groups, including the 200-E-114 Pipeline, presuming it contains residual contamination.

6.2.1.3 Long-Term Effectiveness and Permanence

Long-Term Effectiveness and Permanence for Human Health. For all three sampled sites and their associated analogous waste sites, the no-action alternative fails to provide long-term effectiveness and permanence for human health, because contaminants would remain on site at concentrations that are above the PRGs. Because of these circumstances, this alternative fails to meet this criterion under CERCLA

Long-Term Effectiveness and Permanence for Groundwater. Contaminants are predicted to reach the groundwater at two of the three sampled sites (216-B-26 Trench and 216-B-46 Crib). Therefore, Alternative 1 does not provide long-term effectiveness for groundwater protection.

Long-Term Effectiveness and Permanence for the Environment. Based on sampled site data, the 216-B-46 Crib meets the standard for protection of the environment in the 0 to 4.6 m (0 to 15-ft) bgs zone. However, based on knowledge of individual analogous sites, there are contaminants in the 0 to 4.6 m (0- to 15-ft) bgs zone. The other two representative sites, the 216-B-26 and 216-B-58 Trenches, also have contaminants located in the shallow soils (0 to 4.6 m [0 to 15 ft] bgs). Therefore, Alternative 1 fails to meet the protectiveness criterion for the environment at all of the waste sites.

6.2.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume would occur at all the waste sites in the form of natural attenuation. Natural attenuation is a process that results in a reduction of toxicity, mobility, or volume through the natural radioactive decay process. Radioactive decay is the only process currently available to eliminate nuclear particle emissions. Most of the contaminants identified during characterization would be influenced by the radioactive decay process;

however, concentrations are high enough to require long time periods for radionuclides to decay to PRG levels (hundreds, and in a few cases thousands, of years).

In EPA/540/R-99/009, the EPA acknowledges that natural attenuation can be an appropriate treatment for contaminated soil. Because of uncertainties in the science of natural attenuation processes, the EPA considers source control and performance monitoring to be fundamental components of the remedy. The no-action alternative does not use any source control or monitoring. Because of the concentrations of contaminants and the substantial length of time required for natural attenuation processes to meet PRGs, this alternative fails to meet this criterion under CERCLA for all waste site groups.

6.2.1.5 Short-Term Effectiveness

No short-term worker risks would be associated with the no-action alternative, because remedial activities would not be conducted. Current risks to workers are not an issue because of existing protective soil covers and appropriate safety measures for work activities. Current risks to the environment would not be addressed for the 216-B-26 and 216-B-58 Trenches, where ecological risk exists (i.e., contaminants are above PRGs in the 0 to 4.6 m [0 to 15-ft] zone). Therefore, this alternative fails to meet this criterion at these two representative sites with shallow contamination. Also, because RAOs will not be achieved except by natural attenuation requiring hundreds to thousands of years, this criterion is not met.

6.2.1.6 Implementability

The no-action alternative could be implemented immediately and would not present any technical problems. All sampled sites and their analogous waste sites currently are undergoing in situ natural attenuation.

6.2.1.7 Cost

The no-action alternative would involve no cost. The ongoing cost of 5-yr reviews was not included, because it would be inconsequential compared to the cost of alternatives requiring remedial action.

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

Under this alternative, the existing soil cover would be maintained to provide protection from intrusion by human and/or biological receptors. Legal and physical barriers also would be used to prevent human access to the site. The existing soil cover would break the exposure pathway between human and ecological receptors and the contaminants. Groundwater monitoring is included in this alternative. Natural attenuation eventually would mitigate risk, although the time required would be unacceptably long for some radionuclides, such as Tc-99.

6.2.2.1 Overall Protection of Human Health and the Environment

Alternative 2 would provide overall protection of human health and the environment for sites that show protection of groundwater and achieve human health and environmental protection within the period of active institutional controls. After this period, an advertent intruder may not be protected. This alternative fails to meet this criterion, because the sampled waste sites have contamination (high concentrations of short-lived radionuclides and long-lived radionuclides) that would not attenuate below PRGs within that time period. Alternative 2 would do nothing to mitigate the potential impact of principal threat waste.

216-B-26 Trench and Its Analogous Sites - This waste site and its analogous waste sites are assumed to exceed human health direct-contact and ecological PRGs in the 0 to 4.6 m (0 to 15 ft) bgs vadose zone, and groundwater protection criteria, based on evaluation of the 216-B-26 Trench site. The sites have or are assumed to have significant concentrations of radionuclides just above 4.6 m (15 ft) that pose a risk to intruders above RAOs (see Table 2-8 and Appendix E). These contaminants will take more than 150 yr to naturally attenuate to levels that would achieve PRGs for the protection of human intruders. As such, this alternative is not protective of human health or the environment for these waste sites.

A potential exception is the 200-E-114 Pipeline. The pipeline is a 6 cm (2.4-in.-) diameter steel pipe connecting the 216-BY-201 Settling Tank located in the BY Tank Farm to the 200-E-14 Siphon Tank in the BC Cribs and Trenches Area. Because there have been no documented leaks in the portion of the pipeline associated with the BC Cribs and Trenches Area, this site may not present excessive risks after 150 yr to human health and the environment. However, sections of the pipeline may contain residual liquid or sludge, which could represent unacceptable risk.

216-B-58 Trench and Its Analogous Sites - The 216-B-58 Trench and its analogous sites exceed human health direct-contact and ecological PRGs in the 0 to 4.6 m (0 to 15-ft) zone. In addition, this site exceeds ecological criteria in the 0 to 4.6 m (0 to 15-ft) bgs zone. The majority of the sites in this waste group have significant concentrations of radionuclides just below 3.7 m (12 ft) that pose a limited threat to intruders (see Table 2-8 and Appendix E). As such, this alternative generally is not protective of human health or the environment.

216-B-46 Crib Analogous Sites - All waste sites in this group are assumed to exceed groundwater protection criteria and to have human health risk above 15 mrem/yr at 150 yr, based on the evaluation of the 216-B-46 Crib representative site. Although the 216-B-46 Crib possesses significant concentrations of radionuclides just below 4.6 m (15 ft) bgs, construction data for the BC Cribs and Trenches Area waste sites indicate that contamination is more shallow (i.e., beginning near 3.6 m (12 ft) bgs). These radionuclides pose a considerable threat to intruders (see Table 2-8 and Appendix E for a summary of intruder risks). These contaminants will take more than 150 yr to naturally attenuate to levels that would achieve PRGs for the protection of human intruders. As such, this alternative generally is not protective of human health or the environment.

A potential exception is the 200-E-14 Siphon Tank, which has unknown contents (it may be essentially empty) and for which there have been no reported leaks.

6.2.2.2 Compliance with Applicable or Relevant and Appropriate Requirements

Under Alternative 2, the ARARs generally would not be met at any of the three sampled sites. Fate and transport modeling indicates that the mobile contaminants (e.g., nitrate and Tc-99) are expected to impact groundwater and may exceed MCLs in the future. In the absence of institutional controls, unauthorized intrusive activities to depths greater than 4.6 m (15 ft) bgs would result in unacceptable exposures at most sites. Additionally, two sampled sites (216-B-26 Trench and 216-B-58 Trench) exceed human health and ecological risk-based PRGs in the 0 to 4.6 m (0 to 15-ft) zone; these PRGs are based on the ARARs. Also, one site, the 200-E-114 Pipeline, may exceed risk based PRGs for ecological protection if past leaks occurred or if residual liquid exists in the piping. Similarly, the 200-E-14 Siphon Tank could exceed PRGs for ecological protection.

6.2.2.3 Long-Term Effectiveness and Permanence

Human Health:

Alternative 2 would rely on natural attenuation (e.g., radioactive decay) to decrease contaminants until concentrations reached levels that would be protective of human health and the environment. As mentioned under Alternative 1, natural attenuation is a proven and acceptable technology. This alternative would incorporate the use of institutional controls to prevent inadvertent human and biological intrusion into the waste until contaminant concentrations beneath the existing soil cover reached acceptable levels. Institutional controls (e.g., deed restrictions, fencing, signage, monitoring of groundwater) would be required components of this alternative. Although institutional controls generally are considered to be proven and acceptable technologies meant to prevent access to residual contamination, they may not be effective for the extended lengths of time needed to address the contaminants at the waste sites in the BC Cribs and Trenches Area (i.e., hundreds to thousands of years). Institutional control and monitoring would be required for the entire time that contaminants exceed PRGs to be effective. In many of these waste sites, the contaminant concentrations remain sufficiently elevated at 150 yr to have an intruder risk above RAOs. However, some degree of long-term stewardship is anticipated to address residual onsite contamination. Table 2-8 illustrates the dose and risk to potential intruders associated with the representative sites at 150 yr.

216-B-26 Trench and Its Analogous Sites - Under Alternative 2, chemicals and radionuclides in this group would remain in the vadose zone beneath the waste sites at concentrations above PRGs and thus would be a potential threat to human health, the environment and groundwater. The sampled site also has contaminants that would remain beyond the assumed 150-yr active institutional control period.

Given the current concentrations at the 216-B-26 Trench, this alternative is not protective in the long term for the representative site or its analogous waste sites except, possibly, for the 200-E-114 Pipeline. If no significant leakage to soil has occurred, and no residual liquid is within the piping, there would be no long-term risk.

216-B-58 Trench and Its Analogous Sites - Under Alternative 2, mobile chemicals and radionuclides would remain in the vadose zone beneath the waste sites at concentrations above

PRGs and thus could be a potential threat to groundwater. In addition, near-surface contaminants at 150 yr still would exceed human health and ecological direct-exposure PRGs.

Given the current concentrations at the 216-B-58 Trench, this alternative is not protective in the long term for the representative site or its analogous waste sites.

216-B-46 Crib Analogous Sites - Under Alternative 2, mobile chemicals and radionuclides would remain in the vadose zone beneath the waste sites at concentrations above PRGs and thus would be a potential threat to groundwater. In addition, radionuclides would remain in the waste sites at near-surface locations (i.e., within 0 to 4.6 m [0 to 15 ft] bgs) and at concentrations that would result in excessive risk to human health.

Protection of Groundwater:

216-B-26 Trench and Its Analogous Sites - The 216-B-26 Trench exceeds the groundwater protection PRGs for nitrate and Tc-99. These contaminants appear as elevated concentrations found to nearly 46 m (150 ft) bgs. Given the current concentrations at the 216-B-26 Trench, this alternative is not protective of the groundwater for the representative site or its analogous waste sites.

216-B-58 Trench and Its Analogous Sites - Although the 216-B-58 Trench exceeds the groundwater protection PRGs for selenium and nitrate, comparison with the 216-B-26 fate and transport modeling indicates this alternative is protective of groundwater.

216-B-46 Crib Analogous Sites - The 216-B-46 Crib exceeds the groundwater protection PRGs for nitrate, uranium, and Tc-99. These contaminants appear as elevated concentrations found throughout the soil column to nearly 67 m (220 ft) bgs. Given the current concentrations at the 216-B-46 Crib, this alternative is not protective of the groundwater for the representative site or its analogous waste sites.

The Environment:

Table 2-3 lists the depths to the top of the contamination for all the waste sites in the BC Cribs and Trenches Area. For sites with contamination in the 0 to 4.6 m (0 to 15-ft) zone, ecological risks are assumed, based on the nature of the contamination at the representative sites. Alternative 2 is not considered protective if the contaminants are in the 0 to 4.6 m (0 to 15-ft) zone. Alternative 2 is considered protective of the environment if contaminants are below this zone.

6.2.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume would occur in the form of natural attenuation at all of the waste sites. Natural attenuation is a process that results in a reduction of toxicity, mobility, or volume through the natural radioactive decay process. Radioactive decay is the only process currently available to eliminate nuclear particle emissions. Most of the contaminants identified during characterization would be influenced by the radioactive decay process; however, concentrations are high enough to require long time periods for radionuclides to decay to PRG levels (hundreds, and in a few cases thousands, of years).

In EPA/540/R-99/009, the EPA acknowledges that natural attenuation can be an appropriate treatment for contaminated soil. Because of uncertainties in the science-of-natural-attenuation process, the EPA considers source control and performance monitoring to be fundamental components of the alternative.

While this alternative provides a reduction in the mass of radioactive contaminants at the site, the time needed to meet the PRGs generally is greater than 150 yr. Furthermore, Alternative 2 does not prevent the transport of contaminants to the water table.

This alternative does not provide any active reduction of toxicity, mobility, or volume through treatment.

6.2.2.5 Short-Term Effectiveness

6.2.2.5.1 Remediation Worker Risk

Risks to workers for this alternative were compared to the baseline no-action alternative. For Alternative 2, only minimal short-term worker risks are expected at all three sampled sites, associated with monitoring and maintenance activities. Most of the analogous sites have a soil cover associated with backfill after construction and with stabilization activities conducted on the Hanford Site. Therefore, short-term risks to the workers under Alternative 2 are minimal and controllable. Experienced workers using appropriate safety precautions would conduct the maintenance and surveillance activities. Risks would decrease over time as the radionuclides decay. DOE control of the Central Plateau is assumed for at least the next 50 years, given DOE's commitment to vitrify the waste in the tank farms. Some form of long-term stewardship is anticipated to address residual onsite waste. Therefore, failure of this alternative in the short term is considered unlikely.

6.2.2.5.2 Impact to Environment During Remediation

This alternative reduces the risk to human and ecological receptors through the use of existing soil covers and the implementation of institutional controls. Currently, essentially all of the sites have contamination within the shallow soils from 0 to 4.6 m (0 to 15 ft) (see Table 2-3). As such, short-term impacts to vegetation and wildlife may occur at these sites during the implementation of this alternative. The waste sites have been highly disturbed, and the existing soil cover does provide protection for all but the deeply rooted plants or deep-burrowing animals. The short-term impacts to the environment are expected to be low. Sites with contamination below 4.6 m (15 ft) do not present short-term impacts to the environment, because the contaminants are located below the zone of intrusion for vegetation and wildlife.

6.2.2.5.3 Time to Meet the Remedial Action Objectives

This alternative reduces the risk to human and ecological receptors through the use of existing soil covers and the implementation of institutional controls to eliminate exposure pathways. The RAOs can be fully met only through natural radiological decay of contaminants, which can take hundreds to thousands of years to achieve. Therefore, this alternative does not meet RAOs in a reasonable time frame, with the exception of the following waste sites:

- The 200-E-114 Pipeline, where only limited contamination is expected at the leak sites that would not pose a threat to groundwater.
- The 200-E-14 Siphon Tank, if it is essentially empty.

6.2.2.6 Implementability

Alternative 2 could be implemented readily and would not present technical problems at any of the representative sites or analogous waste sites. This alternative currently is being implemented through Hanford Site access controls, surface and subsurface radiation area work and access controls, and the waste site/radiation area surveillance and maintenance program.

6.2.2.7 Cost

Cost estimates for the alternative were developed based on existing costs for similar activities currently conducted on the Hanford Site. Details of the cost estimates are presented in Appendix D. The costs for implementing Alternative 2 at each waste site, or group of waste sites, are summarized in Table 6-1. The input parameters used in these estimates are the best available at this time, but in many cases the data on contaminants of concern, site locations, and site dimensions are limited. The uncertainties identified above are similar for all of the sites evaluated in this FFS. Despite these uncertainties, the cost estimates are of sufficient quality to fulfill the primary objective, which is to aid in selecting preferred remedial alternatives.

This alternative involves costs for activities similar to current activities. These include periodic surveillance of the waste sites for evidence of contamination and biologic intrusion; emplacement of vegetation, herbicide application, or other activities to control deep-rooted plants; control of deep burrowing animals; maintenance of signs and/or fencing; maintenance of the existing soil cover (including an assumed periodic addition of soil); administrative controls; and site reviews. The present-worth costs assume a 3.1 percent discount rate (based on 2004 Office of Management and Budget information) and assumes an operation and maintenance period equal to the time required for PRGs to be met. Long-term monitoring costs associated with groundwater are included in this cost estimate. However, cost to remediate contaminated groundwater, which will be addressed by the 200-PO-1 OU, is not included.

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

Under Alternative 3, contaminated soil and debris (such as concrete or wood associated with cribs and the siphon tank) would be removed, treated as necessary to meet waste acceptance criteria, and disposed of to an approved waste disposal facility. Soils would be removed to meet PRGs. Alternative 3 soils will be disposed of onsite at the ERDF. Extensive soil blending will be required to meet health and safety standards and waste acceptance criteria before the most highly contaminated soils from most waste sites are disposed of at the ERDF, based on the data collected for the representative waste sites that have been characterized. Alternative 3 would remove contaminated waste and soil from waste sites to a depth to meet the RAOs. Soil contamination above PRGs is encountered from 3.4 m to as deep as 67 m (11 to 220 ft) bgs.

This alternative would remove the 200-E-14 Siphon Tank and its contents.

One of the analogous sites, the 216-B-53A Trench, previously was predicted to have soil concentrations of Pu-239/240 above 100 nCi/g. However, recent adjustments to the inventory for this waste site have halved the transuranic radionuclide content, which makes the expectation of transuranic concentrations at levels of concern unlikely. However, excavated soil that is determined to contain more than 100 nCi/g of transuranic constituents will be handled, packaged, stored, and ultimately disposed of appropriately.

Alternative 3 generally provides a high degree of overall protection of human health and the environment, because contaminants are removed to meet PRGs. However, under this alternative, workers potentially are exposed to highly contaminated soils with substantial dose rates. Removal of the contaminants provides for the most flexibility for future land use.

Except for the 216-B-58 Trench, the sampled sites have contamination to depths greater than 30 m (100 ft) bgs. In addition, contaminant concentrations at the bottom of the representative sites tended to be very high, especially for Cs-137 and Sr-90. Excavation to these depths and in these levels of contamination is difficult and potentially exposes workers to the high contaminant concentrations as well as to risks associated with deep excavations. This type of excavation is expensive and creates considerable waste that requires disposal.

This alternative would provide protection to humans and the environment because the contaminants are removed from the waste site. The groundwater would be protected. Because contaminants above PRGs would be removed from a waste site and placed in an approved disposal facility, failure of this alternative is not likely. Residual risks would be at acceptable levels for human health, environmental, and groundwater protection. Verification sampling would be conducted to determine that PRGs are met by the removal activities. Risks associated with the failure of the disposal facility are not evaluated here, but are evaluated as part of the permitting process for the facility.

The contaminants associated with the BC Cribs and Trenches Area waste sites result in significant potential dose to workers, who would be exposed during the excavation and disposal processes. Table 6-2 summarizes the estimated dose to workers associated with the excavation and disposal process. Special excavation techniques, such as limited excavation lifts, down blending high-activity soil to achieve acceptable dose rates for health and safety, and protection systems (e.g., equipment modifications, decontamination areas) likely would be necessary to support this alternative, which would significantly increase costs and disposal capacity (these are discussed in greater detail in the following subsections).

6.2.3.1 Overall Protection of Human Health and the Environment

Alternative 3 would remove all principal threat waste and transfer it the ERDF.

216-B-26 Trench and Its Analogous Sites - Contaminants at this representative site extend from 3.4 to 45.7 m (11 to 150 ft) bgs. High concentrations of Cs-137 and Sr-90 are found at the bottom of the trench (e.g., 529,000 pCi/g of Cs-137 and 974,000 pCi/g Sr-90). Also, significant concentrations of Tc-99 and nitrate are present in a plume, as indicated by high resolution resistivity, between 30 and 40 m (100 to 130 ft) bgs. Comparison of soil analyses with spectral gamma logging data suggests that Cs-137 maximum values may be ten to twenty times higher

(see Appendix F). Contamination associated with the 200-E-114 Pipeline is expected to be relatively minor and much shallower.

216-B-58 Trench and Its Analogous Sites - Contaminants at this representative site extend from 3.4 to 7.6 m (11 to 25 ft) bgs. Low concentrations of Cs-137 (14,000 pCi/g) were found at the bottom of the trench. Excavation to this depth and in these concentrations is accomplished with standard construction equipment.

216-B-46 Crib Analogous Sites - Contaminants at this representative site extend from 4.6 to 67 m (15 to 220 ft) bgs. High concentrations of Cs-137 and Sr-90 (e.g., 280,000 pCi/g Cs-137 and 260,000 pCi/g Sr-90) were found at the bottom of the waste site. Other analogous cribs located in the BY Farm grouping of cribs exhibited considerably higher Cs-137 and Sr-90 concentrations (12.9 million pCi/g Cs-137 at the 216-B-48 Crib and 14.2 million pCi/g Sr-90 at the 216-B-47 Crib) (DOE/RL-92-70). (Activities reflect as-sampled data, without additional decay.) Contamination associated with the 200-E-14 Siphon Tank is expected to be much less than at the cribs and is expected to be confined to the tank interior.

6.2.3.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 3 would comply with the ARARs by removing soil that exceeds the PRGs and by removing structures. Action-specific ARARs, such as worker and environmental exposure standards, could be exceeded under this alternative without proper protection standards during implementation.

6.2.3.3 Long-Term Effectiveness and Permanence

Human Health:

Alternative 3 will remove contaminants to meet human health RAOs. Both EPA and Ecology cleanup authorities prescribe remedies that use permanent solutions to the maximum extent practicable and where cost effective. Removal of contaminants would be a permanent solution at the waste sites; much of the waste would, however, remain on site at the ERDF.

Excavation is a proven and acceptable technology used to remove contaminated soils. However, excavation to depths below 7.6 m (25 ft) bgs can become difficult and can require the use of more sophisticated digging techniques, such as the use of approach ramps, extensive removal of clean material to obtain adequately safe side slopes, limited surface exposure, or limited lift removal. Excavation with dust suppression and health and safety controls is proven to handle potential problems with excavating large soil sites.

Overall Protection of Groundwater:

Contaminants are removed to meet the RAOs and, as such, this alternative meets the objectives of this criterion for all the waste sites.

Overall Protection of the Environment:

Alternative 3 removes all contaminated soil in the 0 to 4.6 m (0 to15 ft) bgs zone. Therefore, this criterion is met. Excavation and transportation of waste and structures would disturb areas

beyond the waste site boundaries during the implementation period. These areas would need to be revegetated after disturbance and would require activities to control intrusion by nonnative, noxious plants. This should not adversely affect the alternative in the long term or permanently. Because of the large volumes of backfill material that would be needed to fill the deep excavations, borrow areas would be impacted. Some of the identified borrow areas are in potentially ecologically sensitive areas.

6.2.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume would occur in the form of natural attenuation through the natural radioactive decay process.

In general, the removal, treatment, and disposal alternative would include treatment to reduce toxicity, mobility, or volume. However, with the availability of the ERDF, treatment is not anticipated. Radiological decay ultimately results in reduction of toxicity and volume. Based on the information contained in the RI reports, waste at all sites meets the ERDF waste acceptance criteria. When the in situ waste soil exceeds the ERDF waste acceptance criterion of 50 mR/h, physical treatment (downblending with less contaminated soil) will be performed at the excavation site to meet health and safety and disposal requirements. Movement of the waste to the ERDF may result in reduction of mobility of Tc-99 and nitrate, but for Tc-99, with a half-life of 213,000 yr, the benefit of moving it to an engineered disposal facility is questionable. The ERDF will provide additional protection against remobilization of contaminants over their current location.

6.2.3.5 Short-Term Effectiveness

Experienced workers using appropriate safety precautions would conduct these activities. Risks to workers for this alternative were compared to the baseline no-action alternative. For Alternative 3, potential dose to the remediation workers would be high. Short-term effects of this alternative would be associated primarily with worker safety during waste excavation (soil and structures), handling, transportation, and disposal. Unprotected workers present an unacceptable risk because of the concentrations and nature of the contaminants at the waste sites. The major contaminants in the waste sites are short-lived radionuclides (particularly Cs-137), which potentially would expose excavation workers, truck drivers, and waste management workers to dose rates that require special protections. These protections would include shielding, possibly high-efficiency particulate air filtration for breathing air, and equipment modification to provide additional shielding from the source. Specific risks are detailed below.

Remediation Worker Risk:

The high radionuclide concentrations associated with many of these sites would result in high doses to workers and would require special protections during excavation, handling, transportation, and disposal of the excavated soils.

216-B-26 Trench and Its Analogous Sites - The high concentrations of Cs-137 and Sr-90 associated with these sites pose a significant dose potential to workers. The collective doses associated with excavation of the 216-B-20 through 216-B-22 Trenches, the 216-B-52 Trench, the 216-B-23 through 216-B-28 Trenches, and the 216-B-29 through 216-B-34 Trenches are estimated to be 54 person-rem for the protected worker (see Appendix F). As such, special

controls and shielding of workers and equipment are necessary. Undoubtedly, additional measures are feasible to further reduce the protected-worker dose.

216-B-58 Trench and Its Analogous Sites - The concentrations of Cs-137 associated with the 216-B-58 Trench and its analogous sites pose a potential dose of 0.41 person-rem for the protected worker (see Appendix F).

216-B-46 Crib Analogous Sites - The high concentrations of Cs-137 and Sr-90 associated with these sites pose a significant dose potential to workers. The collective dose associated with excavation of the 216-B-14 through 216-B-19 Cribs and the 200-E-14 Siphon Tank is estimated to be 21 person-rem for the protected worker (see Appendix F). Undoubtedly, additional measures are feasible to further reduce the protected worker dose. Modifications are necessary to standard excavation equipment such as shielding, extra long excavation sticks (to provide distance from the actual excavation area), and specialized monitoring and sampling equipment. Also, to satisfy waste acceptance criteria at the ERDF, extensive soil mixing at rates up to 7:1 are anticipated to achieve acceptable soil dose rates. Soil mixing at this ratio would be performed within the waste site; higher mixing ratios associated with localized regions of higher contamination would be achieved outside of the waste site in specially modified equipment.

Impact to Environment during Remediation:

Physical disruption of the waste sites during excavation, increased human activity and noise, and the generation of fugitive dust, will affect local biological resources. Both Cs-137 and Sr-90 have low screening levels for biota. Extra efforts would need to be in place to limit exposure during remediation. 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. Substantial backfill material would be required to fill up the excavation. Obtaining and transporting the backfill would require expansion of existing borrow sites and/or creation of new borrow sites.

216-B-26 Trench and Its Analogous Sites - The excavation for the 216-B-26 Trench and its analogous sites would cover approximately 26.7 ha (65.9 acres). This is more than 3 times the collective areas of these three groupings of trenches.

216-B-58 Trench and Its Analogous Sites - The excavation of the 216-B-58 Trench representative site and all of its analogous sites would cover approximately 0.7 ha (1.8 acres).

216-B-46 Crib Analogous Sites - The excavation for the 216-B-14 Series Cribs would cover approximately 8.7 ha (21.5 acres). This is nearly ten times the area of the grouping of cribs.

Time to Meet the Remedial Action Objectives:

Alternative 3 prevents risk to human or ecological receptors by moving the source to an engineered disposal facility. Once the contaminants are removed, two of the three RAOs are met. The only RAO not met is minimizing the general disruption of environment wildlife habitat. However, these waste sites are located in an industrial setting, providing little habitat for vegetation and wildlife.

216-B-26 Trench and Its Analogous Sites - Mobilization, excavation, site restoration, and demobilization activities for the removal, treatment, and disposal alternative for the 216-B-20 through 216-B-34 and 216-B-52 Trenches would take 17.0 years to implement (see Appendix D for assumptions).

216-B-58 Trench and Its Analogous Sites - Mobilization, excavation, site restoration, and demobilization activities for the removal, treatment, and disposal alternative for the 216-B-58, 216-B-54, 216-B-53A, and 216-B-53B Trenches would take 6.7 months to implement.

216-B-46 Crib Analogous Sites - Mobilization, excavation, site restoration, and demobilization activities for the removal, treatment, and disposal alternative for the 216-B-14 Series Cribs would take 3.7 years to implement.

200-E-114 Pipeline - Mobilization, excavation, site restoration, and demobilization activities for the removal, treatment, and disposal alternative for the 200-E-114 Pipeline would take 1.4 months to implement.

200-E-14 Siphon Tank - Mobilization, excavation, site restoration, and demobilization activities for the removal, treatment, and disposal alternative for the 200-E-14 Siphon Tank would take 1.2 months, plus the time to remove the sludge, to implement.

6.2.3.6 Implementability

The excavation of contaminated soils is technically implementable, although more sophisticated excavation equipment and techniques, the use of approach ramps, and possibly shoring would be required. Excavating large areas to depths of 46 to 67 m (150 to 220 ft) would make dust control and controlling potential animal intrusion more difficult. Also, providing for sufficient disposal capacity would require expansion of the ERDF.

216-B-26 Trench and Its Analogous Sites - To remove soils above the PRGs, the excavation would be advanced to a depth of 46 m (150 ft). 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. Excavation of the 216-B-26 and its analogous sites would encompass 26.7 ha (65.9 acres). To remove the contaminants of concern at this waste site group, 3.6 million m^3 (4.7 million yd^3) of contaminated soil would be disposed of at the ERDF. The current remaining capacity of the ERDF is 5.85 million m^3 (7.65 million yd^3) (as of February 6, 2004).

Excavation of the shallow (2-3 m [7-10 ft)]) deep 200-E-114 Pipeline is readily implementable.

216-B-58 Trench and Its Analogous Sites - The excavation of contaminated soils is technically implementable for these waste sites. To remove soils above the PRGs, the excavation would be advanced to a depth of 7.3 m (25 ft) bgs. Every 0.3 m (1 ft) of excavation would require 0.46 m (1.5 ft) of side slope for a 1:1.5 vertical-to-horizontal ratio. This safety measure increases the amount of material excavated. To remove the contaminants of concern at these waste sites, 4,830 m^3 (6,320 yd^3) of soil would be disposed of at the ERDF. The current remaining capacity of the ERDF is 5.85 million m^3 (7.65 million yd^3) (as of February 6, 2004). Given the shallow depth of contamination and the lower contamination levels, this alternative is considered implementable for the 216-B-58 Trench and its analogous waste sites.

216-B-46 Crib Analogous Sites - To remove soils above the PRGs, the excavation would be advanced to a depth of 67 m (220 ft) bgs. Every 0.3 m (1 ft) of excavation would require 0.46 m (1.5 ft) of side slope for a 1:1.5 vertical-to-horizontal ratio. This safety measure significantly increases the amount of material excavated. At the 216-B-14 through 216-B-19 Cribs, plus the 200-E-14 Siphon Tank, the excavation would encompass 8.7 ha (21.5 acres). Total contaminated volume of soil to be disposed of at the ERDF is 0.53 million m^3 (0.70 million yd^3).

Another consideration for all of the waste sites is coordination with other agencies. 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. Also, if waste with TRU concentrations is generated, coordination with the Waste Isolation Pilot Plant facility will be required for its disposal.

Finally, if the entire volume of contaminated soil from all of the waste sites were disposed of at the ERDF, its current capacity would be exceeded.

6.2.3.7 Cost

Costs for Alternative 3, shown on Table 6-2, are based on the use of standard excavation equipment without modifications for use in high-dose areas (e.g., hydraulic excavators, front-end loaders, tractor trailers). Modifications to the standard equipment would be determined and would add additional cost to this alternative. This additional cost is considered minor with respect to the cost to implement the alternative and would fall within the CERCLA cost-estimate range. A capital cost not normally associated with excavation that may be needed is a soil mixing apparatus that would be used to blend highly contaminated soil to meet the ERDF waste acceptance criteria. Costs for the 200-E-14 Siphon Tank assume sludge removal prior to tank excavation. Also included in the costs are mobilizing personnel and equipment; monitoring, sampling, and analysis; and excavating, transporting the waste to the ERDF, disposing of the waste at the ERDF, backfilling with onsite resources, additional backfilling from a local stockpile, revegetating, and performing prime contractor oversight. The costs are based on the assumption that a subcontractor will do the work, with oversight performed by prime contractor personnel. The cost estimate assumes that the subcontractor personnel are wearing Level D personal protective equipment (e.g., coveralls and no respirators). Additional detail regarding the cost basis can be found in Appendix D. Costs in Appendix D represent the cost to remove the radionuclides and chemical contamination to the PRGs. To remediate all chemical contaminants and Tc-99, which is required to protect groundwater, excavations would extend to a depth of approximately 67.1 m (220 ft) bgs. Total cost to remove all contaminated soils to meet PRGs is nearly $1.1 billion.

6.2.4 Detailed Analysis of Alternative 4: Capping

The capping alternative considers an ET cap with associated institutional controls and monitoring. Portions of the cap directly over the waste sites, which possess high concentrations of near-surface contamination, would include intrusion-deterrent features. The actual cap used would be determined through design activities to meet the criteria of limiting percolation and providing intruder protection.

6.2.4.1 Overall Protection of Human Health and the Environment

Alternative 4 would remove or reduce the exposure pathways to receptors through placement of a surface barrier to limit both percolation and intrusion. The cap would be sufficiently robust to account for the types and levels of contamination in the waste sites. The cap would provide additional distance between potential human and ecological receptors, above and beyond the existing soil covers over the waste sites. Where required, the cap would include an intruder-deterrent layer that would limit unwanted intrusion and provide a warning to potential intruders. Institutional controls including maintenance of the cap, use restrictions, and monitoring would be instituted at capped sites. For some contaminants representing a potential groundwater threat, the cap would provide a sufficient extension of time before groundwater is impacted to develop effective groundwater remedial actions. Institutional controls would provide additional protection against human intrusion and would provide for groundwater monitoring as a means of identifying impacts to groundwater. Because the waste sites are located in an area anticipated to be devoted to long-term stewardship and waste management activities, periodic cap maintenance would be performed. Groundwater monitoring would be coordinated with monitoring at the appropriate groundwater OU.

Alternative 4 would contain, rather than remove or treat, principal threat waste, which, by definition, represents higher risk requiring special considerations. Pathways to potential receptors from shallow and deep principal threat waste would be broken by the cap, which would include intrusion-deterrent features. Extended institutional controls associated with maintaining the cap would reinforce intrusion deterrence. Groundwater would be protected to the extent that reduced recharge slows contaminant transport toward groundwater.

The contents of the 200-E-14 Siphon Tank would not be removed under this alternative.

6.2.4.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 4 would comply with all ARARs for the waste sites if the exposure pathway were removed and caps were emplaced that meet the intent of the regulations, except that groundwater protection requirements may not be met. Fate and transport modeling shows that Tc-99 and nitrate concentrations reaching groundwater will exceed MCLs (see Appendix G), but that groundwater protection requirements will be met at a point that is 100 m (328 ft) down-gradient. All of the representative sites have deep contamination except for the 216-B-58 Trench, where significant contamination only extends to approximately 7.3 m (24 ft) bgs. In addition to the cap, institutional controls such as additional land-use restrictions and groundwater monitoring are elements of this alternative. Where necessary, groundwater remediation would be performed under the future groundwater OU ROD. If groundwater standards are eventually exceeded, waivers to 40 CFR 141 and WAC 173-340-747 and adoption of alternate concentration limits would be required.

6.2.4.3 Long-Term Effectiveness and Permanence

Overall Protectiveness of Human Health:

The capping alternative would be protective of human health and the environment for all waste site groups by breaking exposure pathways. Chemicals and radionuclides left in place at the waste sites would be physically separated from receptors by the thickness of the cap and by the

additional thickness of the existing soil covers. However, because the top of the 200-E-14 Siphon Tank is approximately 2 m (7 ft) bgs, a cap may not provide sufficient overall cover. Intrusion layers in the caps would help protect against inadvertent intruders, along with institutional controls such as markers and land-use restrictions. Because contaminants at the waste sites have the potential to impact groundwater, caps will be designed to limit and control infiltration.

Because much of the risk attenuates for the sites within the institutional controls period, failure of the caps in later years would be associated with lower risks than at present (see Table 2-8 for intruder risks and doses). Additionally, the 5-yr reviews required for sites with contaminants above PRGs would serve to monitor the effectiveness and reliability of the caps; adjustments and maintenance activities could be instituted to help prevent failure, based on the 5-yr review results.

The long-term effectiveness depends on the proper construction and maintenance of the barrier and associated institutional controls throughout the natural attenuation timeframe to prevent exposure to potential receptors. Maintenance activities would include erosion repairs and vegetation maintenance. Subsidence is not considered a major factor in maintenance activities for these waste sites. Failure of the cap is unlikely if maintenance and institutional control activities are performed on a routine basis. Ideally, caps would be designed and constructed to account for the necessary timeframe to reach PRGs and to minimize maintenance requirements and impacts from institutional controls failure. The Modified RCRA Subtitle C Barrier has a nominal design life of 500 yr. The waste sites in the BC Cribs and Trenches Area generally have minor intruder risk at 500 yr, suggesting that if replacement of the cap is necessary at 500 yr or more, the replacement cap will be less costly.

Because contaminants would remain underneath the cap, there could be some uncertainty regarding details of their nature and extent, resulting in reduced confidence in long-term effectiveness of the remedial action. Thus, management controls (e.g., deed restrictions, fencing, signage, monitoring of groundwater) would be required components of this alternative. Once remediated, the barrier and surrounding disturbed area would be revegetated to further enhance ET, limit erosion, and blend the site area into the surrounding landscape.

Overall Protection of Groundwater:

Alternative 4 is at least partially protective of the groundwater at all waste group sites, because it limits infiltration at the waste site. The caps form a protective barrier to infiltration and intruder risk until RAOs are met, or sufficiently slow the transport of contaminants to the groundwater to facilitate future groundwater remediation. Detailed fate and transport modeling of the 216-B-26 Trench predicts that capping will allow the groundwater protection standards for Tc-99 and nitrate to be met, if a point of compliance for assessing groundwater compliance is defined that is 100 m (328 ft) down-gradient rather than evaluating the leachate concentrations as they enter the groundwater. Also, the 5-yr review would focus on groundwater protection monitoring and effectiveness of the cap in addressing the mobile contaminants at depth (e.g., Tc-99, nitrate). If compliance with 40 CFR 141 and WAC 173-340-747 is not achieved, waivers to those requirements and adoption of alternate concentration limits will be necessary.

Overall Protection of the Environment

This alternative would provide protection to the environment at all of the representative sites and their analogous waste sites by placing a barrier between the waste and the surface flora and fauna. The caps will be designed to prevent the intrusion of deep-rooted flora and burrowing fauna below the 4.6 m (15 ft) bgs level. The long-term impacts to the environment at the waste sites could be beneficial , because the sites have been highly disturbed and currently have generally poor quality habitat. Some borrow areas may be located in potentially ecologically sensitive areas.

6.2.4.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Reduction of toxicity, mobility, or volume would occur in the form of natural attenuation through the natural radioactive decay process.

The capping alternative would address the mobility of contaminants by limiting percolation of precipitation to the waste, thereby limiting the driving force to move contaminants to the groundwater. Some contaminant transport to groundwater likely will result eventually, however, particularly those highly mobile contaminants such as Tc-99 and nitrate. By slowing contaminant transport, their eventual concentration in the groundwater is reduced. This feature of the capping alternative would use natural attenuation processes (most importantly radioactive decay) to reduce radioactivity, but the long half-lives of Tc-99 and uranium isotopes prevent the natural attenuation process from being effective for groundwater protection.

6.2.4.5 Short-Term Effectiveness

Remediation Worker Risk:

For Alternative 4, only low short-term risks are expected. Experienced workers using appropriate safety precautions would conduct these activities. Risks to workers for this alternative were compared to the baseline no-action alternative. The capping alternative would not require excavation of contaminated soils, so the risks to workers primarily would be associated with general construction activities at the borrow sites and placement of the cap. 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. Installation of monitoring wells would be at low-risk locations with minimal risk to workers.

Impact to Environment during Remediation:

Physical disruption of the waste sites during excavation, increased human activity and noise, and the generation of fugitive dust affect local biological resources. However, the waste sites are located within historically disturbed industrial areas. As such, short-term impacts to vegetation and animals at these sites would be low because these sites currently are poor wildlife habitats.

Construction activities at the borrow areas could disrupt wildlife in the area because of increased noise and human activity. The waste sites are located in areas already disturbed by earlier facility operations, so impacts on biological resources would be low.

Time to Meet the Remedial Action Objectives:

Completing the capping activities for the 216-B-14 Series Cribs could take approximately 5.0 months. Completing the capping activities for the 216-B-20 through 216-B-34 and 216-B-52 Trenches could take approximately 2.4 years. Completing the capping activities for the 216-B-58 Trench and analogous waste sites could take approximately 4.7 months. Overall time to complete the remediation would be dependent on the number of construction teams. The groundwater protection RAO, based on fate and transport modeling, would be met upon completion of the caps. Similarly, the RAO related to protecting human health and the environment is met. The caps would act to eliminate or reduce exposure pathways immediately upon installation.

6.2.4.6 Implementability

The capping alternative is considered implementable at all waste sites. A prototype Hanford Barrier has been implemented at the Hanford Site at the 216-B-57 Crib (CP-18187). Other types of barriers have not been used at the Hanford Site, but have been implemented at other sites and are easy to construct and maintain. The existing soil covers over the waste sites would be considered a part of the overall design to minimize the cost of materials and to minimize the impact to visual aesthetics.

Construction of the caps would follow standard procedures that have been thoroughly field tested. The caps likely would require minor repair and possibly replacement during the restoration timeframe. Monitoring the continued integrity of the caps would be accomplished through visual inspection and would be supplemented with groundwater monitoring. Implementation of the capping alternative would require additional design data, because existing data may not be adequate for determining the lateral extent of the caps.

Silt/loam soil used for the caps would be transported from borrow areas located on or near the Hanford Site. Anticipated volumes of these materials are identified in Appendix D. Area C, located west of State Highway 240 south of the Yakima Barricade, 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. Borrow material occurs in environmentally sensitive areas; obtaining sufficient capping material, especially for a multilayered cap, would affect areas of potential ecological significance and is a consideration in evaluating the relative risk reduction gained by installing the cap. Materials such as rip rap or quarry spall that may be used in the cap construction could be obtained on the Hanford Site or could be purchased from local dealers.

Capping materials hauled to the Central Plateau from borrow areas and gravel pits within the Hanford Site would increase heavy equipment use and transportation activities at the sites. However, radioactive or hazardous waste would not have to be hauled away from the Site.

Using a 22.9 m (75-ft) capping overrun from the edge of the waste site footprint, as indicated by recent geophysical characterization of the 216-B-26 Trench, will result in a continuous cap between the 216-B-20 to 216-B-22 and the 216-B-52 to 216-B-28 geographical groupings of trenches. Sections of cap overlap between the 216-B-52 to 216-B-28 and 216-B-29 to 216-B-34

geographical groupings also are anticipated. Specific cap size would be determined during the design phase.

6.2.4.7 Cost

Costs associated with Alternative 4, shown in Table 6-3, include stabilization of the existing site; excavation or import, transportation, and placement of capping material; prime contractor oversight; and confirmatory sampling, including groundwater monitoring. Because recent geophysical characterization in the vicinity of the 216-B-26 Trench indicates apparent lateral contamination spread at least 15 m (50 ft) beyond the footprint of that trench, the cap is projected to extend at least 22.9 m (75 ft) beyond groupings of waste sites (except for the former 200-LW-1 OU waste site grouping that received much less effluent, where an overrun of 6.1 m (20 ft) is used). Individual waste sites (cribs, trenches, pipeline, and siphon tank) are assumed to be covered with a cap represented by the intrusion-deterrent and ET features associated with the Modified RCRA Subtitle C Barrier. These caps are surrounded by a simple ET cap providing only groundwater protection. Costs are based on the use of standard equipment (e.g., hydraulic excavators, front-end loaders, bulldozers) and assume that a subcontractor would do the work, with oversight performed by the prime contractor. The subcontractor personnel are assumed to be wearing Level D personal protective equipment (e.g., blues and no respirators) during construction. The present-worth costs assume a 3.1 percent discount rate (based on 2004 Office of Management and Budget information) and assumes operation and maintenance for 150 yr. The operation and maintenance costs include site inspection/surveillance, periodic radiation site surveys of surface soil, and biotic control; maintenance of signs and markers; cover maintenance; and site reviews. Long-term monitoring costs associated with groundwater are included in this cost estimate. However, potential groundwater remediation costs are not included because contaminated groundwater in the 200 East Area will be addressed by the 200-PO-1 groundwater OU.

6.2.5 Detailed Analysis of Alternative 5: Partial Removal, Treatment, and Disposal with Capping

Alternative 5 includes the removal of contaminants extending to depths shown on Table 5-3, which are estimated to be sufficient to remove the worst of the near-surface contamination. The excavation would be filled with borrow material obtained on the Hanford Site. When the backfilling operation was finished, the site would be capped with an ET barrier that did not include intrusion-deterrent features. These activities remove more than 95 percent of the near-surface contaminant load (see Appendix F, Table F1-8) and provide protection to the groundwater from deeper contaminants that are impracticable to remove. The removal, treatment, disposal, and capping activities would be the same as those described earlier. This alternative is not applicable to sites where contamination is shallow with no deep component or where contamination is very deep with no shallow component.

6.2.5.1 Overall Protection of Human Health and the Environment

The objective of Alternative 5 is to eliminate human health and ecological risk, drastically reduce intruder risk, and protect groundwater.

Removal of the shallow contamination would eliminate human health and ecological risk for those sites where contamination is in the 0 to 4.6 m (0 to 15-ft) bgs zone and intruder risk is associated with the presently high concentrations at the bottom of the waste site (see Appendix E). This alternative would break potential exposure pathways to receptors through placement of a cap to limit infiltration at this waste group, except as noted below. The partial removal activity would remove the presently high contamination zone at the bottom of the waste site, leaving only the lower concentration, deeper contaminants that mainly pose a risk to groundwater. While, in the long term, this alternative is protective of human health and the environment, the radiological risk to workers during the excavation is essentially the same as for Alternative 3, because the material being removed under Alternative 5 is the same material that causes the dose rate for the full-excavation alternative. Industrial risk to workers would be significantly reduced because the excavation would be relatively shallow.

Institutional controls including maintenance of the cap, land-use restrictions, and monitoring would be instituted at capped sites until the RAOs are achieved through natural attenuation. For some contaminants representing a potential groundwater threat, the cap would provide a sufficient extension of time before groundwater is impacted to develop effective groundwater remedial actions. The cap would be designed to maximally limit infiltration. Institutional controls would provide additional protection for groundwater monitoring by providing a means to identify potential impacts to groundwater. Groundwater monitoring would be coordinated with monitoring at the appropriate groundwater OU. Those sites where this alternative is not applicable are discussed in the following text.

216-B-58 Trench and Its Analogous Sites – Implementing this alternative at these waste sites is not applicable. Based on the results of the investigation at the 216-B-58 Trench, these sites are assumed to have only shallow contamination and would not require a cap to protect deeper contaminants.

Alternative 5 would remove the near-surface principal threat waste and dispose of it at the ERDF. It would contain the deep principal threat waste beneath a cap, which would slow contaminant transport toward groundwater by limiting recharge.

6.2.5.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternative 5 would comply with the ARARs for the waste sites if the exposure pathway were removed and caps were emplaced that meet the intent of the regulations, except that groundwater protection requirements may not be met. Fate and transport modeling shows that Tc-99 and nitrate concentrations reaching groundwater will exceed MCLs (see Appendix G), but that groundwater protection requirements will be met at a point of compliance that is 100 m (328 ft) down-gradient. All of the representative site waste groups have deep contamination, except the 216-B-58 Trench and its analogous sites, where contamination is approximately 7.3 m (24 ft) bgs. In addition to the cap, institutional controls such as additional land-use restrictions and groundwater monitoring are elements of this alternative.

6.2.5.3 Long-Term Effectiveness and Permanence

Human Health:

216-B-26 Trench and Its Analogous Sites - This alternative will remove contaminants to about 4.5 m (15 ft) bgs to remove the high concentrations of Cs-137 (529,000 pCi/g) and Sr-90 (974,0000 pCi/g). (Note that these values reflect soil sampling near the region of highest contamination - not directly from the region of highest contamination. Actual concentrations are estimated to be approximately twenty-two times higher [see Section 2.5.1.1].)

Intruder dose 150 yr from the present for the 216-B-26 Trench for a future rural residential intruder would be 5599 mrem/yr under the no-action alternative (see Chapter 2.0, Table 2-8, and Appendix E). Partial removal of the contamination to 4.5 m (15 ft) bgs would essentially eliminate the intruder dose. Appendix F, Table F1-8, shows that contaminant concentrations in this layer are approximately 35 times those in the next 1.2 m (4 ft) thick layer. The cap would provide protection for groundwater from the remaining contaminants. The environment would be protected because accessible contaminants would be removed.

216-B-46 Crib Analogous Sites - Alternative 5 will remove contaminants to a depth of 6 m (20 ft) bgs. Modifications to standard excavation equipment such as shielding, extra long excavation sticks (to provide distance from the actual excavation area), and specialized monitoring and sampling equipment are necessary to provide worker protection. The protected worker dose, using special controls and shielding of workers and equipment, is estimated at 21.2 person-rem. Further dose reduction could be expected by employing more stringent controls.

These sites generally have significant contaminant concentrations that would exist 150 yr from the present that could pose a significant risk to intruders (see Appendix E). Intruder dose at 150 yr for the 216-B-46 Crib for a future rural residential intruder would be 137 mrem/yr under the no-action alternative. Partial removal of the 216-B-46 Crib contamination to 6 m (20 ft) would reduce the intruder dose to near 15 mrem/yr. Extrapolation of these data to the BC Cribs and Trenches Area suggests that excavation to about 6 m (20 ft) would achieve substantial risk reduction. The cap would provide protection for groundwater from the remaining contaminants. The environment would be protected, because accessible contaminants would be removed.

The sludge would be removed from the 200-E-14 Siphon Tank with this alternative. Although the siphon tank is not believed to represent a groundwater threat, it probably would be covered by the cap for the associated cribs.

216-B-58 Trench and Its Analogous Sites - Alternative 5 is not applicable to these waste sites.

Overall Protection of Groundwater:

Alternative 5 would protect groundwater through placement of a cap that would limit infiltration. In addition to the cap, institutional controls such as additional land-use restrictions and groundwater monitoring are protective elements of this alternative.

Overall Protection of the Environment:

Alternative 5 removes all contaminated soil in the 0 to 4.6 m (0 to 15-ft) bgs zone. Therefore, this alternative provides overall protection to the environment following implementation. The environment could be impacted through removal activities, capping activities, and activities at borrow sites. The long-term impacts to the environment at the waste sites could be beneficial, because the sites have been highly disturbed and currently have generally poor quality habitat. Some borrow areas may be located in potentially ecologically sensitive areas.

6.2.5.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume would occur in the form of natural attenuation through the natural radioactive decay process.

The partial removal, treatment, and disposal with capping alternative would address the mobility of contaminants by removing a portion of the contaminants and limiting infiltration to the vadose zone, thereby limiting the mass and driving force to move contaminants to the groundwater. Natural attenuation is an important treatment component of this alternative that results in the reduction of toxicity, mobility, and volume of the radionuclides.

When the waste soil exceeds the ERDF waste acceptance criteria physical treatment standard, downblending with less contaminated soil will be performed in the excavation site. Movement of the waste to the ERDF will result in a reduction of mobility, because the ERDF is a potentially less mobile environment that includes monitoring. However, most of the contaminants that would be removed do not pose a risk to groundwater.

6.2.5.5 Short-Term Effectiveness

Experienced workers using appropriate safety precautions would conduct these activities. Risks to workers for this alternative were compared to the baseline no-action alternative. For Alternative 5, potential dose to the remediation worker would be high. Short-term effects of this alternative would be associated primarily with worker safety during waste excavation, handling, transportation, and disposal. Unprotected workers would receive an unacceptable risk because of the concentrations and nature of the contaminants at the waste sites. The major contaminants in the waste sites are short-lived radionuclides (e.g., Cs-137). Excavation workers, truck drivers, and waste management workers would be exposed to dose rates that require special protections. These protections would include shielding, possibly high-efficiency particulate air filtration for breathing air, and equipment modification to provide additional shielding from the source.

Remediation Worker Risk:

The protected worker dose, using special controls and shielding of workers and equipment, is estimated at 54 person-rem.

Impact to Environment during Remediation:

The environment could be impacted through removal activities, capping activities, and activities at borrow sites. The impacts at the waste sites are expected to be minimal, because the sites have been highly disturbed and have generally poor quality habitat. Some borrow areas may be located in potentially ecologically sensitive areas.

Time to Meet the Remedial Action Objectives:

216-B-26 Trench and Its Analogous Sites - Completing the partial removal, treatment, and disposal with capping alternative for the 216-B-20 through 216-B-34 and 216-B-52 Trenches would take approximately 2.6 years. Once the contaminants were removed and the cap was installed, two of the three RAOs would be met. The RAO to minimize the general disruption of environment wildlife habitat would be challenged. However, these waste sites are located in an industrial setting, providing little habitat for vegetation and wildlife.

216-B-46 Crib Analogous Sites - Completing the partial removal, treatment, disposal, and capping activities for these waste sites could take 10 months. Once the contaminants were removed and the cap was installed, two of the three RAOs would be met. The RAO to minimize the general disruption of environment wildlife habitat would be challenged. However, these waste sites are located in an industrial setting, providing little habitat for vegetation and wildlife.

216-B-58 Trench and Its Analogous Sites – Alternative 5 is not applicable to these waste sites.

6.2.5.6 Implementability

The implementability of Alternative 5 is similar to Alternatives 3 and 4 except that excavation of the near-surface contaminated soils is facilitated because it is relatively shallow. The implementation of this alternative would reduce the contaminant mass at the base of the waste sites at depths up to 6.1 m (20 ft) bgs. Every 0.3 m (1 ft) of excavation would require 0.45 m (1.5 ft) of side slope for a 1:1.5 vertical-to-horizontal ratio. This safety measure significantly increases the amount of material excavated but is considered implementable. All excavated material would be disposed of at the onsite disposal facility (ERDF).

Construction of the caps would follow standard procedures that have been thoroughly field tested. The caps likely would require repair during the restoration timeframe. Monitoring the continued integrity of the caps would be accomplished through visual inspection and would be supplemented with groundwater sampling. Implementation of the capping alternative would require additional design data and possibly confirmatory sampling, because existing data are not adequate for determining the lateral extent of the caps.

Silt/loam soil used for the caps would be transported from borrow areas located on or near the Hanford Site. Anticipated volumes of these materials are identified in Appendix D. Area C has been 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. Borrow material occurs in environmentally sensitive areas; obtaining sufficient capping material would affect areas of ecological significance and is a consideration in evaluating the relative risk reduction gained by installing the cap.

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.

216-B-26 Trench and Its Analogous Sites - The contaminated soil volume for the 216-B-20 through 216-B-34 and 216-B-52 Trenches is 68,000 m^3 (89,000 yd^3), assuming excavation of each trench to a depth of 4.6 m (15 ft). Appendix F describes the contamination profile at this trench and concludes that a narrow band ending at 4.6 m (15 ft) bgs contains essentially all of the Cs-137 and Sr-90 contamination. The estimate of contamination volume includes downblending half of this layer, using 7 parts of relatively clean soil to 1 part of highly contaminated soil. Therefore, capacity exists at the ERDF to meet the required disposal volume under this alternative.

216-B-58 Trench and Its Analogous Sites – This alternative is not applicable to these waste sites.

216-B-46 Crib Analogous Sites - The contaminated soil volume for these waste sites is 24,000 m^3 (31,000 yd^3), assuming excavation of each crib to a depth of 6.1 m (20 ft). Therefore, capacity exists at the ERDF to meet the required disposal volume under this alternative.

6.2.5.7 Cost

Costs associated with Alternative 5, shown on Table 6-4, include stabilization of the existing site; excavation or import, transportation, and placement of material; compaction of the cap; prime contractor oversight; and confirmatory sampling. The cost of excavating the highly contaminated near-surface contamination assumes that all of each crib and trench would be excavated. However, to represent a reasonable estimate in view of the lack of comprehensive characterization of each waste site, only half of the highly contaminated layer of the trenches is assumed to require downblending to satisfy the ERDF waste acceptance criteria. Because the cribs had more uniform liquid dispersion, the entire highly contaminated layer associated with the cribs is assumed to require downblending. Recent geophysical characterization in the vicinity of the 216-B-26 Trench indicates apparent lateral contamination spread at least 15 m (50 ft) beyond the footprint of that trench, leading to estimates that the cap will extend at least 22.9 m (75 ft) beyond groupings of waste sites. Because removal of the near-surface contamination essentially would eliminate intruder risk, only a simple ET cap without intruder-deterrent features is assumed. For the 200-E-14 Siphon Tank, sludge removal is assumed, followed by filling the tank with grout and then covering the site with a simple ET cap. Costs are based on the use of standard equipment (e.g., hydraulic excavators, front-end loaders, dozers) and assume that a subcontractor would do the work, with oversight performed by the prime contractor. The subcontractor personnel are assumed to be wearing Level D personal protective equipment (e.g., blues and no respirators) during construction. The present-worth costs assume a 3.1 percent discount rate (based on 2004 Office of Management and Budget information) and assumes operation and maintenance for 150 yr. The operation and maintenance costs include site inspection/surveillance, periodic radiation site surveys of surface soil, and biotic control; maintenance of signs and markers; cover maintenance; and site reviews. Long-term monitoring costs associated with groundwater are included.

6.3 NATIONAL ENVIRONMENTAL POLICY ACT OF 1969 VALUES EVALUATION

The NEPA process is intended to help Federal agencies to make decisions that are based on understanding environmental consequences and then to take actions that protect, restore, and enhance the environment. It is DOE's policy (DOE 1994 and DOE O 451.1B, Change 1) 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 National Environmental Policy Act of 1969 Values

CERCLA evaluation criteria involve detailed consideration of environmental resources with an emphasis on meeting the substantive standards of other environmental laws and requirements. NEPA is a procedural statute reflecting many of the same values that are incorporated into the CERCLA process. Some values that may not be as fully addressed or developed in the CERCLA context are, under DOE's policy to integrate NEPA values to the extent practicable, considered by DOE in the RI/FS process. The NEPA-related resources and values that DOE has considered in this evaluation include the following.

- Off-Site Impacts. This value evaluates the off-site impact of the proposed remedial action, considering transportation impacts, air quality, and noise, visual, and aesthetic effects.

- Ecological Impacts. This value evaluates the impact that the proposed remedial action could have on the environment. Although the waste sites are within areas that have been largely disturbed and are generally poor habitat, large scale excavation would be avoided during the bird nesting season. This same caution would be applied to use of soil borrow sites.

- Socioeconomic Impacts. This value considers impacts pertaining to employment, income, and 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.

6.3.2 Detailed Evaluation of the National Environmental Policy Act of 1969

6.3.2.1 Off-Site Impacts

Implementation of remedial action at the waste sites likely would have some short-term impacts on traffic in the surrounding region. For Alternatives 4 and 5, impacts would result from hauling cover material from the borrow site on the west side of State Highway 240 to the waste site areas. For Alternatives 3, 4, and 5, impacts could be expected from increased traffic bringing supplies, equipment, and workers to the sites. To mitigate these impacts, a transportation safety analysis would be performed before any transport activities began. The analysis would identify the need for specific precautions (e.g., road closures, preferred hauling times, staggered work shifts) to be taken as necessary. Increases in the workforce traffic related to waste treatment would be expected to be minor.

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 and 4 are expected to be minor and could be mitigated through appropriate engineering controls.

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

Alternatives 1 and 2 would have little to no impact on current noise characteristics. Alternative 3 would increase noise levels and impair visual values, but the impacts would be short term during remedial actions and ultimately would improve the aesthetics by revegetating affected areas. Likewise, Alternatives 4 and 5 would increase noise levels and impair visual values in the short term during construction of the cap. These alternatives also could have some long-term visual and aesthetic impacts, both positive and negative. Positive impacts would result from revegetation activities. Negative impacts would be associated with the visibility and aesthetics of the caps over large distances if they are not contoured to blend in with the surrounding area. Aesthetically, given the past disturbance on the Central Plateau, no impacts would be expected from the alternatives.

6.3.2.2 Ecological Impacts

Alternative 1 would have negative ecological impact, because many of the waste sites have contamination within reach of ecological receptors. Future changes in topography from wind storms and range fires also would have potential to result in wind-blown contamination and consequent ecological harm. Alternative 2 would have lesser ecological impact, because ongoing surveillance would maintain sufficient groundcover over the waste sites to minimize animal intrusion. Also, periodic herbicide application would limit the establishment of deep-rooted plants that potentially could reach the contamination. Alternative 3 would prevent contact between the contamination and biota by removing the contamination and transferring it to the

ERDF, but substantial expansion of borrow sites would be required to fill the excavation. However, most of the borrow sites that would be used for this purpose are on the Hanford Site and are in areas that already have poor habitat. Alternative 3 also would require expansion of the ERDF, which already is planned. Alternative 4 also would prevent contact between the contamination and biota, by placement of a cap, but collection of cap materials would adversely impact the soil borrow site. The likely location of the cap material borrow site is in an undisturbed area. Alternative 5 also would negatively impact the soil borrow area where cap materials are located. Alternatives 3, 4, and 5 have the potential to disturb nesting birds at the waste sites and borrow material sites.

6.3.2.3 Socioeconomic Impacts

Alternative 1 would have no socioeconomic impacts. The other four alternatives would have some positive socioeconomic impacts related to the employment opportunities that would occur during the life of the remedial action project. The labor force required to implement remedial action would be drawn from current Hanford Site contractors and the local labor force, so the socioeconomic impacts would be expected to be minimal.

6.3.2.4 Environmental Justice

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

6.3.2.5 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 nuclear fuel manufacturer, 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 impact on groundwater. The BC Cribs and Trenches Area wastes sites are a fraction of the Hanford Site waste sites with potential to impact groundwater. Any introduction of contaminants to the groundwater from the BC Cribs and Trenches Area waste sites will be additive to what is already there. All of the proposed alternatives except Alternative 1 would require long-term land-use restrictions.

To varying degrees, Alternatives 2, 3, 4, and 5 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 and 5 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, and 5, cumulative impacts also would occur with respect to the irretrievable and irreversible commitment of geologic resources. The Central Plateau waste sites constitute only a portion of the total actions requiring material for barriers and backfill at the Hanford Site. The total quantity of geologic materials required for other Hanford Site actions currently is being identified (BHI-01551, *Alternative Fine-Grained Soil Borrow Source Study Final Report*) and may be subject to a separate NEPA evaluation.

6.3.2.6 Summary of National Environmental Policy Act of 1969 Evaluation

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

Figure 6-1. Logic Diagram for Selecting Applicable Alternatives.

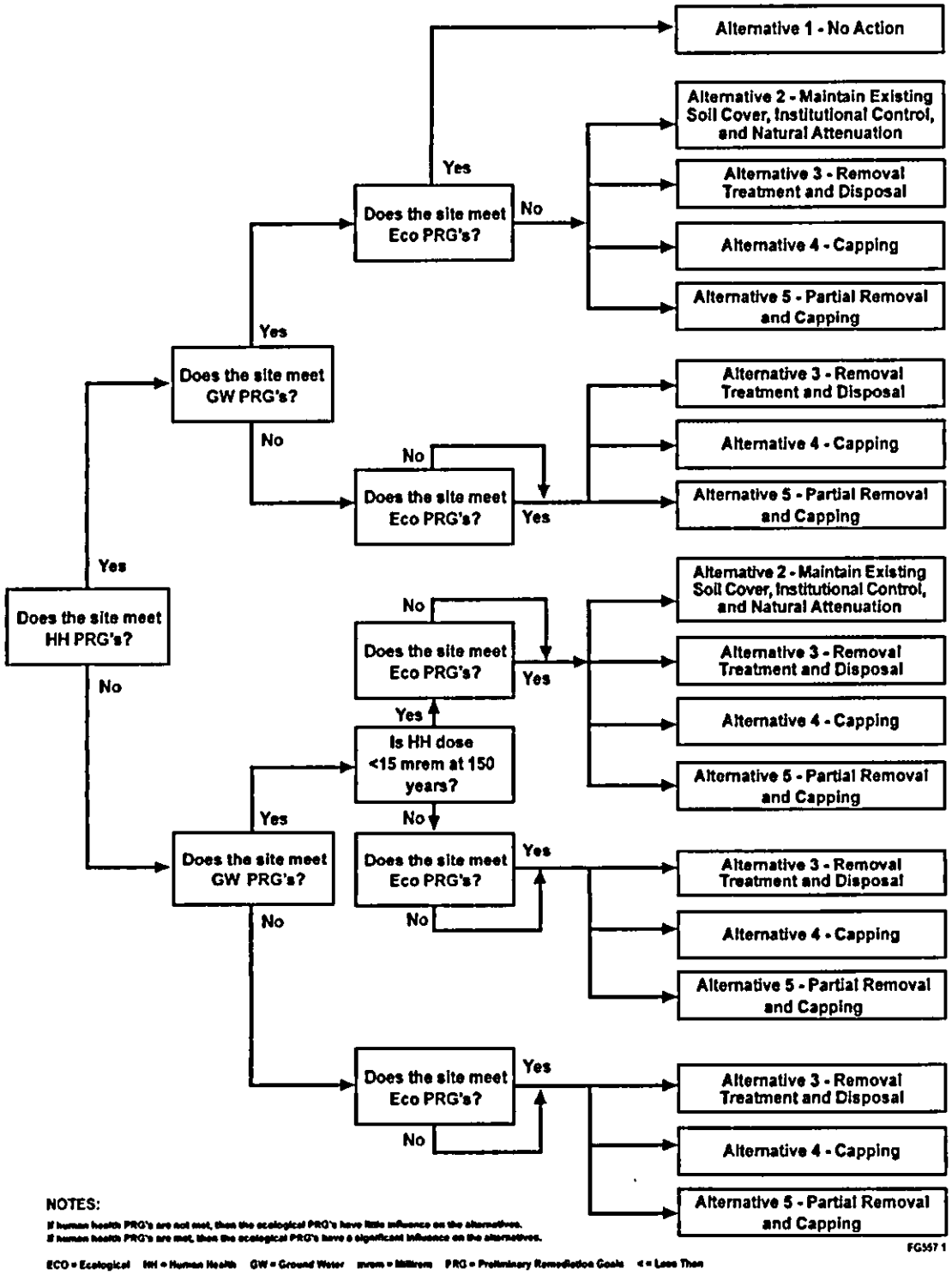

Table 6-1. Detailed Analysis Summary for Alternative 2 -- Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation.

Waste Site	Threshold Criteria			Balancing Criteria			
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Present Worth ($000) (-30% +50%)
Waste Sites Analogous to 216-B-46 Crib							
216-B-14 through 216-B-19 Cribs.	Not protective because contaminants remain above PRGs after 150 yr.	Does not comply.	Elevated contaminant concentrations will remain past 150 yr; groundwater is not protected.	Reduction through natural attenuation of radionuclides.	No short-term risks to workers; ecological risks may be expected because contaminants are less than 4.6 m (15 ft).	Readily implementable.	$1,470 ($1,029 to $2,205)
200-E-14 Siphon Tank	Not protective because of potential contact with sludge.	Does not comply.	Contaminant concentrations expected to remain high past 150 yr; no anticipated risk to groundwater	Reduction through natural attenuation of radionuclides.	No short-term risks to workers; ecological risks may be expected because contaminants are less than 4.6 m (15 ft).	Readily implementable	$950 ($665 to $1,425)
Representative Site 216-B-26 Trench and Analogous Sites							
216-B-26 Trench and Analogous sites: 216-B-20 through 216-B-25 Trenches, 216-B-27 through 216-B-34 Trenches, 216-B-52 Trench	Not protective because contaminants remain above PRGs after 150 yr.	Does not comply.	Contaminant concentrations expected to remain high past 150 yr; groundwater is not protected.	Reduction through natural attenuation of radionuclides.	No short-term risks to workers; ecological risks may be expected because contaminants are less than 4.6 m (15 ft).	Readily implementable	$4,334 ($3,034 to $6,501)
200-E-114 Pipeline	May be protective unless significant soil contamination or residual liquid within piping is found.	May comply unless significant soil contamination or residual liquid within piping is found.	Effective if no significant soil contamination has occurred and no residual liquid within piping exists. Groundwater protection not required.	Reduction through natural attenuation of radionuclides	No short-term risks to workers; ecological risks may be expected because contaminants are less than 4.6 m (15 ft).	Readily implementable	$930 ($651to $1,395)
Representative Site 216-B-58 Trench and Analogous Sites							
216-B-58 Trench and Analogous sites: 216-B-53A Trench, 216-B-53 Trench, 216-B-54 Trench	Not protective because contaminants remain above PRGs after 150 yr.	Does not comply.	Contaminant concentrations expected to remain high past 150 yr.	Reduction through natural attenuation of radionuclides	No short-term risks to workers; ecological risks may be expected because contaminants are less than 4.6 m (15 ft).	Readily implementable.	$2,675 ($1,872 to $4,012)

ARAR = applicable or relevant and appropriate requirement.
PRG = preliminary remediation goal.

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (2 Pages)

Waste Site	Threshold Criteria			Balancing Criteria			
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($000) (present worth) (-30% + 50%)
Waste Sites Analogous to 216-B-46 Crib							
216-B-14 through 216-B-19 Cribs.	Protective because contaminants are removed to meet PRGs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet PRGs. Excavation proven technology, with little chance of failure	Contaminants are moved to an engineered waste disposal facility. Reduction through natural attenuation of radionuclides	High short-term risks to workers; dose to workers estimated to be 21 person-rem, ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources because of the large excavation area. Implementation time: 3.7 yr.	Excavation to 67 m (220 ft) is necessary to remove contaminants to PRGs. Difficult to implement.	$159,074 ($111,352 to $238,611)
200-E-14 Siphon Tank	Sludge and tank removal would leave only minimal contamination that is anticipated to reach PRGs within 150 yr.	Complies with ARARs by removal of sludge; complies with disposal requirements	After sludge and tank are removed, only minimal risk remains; no anticipated risk to groundwater	Reduction through natural attenuation of radionuclides; sludge would be treated as required to meet waste acceptance criteria	Short-term risks to workers are anticipated to be high for removal of the sludge; Short-term impacts to vegetation and wildlife associated with sludge and tank removal. Implementation time: 1.2 mo plus the time to remove the sludge.	Readily implementable	$5,113 ($3,579 to $7,670)
Representative Site 216-B-26 Trench and Analogous Sites							
216-B-26 Trench and Analogous sites: 216-B-20 through 216-B-25 Trenches, 216-B-27 through 216-B-34 Trenches, 216-B-52 Trench	Protective because contaminants are removed to meet PRGs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet PRGs. Excavation proven technology, with little chance of failure	Contaminants are moved to an engineered waste disposal facility. Reduction through natural attenuation of radionuclides	High short-term risks to workers; dose to workers estimated to be 54 person-rem, ecological risks not expected because contaminants are removed. Higher possibility of impacting biological and/or cultural resources because of the large excavation area. Implementation time: 17.0 yr.	Excavation to 45.7 m (150 ft) is necessary to remove contaminants to PRGs. Difficult to implement.	$886,593 ($620,615 to $1,329,889)

Table 6-2. Detailed Analysis Summary for Alternative 3 – Removal, Treatment, and Disposal. (2 Pages)

Waste Site	Threshold Criteria			Balancing Criteria			
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($000) (present worth) (-30% + 50%)
200-E-114 Pipeline	Protective because contaminants are removed to meet PRGs.	Complies with ARARs by removing contaminants	Removal of the pipeline would be a permanent remedy	Contaminants are moved to an engineered waste disposal facility. Reduction through natural attenuation of radionuclides	Low short-term worker risk with minor contaminants 2 to 3 m (7 to 10 ft) deep; short-term ecological impacts because of excavation of pipeline. Implementation time: 1.4 mo.	Readily implementable	$557 ($390 to $836)
Representative Site 216-B-58 Trench and Analogous Sites							
216-B-58 Trench and Analogous sites: 216-B-53A Trench, 216-B-53 Trench, 216-B-54 Trench	Protective because contaminants are removed to meet PRGs.	Complies with ARARs by removing contaminants	Contaminant concentrations are removed to meet PRGs. Excavation proven technology, with little chance of failure	Contaminants are moved to an engineered waste disposal facility. Reduction through natural attenuation of radionuclides	Short-term risk to workers is moderate; dose to workers estimated to be approximately 0.07 person-rem; ecological risks not expected because contaminants are removed. Implementation time: 6.7 mo.	Readily implementable contaminants approxi-mately 7.6 m (25 ft) bgs	$3,115 ($2,180 to $4,672)

ARAR = applicable or relevant and appropriate requirement.
ERDF = Environmental Restoration Disposal Facility.
PRG = preliminary remediation goal.

Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (2 Pages)

Waste Site	Threshold Criteria			Balancing Criteria			
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($000) (present worth) (-30% + 50%)
Waste Sites Analogous to 216-B-46 Crib							
216-B-14 through 216-B-19 Cribs.	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	May not comply with groundwater protection ARARs depending on point of compliance location.	ET barrier that includes intruder-deterrent features is protective to 500 yr. PRGs related to potential intruders are reached in <250 yrs for this site.	Reduction through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected at waste sites; sites will be capped and clean soil placed as the final layer. Potential ecological impact at borrow site. Implementation time: 5.0 mo.	Readily implementable; source of fine grain capping materials tentatively identified.	$6,136 ($4,295 to $9,203)
200-E-14 Siphon Tank	Cap may not provide adequate thickness (4.6 m or 15 ft.) to deny access to residual sludge.	Complies with ARARs because there are no deep mobile contaminants	ET barrier that includes intruder-deterrent features is protective to 500 yr.	Reduction through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected at waste site; site will be capped and clean soil placed as the final layer. Potential ecological impact at borrow site. Implementation time: 1.5 mo plus time to remove sludge.	Readily implementable; source of fine grain capping materials has been tentatively identified.	$1,087 ($761 to $1,631)
Representative Site 216-B-26 Trench and Analogous Sites							
216-B-26 Trench and Analogous sites: 216-B-20 through 216-B-25 Trenches, 216-B-27 through 216-B-34 Trenches, 216-B-52 Trench	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	May not comply with groundwater protection ARARs depending on point of compliance location.	ET barrier that includes intruder-deterrent features is protective to 500 yr. PRGs related to potential intruder are reached in <500 yrs for this site.	Reduction through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected at waste sites; sites will be capped and clean soil placed as the final layer. Potential ecological impact at borrow site. Implementation time: 2.4 yr.	Readily implementable; source of fine grain capping materials tentatively identified.	$36,195 ($25,336 to $54,292)
200-E-114 Pipeline	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because the barrier is in place	ET barrier that includes intruder-deterrent is protective to 500 yr.	Reduces through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected at waste site; site will be capped and clean soil placed as the final layer Implementation time: 2.9 mo.	Readily implementable; source of fine grain capping materials has been tentatively identified.	$2,875 ($2,012 to $4,312)

Table 6-3. Detailed Analysis Summary for Alternative 4 – Capping. (2 Pages)

Waste Site	Threshold Criteria			Balancing Criteria			
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($000) (present worth) (-30% + 50%)
Representative Site 216-B-58 Trench and Analogous Sites							
216-B-58 Trench and Analogous sites: 216-B-53A Trench, 216-B-53 Trench, 216-B-54 Trench	This alternative would break potential exposure pathways to receptors through placement of a surface barrier to limit both infiltration and intrusion.	Complies with ARARs because there are no deep contaminants	ET barrier that includes intruder-deterrent features is protective to 500 yr. PRGs related to potential intruder are reached in <150 yrs.	Reduction through natural attenuation of radionuclides	Limited short-term risks to workers; no ecological risks expected at waste sites; sites will be capped and clean soil will be placed as the final layer. Potential ecological impact at borrow site. Implementation time: 4.7 mo.	Readily implementable; source of fine grain capping materials has been tentatively identified.	$5,204 ($3,643 to $7,806)

ARAR = applicable or relevant and appropriate requirement.
ET = evapotranspiration.
PRG = preliminary remediation goal.

Table 6-4. Detailed Analysis Summary for Alternative 5 – Partial Removal, Treatment, and Disposal with Capping. (2 Pages)

Waste Site	Threshold Criteria			Balancing Criteria			
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($000) (present worth) (-30% + 50%)
Waste Sites Analogous to 216-B-46 Crib							
216-B-14 through 216-B-19 Cribs.	This alternative would break potential exposure pathways to receptors by removal of near-surface contaminants and through placement of a surface barrier to limit both infiltration and intrusion.	May not comply with groundwater protection ARARs depending on point of compliance location.	This alternative is protective of human health and the environment by removing near-surface contaminants. Some chemicals and radionuclides are left in place. Caps will be designed to limit and control infiltration.	Reduction through natural attenuation of radionuclides.	High short-term risks to workers; dose to workers estimated to be 21 person-rem; ecological risks not expected at waste sites because contaminants are removed. Potential ecological impact at borrow site. Implementation time: 10.1 mo.	Readily implementable; source of fine grain capping materials tentatively identified.	$14,600 ($10,220 to $21,900)

Table 6-4. Detailed Analysis Summary for Alternative 5 – Partial Removal, Treatment, and Disposal with Capping. (2 Pages)

Waste Site	Threshold Criteria			Balancing Criteria			
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost ($000) (present worth) (-30% + 50%)
200-E-14 Siphon Tank	This alternative would remove residual sludge; remaining contamination not believed to be a risk to groundwater.	Complies with ARAR because essentially all contamination removed.	Highly protective of human health and environment because essentially all contamination removed.	Reduction through natural attenuation of radionuclides.	Potential high short-term worker risk during sludge removal. Implementation time: 1.4 mo plus the time to remove the sludge.	Readily implementable.	$5,650 ($3,955 to $8,475)
Representative Site 216-B-26 Trench and Analogous Sites							
216-B-26 Trench and Analogous sites: 216-B-20 through 216-B-25 Trenches, 216-B-27 through 216-B-34 Trenches, 216-B-52 Trench	This alternative would break potential exposure pathways to receptors by removal of near-surface contaminants and through placement of a surface barrier to limit both infiltration and intrusion.	May not comply with groundwater protection ARARs depending on point of compliance location.	This alternative is protective of human health and the environment by removing near-surface contaminants. Some chemicals and radionuclides are left in place. Caps will be designed to limit and control infiltration.	Reduction through natural attenuation of radionuclides	High short-term risks to workers; dose to workers estimated to be 54 person-rem; ecological risks not expected at waste sites because contaminants are removed. Potential ecological impact at borrow site. Implementation time: 2.6 yr.	Readily implementable; source of fine grain capping materials tentatively identified.	$54,267 ($37,987 to $81,400)
200-E-114 Pipeline	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Representative Site 216-B-58 Trench and Analogous Sites							
216-B-58 Trench and Analogous sites: 216-B-53A Trench, 216-B-53 Trench, 216-B-54 Trench	N/A	N/A	N/A	N/A	N/A	N/A	N/A

ARAR = applicable or relevant and appropriate requirement.
N/A = not applicable.

7.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

This chapter presents the comparative analysis of the five remedial alternatives for the BC Cribs and Trenches Area waste sites to identify their relative advantages and disadvantages. This comparison is based on the seven CERCLA evaluation criteria discussed in Chapter 6.0. The results of this analysis provide a basis for selecting a remedial alternative for each representative waste site and associated analogous waste sites. These remedial alternatives are as follows:

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

7.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

7.1.1 216-B-26 Trench and Analogous Trenches, Cribs Analogous to the 216-B-46 Crib

Alternative 4 (Capping) is most protective of overall human health and the environment, because the cap breaks exposure pathways, including pathways to potential inadvertent intruders, and protects groundwater. The thickness of the cap would provide a minimum of 4.6 m (15 ft) of clean soil between the waste and the surface. The cap would provide features to keep both human and ecological intruders from digging into the waste. Institutional controls associated with maintaining the cap would reinforce the effectiveness of the intruder-deterrent features. The cap would limit percolation of precipitation into the waste to slow contaminant transport toward groundwater. The cap would improve the ecological health of the waste sites area, because the current environment is highly disturbed and sparsely vegetated. However, habitat at the soil borrow site would be disrupted.

Alternative 5 (Partial Removal, Treatment, and Disposal with Capping) is next in the ranking of protectiveness. This alternative removes the near-surface contamination and transfers it to the ERDF to essentially eliminate the potential intruder risk, but does so at considerable worker risk. As with Alternative 4, the cap would limit percolation of precipitation into the waste to slow contaminant transport toward groundwater. The cap would improve the ecological health of the waste sites area, because the current environment is highly disturbed and sparsely vegetated. However, habitat at the soil borrow site would be disrupted.

Alternative 3 (Removal, Treatment, and Disposal) is next in the ranking of protectiveness. This alternative would remove all of the contamination that exceeds risk-based criteria and transfer it

to the ERDF. The worker risk from a dose perspective is essentially the same as for Alternative 5, with the added industrial risk of a very large-scale excavation. Groundwater would be fully protected, because all contaminants above risk-based criteria would be removed. However, these mobile contaminants still would be in an engineered waste disposal facility that has features to control percolation into the waste similar to those of the caps associated with Alternatives 4 and 5. This alternative would cause substantial disruption to the environment because of its very large scale.

Alternative 2 (Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation) and Alternative 1 (No Action) do not satisfy the minimum requirements.

7.1.2 216-B-58 Trench and Analogous Sites, and 200-E-114 Pipeline

Alternative 5 (Partial Removal, Treatment, and Disposal with Capping) is not applicable to the 200-E-114 Pipeline and the 216-B-58 Trench and analogous waste sites, because these sites are shallow to the point where, if the near-surface waste were excavated, there would be essentially no residual waste needing protection from a cap.

Alternative 3 (Removal, Treatment, and Disposal), which would remove all contamination exceeding risk-based criteria and dispose of it in an engineered waste disposal facility, is most protective of overall human health and the environment. The waste is near the surface and could be readily excavated without significant worker risk, particularly because the waste does not have high activity.

Alternative 4 (Capping) is ranked next, because it would break exposure pathways, including pathways to potential inadvertent intruders, and protects groundwater. The thickness of the cap would provide a minimum of 4.6 m (15 ft) of clean soil between the waste and the surface.

Alternative 2 (Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation) and Alternative 1 (No Action) do not satisfy the minimum requirements.

7.1.3 200-E-14 Siphon Tank

Alternative 3 (Removal, Treatment, and Disposal) is most protective of human health and the environment, because it would remove the tank and its contents and dispose of them to the ERDF. This alternative also would remove any contaminated soil associated with past leaks.

Alternative 5 (Partial Removal, Treatment, and Disposal with Capping) is ranked next in terms of protectiveness for the 200-E-14 Siphon Tank, because it would remove the contents of the tank and then provide a cap to protect groundwater from any minor leaks that may have occurred over the history of tank use. It should be noted that no such leaks are documented. This alternative potentially would disrupt the habitat associated with the soil borrow site.

Alternative 4 (Capping) would not be protective, because the tank contents would be accessible.

7.2 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

All Sites

Alternative 3 (Removal, Treatment, and Disposal) complies most fully with the ARARs by removing all contamination and transferring it to an engineered waste disposal facility (ERDF). Groundwater protection requirements would be satisfied, although the mobile long-lived contaminants disposed of to the ERDF eventually would reach groundwater, albeit at reduced concentrations in the distant future.

Alternative 4 (Capping) and Alternative 5 (Partial Removal, Treatment, and Disposal with Capping) would have equal compliance with the ARARs. Groundwater protection would be achieved by caps that limit percolation of precipitation into the waste to slow contaminant transport toward groundwater. However, depending on the point of compliance for evaluating groundwater quality, minimum drinking water standards may be exceeded. It may be necessary to seek waivers to these standards if groundwater monitoring shows adverse impacts.

Alternative 2 (Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation) would not comply with the ARARs, because it is not protective of human health and the environment. The ARARs may be met under Alternative 2 for the 200-E-114 Pipeline, which is a 5 cm (2-in.) steel pipeline that runs from the BY and C Tank Farms to the 200-E-14 Siphon Tank. The only evidence of leakage was a small amount near the tank farms source, which is outside of the BC Cribs and Trenches Area. Because of the small diameter, the steel construction, and basic/neutral waste stream, significant leaks along the pipeline are unlikely. Confirmatory sampling would be required before this alternative is implemented.

Alternative 1 (No Action) does not comply with the ARARs, because no sites meet the criteria.

7.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

7.3.1 216-B-26 Trench and Analogous Trenches, Cribs Analogous to the 216-B-46 Crib, and 200-E-14 Siphon Tank

Alternative 3 (Removal, Treatment, and Disposal) best satisfies this criterion, because it would completely remove all contamination that exceeds risk-based standards and transfer it to the ERDF. Ongoing monitoring would not be needed because, effectively, there would be no residual contamination.

Alternative 5 (Partial Removal, Treatment, and Disposal with Capping) is the next most effective, because it would remove the near-surface contamination and then provide a cap to protect groundwater from the deeper, more mobile contaminants by limiting percolation of precipitation into the waste.

Alternative 4 (Capping) is the next most effective, because the cap would provide protection from the near-surface contaminants by a combination of intrusion-deterrent features and institutional controls associated with cap maintenance and would protect groundwater as described for Alternative 5.

Alternatives 1 and 2 would not provide any significant long-term effectiveness and permanence.

7.3.2 216-B-58 Trench and Analogous Sites, and 200-E-114 Pipeline

Alternative 3 (Removal, Treatment, and Disposal) best satisfies this criterion, because it would completely remove all contamination that exceeds risk-based standards and transfer it to the ERDF. Ongoing monitoring would not be needed because, effectively, there would be no residual contamination.

Alternative 4 (Capping) is the next most effective, because the cap would provide protection from the near-surface contaminants by a combination of intrusion-deterrent features and institutional controls associated with cap maintenance and would protect groundwater, although groundwater protection should not be threatened by these waste sites.

Alternatives 1 and 2 would not provide any significant long-term effectiveness and permanence. Alternative 5 is not applicable to these waste sites.

7.4 REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

7.4.1 216-B-26 Trench and Analogous Sites, Sites Analogous to the 216-B-46 Crib, 216-B-58 Trench and Analogous Sites, and 200-E-114 Pipeline

None of the alternatives include active treatment. All include natural attenuation and capping (except for Alternatives 1 and 2), at least to the extent that excavated waste that is transferred to the ERDF eventually would be capped to protect it from intrusion and protect groundwater from mobile contaminants disposed of there.

Alternative 3 (Removal, Treatment, and Disposal) and Alternative 5 (Partial Removal, Treatment, and Disposal with Capping) best satisfy this criterion, because they would remove the near-surface contamination and transfer it to the ERDF. Alternative 3 also would remove the deeper contamination. Some reduction of toxicity would result from implementation of these alternatives, particularly for the high concentrations of the removed contamination, because it would require downblending to satisfy the ERDF waste acceptance criteria. The cap associated with Alternative 5 would limit percolation of precipitation into the residual deep mobile waste, which would reduce the mobility of the contaminants and slow their transport toward groundwater. For Alternative 3, the ERDF cap would perform a similar function for the mobile contaminants disposed of there.

Alternative 4 (Capping) is the next best in satisfying this criterion, because it would reduce the mobility of the deep mobile contaminants by limiting contact between the waste and precipitation percolation by covering the waste with a cap.

Alternatives 1 and 2 would not provide any element relative to this criterion other than to employ natural attenuation.

7.4.2 200-E-14 Siphon Tank

Alternatives 3 and 5, which would remove the tank contents, would include some type of treatment to dewater the waste before its disposal at the ERDF. However, this "treatment" would not effectively reduce the toxicity, mobility, or volume of the waste that is anticipated to exist within the tank. Alternatives 1, 2, and 4 would not provide any element relative to this criterion other than to employ natural attenuation.

7.5 SHORT-TERM EFFECTIVENESS

7.5.1 216-B-26 Trench and Analogous Trenches, Cribs Analogous to the 216-B-46 Crib

Alternative 4 (Capping) would provide the most short-term effectiveness; it would complete the remedial action in the least time and with the least worker risk, because there would be no contact with the wastes. Environmental quality at the waste sites would be improved, because the cap would be vegetated with sustainable plants. Some degradation of environment quality would occur at the soil borrow site used to obtain capping material.

Alternative 5 (Partial Removal, Treatment, and Disposal with Capping) would be next in short-term effectiveness, because it could be accomplished in a slightly longer time but would involve significant worker risk involved with excavation of the high concentration of near-surface contamination. Impacts to the environment would be similar to those associated with Alternative 4.

Alternative 3 (Removal, Treatment, and Disposal), which would excavate all of the contaminated soil that exceeds risk-based criteria, would provide substantially less short-term effectiveness

because of the much longer time required to complete the action, combined with still increased worker risk. Not only would workers potentially be exposed to the high concentrations of near-surface contamination, but they would be subjected to the industrial hazards associated with large-scale deep excavations. Impact to the environment would be greater at both the waste site and the borrow sites used to fill the excavation because of the magnitude of the excavation.

Alternative 1 (No Action) and Alternative 2 (Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation) do not provide short-term effectiveness, because RAOs would not be met.

7.5.2 216-B-58 Trench and Analogous Sites, and 200-E-114 Pipeline

Alternative 4 (Capping) provides the most short-term effectiveness, because it will achieve RAOs with minimal worker risk in just a few months. Alternative 4 would temporarily disrupt the environment in the vicinity of the pipeline and the cap soil borrow site.

Implementation of Alternative 3 (Removal, Treatment, and Disposal) would involve increased worker risk, because of potential interaction with low contaminant levels, in approximately the same time frame. Alternative 3 impacts to the environment at both the waste sites and soil borrow site would be greater than for Alternative 4, because of the disruptive nature of excavation.

Alternate 5 (Partial Removal, Treatment, and Disposal with Capping) is not applicable to these waste sites.

Alternative 2 (Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation) would not provide short-term effectiveness for the 216-B-58 Trench and analogous sites because RAOs would not be met. Alternative 2 may be appropriate for the 200-E-114 Pipeline, because no leaks have been documented in the BC Crib and Trenches Area. However, no characterization of the pipeline has been performed to justify selection of this alternative.

Alternative 1 (No Action) would not provide short-term effectiveness for any of these sites, because RAOs would not be met.

7.5.3 200-E-14 Siphon Tank

Alternative 5 (Partial Removal, Treatment, and Disposal with Capping), which would fill the tank with grout after removing its contents and then cover it with a cap, would best satisfy this criterion. Worker risk during tank contents removal is readily controlled, and the time to effect this remedy is essentially the same as for Alternative 3.

Alternative 3 (Removal, Treatment, and Disposal) would be slightly less effective because of the somewhat increased worker risk associated with tank removal. Environmental impacts to the waste site would be minimal for each of these alternatives because of its small size.

Alternative 4 (Capping) would not achieve RAOs, because access to tank contents is near the surface. Even with effective intrusion-deterrent features in the cap and institutional controls, it is not acceptable to leave potential liquid waste this close to the surface.

Alternatives 1 and 2 would not provide short-term effectiveness for any of these sites, because RAOs would not be met.

7.6 IMPLEMENTABILITY

7.6.1 216-B-26 Trench and Analogous Trenches, Cribs Analogous to the 216-B-46 Crib

Alternative 4 (Capping) best satisfies this criterion, because it uses proven technology, has no administrative roadblocks, and uses available materials and services. In particular, the silt loam necessary for the water storage layer of the cap is available from the Hanford Site.

Alternative 5 (Partial Removal, Treatment, and Disposal with Capping) also is implementable but is more complicated, because it requires excavation of the near-surface contamination and backfilling the excavation before constructing a cap.

Alternative 3 (Removal, Treatment, and Disposal), which would completely remove all contamination exceeding risk-based criteria, is still less implementable because of the magnitude of the excavation that would cover several dozen acres and would be from 46 to 61 m (150 to 220 ft) deep.

Alternatives 1 and 2 are implementable but would not achieve RAOs.

7.6.2 216-B-58 Trench and Analogous Sites, and 200-E-114 Pipeline

Alternative 3 (Removal, Treatment, and Disposal), which would completely remove all contamination exceeding risk-based criteria, is readily implementable, because these sites are shallow (i.e., technically feasible), and there are no administrative roadblocks. Also, borrow soil for backfilling the excavations is readily available.

Alternative 4 (Capping) is equally implementable. No excavation is required, which eliminates the need for backfill soil. Borrow soil is available, which would be required for the soil storage layer of the cap.

Alternative 5 (Partial Removal, Treatment, and Disposal with Capping) is not applicable to these sites, because if the near-surface contamination were removed, there would be no need to place a cap over the residual contamination.

Alternatives 1 and 2 are implementable but would not achieve RAOs, except possibly for the 200-E-114 Pipeline.

7.6.3 200-E-14 Siphon Tank

Alternative 3 (Removal, Treatment, and Disposal) and Alternative 5 (Partial Removal, Treatment, and Disposal with Capping) are equally implementable. The technology exists to remove the contents of the tank and either fill it with grout before capping or completely remove the tank and backfill the excavation.

Although readily implementable, Alternative 4 (Capping) would not achieve RAOs, because the tank contents would be accessible.

Alternatives 1 and 2 are implementable but would not achieve RAOs, except possibly for the 200-E-114 Pipeline.

7.7 COST

7.7.1 216-B-26 Trench and Analogous Trenches, Cribs Analogous to the 216-B-46 Crib

Alternative 4 (Capping) best satisfies this criterion, but its present worth minus 30% plus 50% values overlap the range of values for Alternative 5 (Partial Removal, Treatment, and Disposal with Capping) ($149 million vs $165 million, nominal costs). If only capital costs are considered, Alternative 4 is less than half the cost of Alternative 5 ($17 million vs $43 million). The cost of Alternative 3 (Removal, Treatment, and Disposal) ($1,046 million) is many times that of Alternatives 4 or 5.

7.7.2 216-B-58 Trench and Analogous Sites, and 200-E-114 Pipeline

Alternative 3 is less costly than Alternative 4. Although the capital cost of Alternative 4 is less than for Alternative 3 ($1.5 million vs $3.7 million, respectively), the present worth cost of Alternative 3 is substantially less ($3.7 million vs $24.8 million, respectively) because of the ongoing monitoring and maintenance costs associated with capping.

7.7.3 200-E-14 Siphon Tank

The estimated costs of Alternatives 3 and 5 are quite similar. Both capital costs and present worth costs are within the margin of error (minus 30% plus 50%). The estimated cost of Alternative 4 is considerably less, but this alternative is not applicable; RAOs would not be achieved because the tank contents are accessible.

8.0 CONCLUSIONS AND PATH FORWARD

This chapter summarizes the results of the FFS and presents the path forward for the BC Cribs and Trenches Area waste sites. As described in DOE/RL-98-28, this chapter identifies the preferred alternatives for remediation of the waste sites.

8.1 FOCUSED FEASIBILITY STUDY SUMMARY

Five remedial alternatives were evaluated for the BC Cribs and Trenches Area waste sites:

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

The alternatives were evaluated against the CERCLA criteria; then they were evaluated against each other using the CERCLA criteria. Tables 8-1 through 8-3 identify the preferred alternative for each waste site in the BC Cribs and Trenches Area and provide justification for the preferred alternative selection based on the detailed and comparative analyses presented in Chapters 6.0 and 7.0 of this FFS.

8.1.1 Representative Site 216-B-26 Trench and Analogous Waste Sites

A summary of the analysis of alternatives supporting the selection of the preferred alternatives for this group of waste sites is provided in Table 8-1. The detailed and comparative analyses are provided in Chapters 6.0 and 7.0, respectively.

The preferred alternative for the 216-B-20 through 216-B-34 and 216-B-52 Trenches is Alternative 4, Capping, because this alternative is most protective of human health, the environment, the groundwater, and waste site remediation workers, and is cost-effective. Until radioactive decay removes excessive concentrations of Cs-137 and Sr-90, human health and environmental protection from near-surface contamination is provided by the barrier and the associated presence of personnel to periodically maintain it.

To address the potential threat to groundwater from deep Tc-99 and nitrate, expanded evaluation of technologies with the potential to immobilize the deep mobile contaminants that may not be satisfactorily controlled by capping is recommended.

The preferred alternative for the shallow 200-E-114 Pipeline is Alternative 3, Removal, Treatment, and Disposal, because this alternative cost-effectively removes all future risk with minimal worker risk.

8.1.2 Representative Site 216-B-58 Trench and Its Analogous Sites

The 216-B-58 Trench is the representative site for the 216-B-53A, 216-B-53B, and 216-B-54 Trenches. A summary of the analysis of alternatives supporting the selection of the preferred alternatives for this group of waste sites is provided in Table 8-2. The preferred alternative for the 216-B-58, 216-B-53A, 216-B-53B, and 216-B-54 Trenches is Alternative 3, Removal, Treatment, and Disposal, because this alternative is most protective of human health, the environment, the groundwater, and workers.

8.1.3 Representative Site 216-B-46 Crib and Its Analogous Waste Sites

The 216-B-46 Crib[3] is the representative site for the216-B-14 through 216-B-19 Cribs and the 200-E-14 Siphon Tank.

A summary of the analysis of alternatives supporting the selection of the preferred alternatives for this group of waste sites is provided in Table 8-3. The detailed and comparative analyses are provided in Chapters 6.0 and 7.0, respectively.

The preferred alternative for the 216-B-14 through 216-B-19 Cribs is Alternative 4, Capping, because this alternative is most protective of human health, the environment, the groundwater, and workers. Until radioactive decay removes excessive concentrations of Cs-137 and Sr-90, human health and environmental protection from near-surface contamination is provided by the barrier and the associated presence of personnel to periodically maintain it.

To address the potential threat to groundwater from deep Tc-99 and nitrate, expanded evaluation of technologies with the potential to immobilize the deep mobile contaminants that may not be satisfactorily controlled by capping is recommended.

The preferred alternative for the 200-E-14 Siphon Tank is Alternative 3, Removal, Treatment, and Disposal, because this alternative removes the sludge from the tank, which provides the most protective remedy. Subsequent to sludge and tank removal, the tank footprint would be capped because of its location within the expected footprint of the cap for the BC Cribs (216-B-14 through 216-B-19 Cribs).

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[3] Note that the 216-B-46 Crib, which is the representative site for some of the BC Cribs and Trenches Area analogous waste sites, is not, itself, located in the BC Cribs and Trenches Area.

8.1.4 Treatment

Expanded evaluation of technologies having the potential to immobilize deep contaminants, particularly Tc-99, is recommended to provide additional groundwater protection assurance. There is time to perform treatability testing, based on fate and transport modeling that predicts no significant groundwater impact for more than 100 yr. At this time, soil desiccation appears to have the potential to directly reduce the driving force deep in the vadose zone for contamination transport toward the groundwater and, thus, significantly increase overall protectiveness.

An independent technical review of the technology review presented in Appendix H is recommended. It also is recommended that participants in that review evaluate the recommendation that soil desiccation has the least uncertainty for potential to immobilize Tc-99 contamination. If the technical review recommends a specific technology, a treatability test would be the next step. Then, depending on the outcome of the treatability test, that technology could become part of the final remedial action.

8.2 PATH FORWARD

The PP has been prepared to document the preferred alternatives for the BC Cribs and Trenches Area waste sites (DOE/RL-2004-69). The PP details the closure options and documents that the waste sites will be remediated in accordance with the ROD to be developed following issuance of the plan.

The representative sites for the BC Cribs and Trenches Area waste sites were evaluated in this FFS, based on data generated through a limited field investigation. The analogous sites for the BC Cribs and Trenches Area waste sites were evaluated based on data generated for the representative sites or on site-specific data. The Implementation Plan (DOE/RL-98-28) defines this strategy as a means to streamline RIs and focus the CERCLA process to obtain a decision. As identified in the Implementation Plan, additional sampling phases conducted post-ROD are meant to augment the RI data, confirm the alternative selection, support the design, and provide information for final site closeout. Because of the overall accelerated schedule for this project, much of this sampling is planned to be performed before the ROD is issued, rather than afterward. Confirmatory sampling is conducted to confirm that the representative site contaminant distribution model used to evaluate the analogous site is appropriate to the site conditions and to confirm that the appropriate remedial alternative was selected. Design sampling is conducted to obtain data necessary to design the remedial alternative and refine cost estimates from the FFS. Geophysical characterization in the form of high-resolution resistivity will be expanded to develop a comprehensive delineation of the deep contamination. Limited soil sampling will be performed to corroborate the high-resolution resistivity characterization and investigate anomalies. Verification sampling is conducted to verify that the remediation goals have been met by the implementation of the remedial alternative. Table 8-4 presents the confirmatory, design, and verification sampling phases and presents assumed data needs for each sampling phase for the representative sites and for analogous sites that are similar (or equal) to the representative sites, are less contaminated (or have lower risk) than the representative sites, or are more contaminated (or have higher risk) than the representative sites (see Chapter 2.0 for additional details). This table builds off of the decision logic presented in Figure 2-12 and

Table 2-2 (analogous site table) and provides a basis for initiating the data quality objectives process for the confirmatory sampling and design sampling phases.

Post-ROD sampling needs will be determined through the DQO process; a SAP will be developed to direct the sampling needed at the analogous sites. This sampling will be used to confirm that the correct alternative has been selected and to provide design data through a plug-in approach as defined in the following subsections. Future characterization is expected to focus on the cribs to establish the nature and extent of deep mobile contaminants. Examination of the 200-E-14 Siphon Tank is necessary to develop specific remedial action. Also, further characterization will be performed to support cap design.

Sites undergoing a removal, treatment, and disposal alternative will use the observational approach during removal. Sites slated for caps will need additional data to confirm the lateral extent of contaminants and to support remedial design. Sites slated for no action (none currently identified for the BC Cribs and Trenches Area) may need verification sampling, depending on the amount, type, and quality of data available to support the no-action decision. The (CERCLA) operation and maintenance sampling could include the monitoring of natural attenuation and performance monitoring of the cap.

Table 8-1. Preferred Alternative for the Representative Site 216-B-26 Trench and Its Analogous Waste Sites. (2 Pages)

CRITERIA	ALTERNATIVES				
	❶ NO ACTION	❷ MESC, IC, MNA[a]	❸ RTD[b]	❹ CAPPING	❺ PARTIAL REMOVAL/ CAPPING
Representative Site 216-B-26 Trench with 216-B-23 through 216-B-28 Trenches and 216-B-52 Trench				☑	
Threshold Criteria					
Overall Protection	☐	☐	☑	☑	☑
Compliance with Laws	☐	☐	☑	☑[d]	☑[d]
Balancing Criteria					
Long-term effectiveness	◇	◇	◆	◈	◈
Short-term effectiveness	◇	◇	◇	◆	◇
Reduction in TMV[c]	◇	◇	◈	◈	◈
Implementability	◆	◆	◇	◆	◈
Cost (in thousands)					
Capital costs	$0	$20	$339,401	$6,063	$14,019
Operating and maintenance costs	$0	$7,565	$0	$41,782	$41,879
Present worth	$0	$1,498	$339,401	$14,826	$22,801
"No discount" scenario	$0	$7,585	$339,401	$47,845	$55,898
Analogous Sites 216-B-20 through 216-B-22 Trenches				☑	
Threshold Criteria					
Overall Protection	☐	☐	☑	☑	☑
Compliance with Laws	☐	☐	☑	☑[d]	☑[d]
Balancing Criteria					
Long-term effectiveness	◇	◇	◆	◈	◈
Short-term effectiveness	◇	◇	◇	◆	◇
Reduction in TMV[c]	◇	◇	◈	◈	◈
Implementability	◆	◆	◇	◆	◈
Cost (in thousands)					
Capital costs	$0	$20	$155,321	$2,977	$5,784
Operating and maintenance costs	$0	$7,002	$0	$20,728	$20,769
Present worth	$0	$1,386	$155,321	$7,265	$10,080
"No discount" scenario	$0	$7,022	$155,321	$23,705	$26,553
Analogous Sites 216-B-29 through 216-B-34 Trenches				☑	
Threshold Criteria					
Overall Protection	☐	☐	☑	☑	☑
Compliance with Laws	☐	☐	☑	☑[d]	☑[d]
Balancing Criteria					
Long-term effectiveness	◇	◇	◆	◈	◈
Short-term effectiveness	◇	◇	◇	◆	◇
Reduction in TMV[c]	◇	◇	◈	◈	◈
Implementability	◆	◆	◇	◆	◈
Cost (in thousands)					
Capital costs	$0	$20	$391,871	$5,509	$12,532
Operating and maintenance costs	$0	$7,404	$0	$40,990	$41,314
Present worth	$0	$1,450	$391,871	$14,104	$21,385
"No discount" scenario	$0	$7,424	$391,871	$46,499	$53,847

Table 8-1. Preferred Alternative for the Representative Site 216-B-26 Trench and Its Analogous Waste Sites. (2 Pages)

CRITERIA	ALTERNATIVES				
	❶ NO ACTION	❷ MESC, IC, MNA[a]	❸ RTD[b]	❹ CAPPING	❺ PARTIAL REMOVAL/ CAPPING
Analogous Site 200-E-114 Pipeline			☑		
Threshold Criteria					
Overall Protection	☐	☐	☑	☑	NA[e]
Compliance with Laws	☐	☐	☑	☑	NA
Balancing Criteria					
Long-term effectiveness	◇	◇	◆	⟐	NA
Short-term effectiveness	◇	◇	◆	⟐	NA
Reduction in TMV[c]	◇	◇	⟐	⟐	NA
Implementability	◆	◆	⟐	⟐	NA
Cost (in thousands)					
Capital costs	$0	$20	$557	$1,422	NA
Operating and maintenance costs	$0	$4,400	$0	$6,875	NA
Present worth	$0	$930	$557	$2,875	NA
"No discount" scenario	$0	$4,420	$557	$8,297	NA

a. Maintain existing soil cover, institutional controls, monitored natural attenuation
b. Removal, treatment, and disposal
c. Toxicity, mobility, or volume through treatment
d. May not be fully compliant with groundwater protection requirements.
e. NA = not applicable.

☑ Indicates the preferred alternative
☑ Yes, meets criterion
☐ No, does not meet criterion
◆ High: satisfies criterion
⟐ Moderate: partially meets criterion
◇ Low: minimally satisfies criterion

Table 8-2. Preferred Alternative for the Representative Site 216-B-58 Trench and Its Analogous Waste Sites.

CRITERIA	ALTERNATIVES				
	❶ NO ACTION	❷ MESC, IC, MNA[a]	❸ RTD[b]	❹ CAPPING	❺ PARTIAL REMOVAL/ CAPPING
Representative Site 216-B-58 Trench and Analogous Sites 216-B-53A Trench, 216-B-53B Trench, and 216-B-54 Trench			☑		
Threshold Criteria					
Overall Protection	☐	☐	☑	☑	NA[d]
Compliance with Laws	☐	☐	☑	☑	NA
Balancing Criteria					
Long-term effectiveness	◇	◇	◆	⟐	NA
Short-term effectiveness	◇	◇	⟐	◆	NA
Reduction in TMV[c]	◇	◇	⟐	⟐	NA
Implementability	◆	◆	⟐	⟐	NA
Cost (in thousands)					
Capital costs	$0	$40	$3,115	$2,080	NA
Operating and maintenance costs	$0	$13,682	$0	$15,830	NA
Present worth	$0	$2,675	$3,115	$5,204	NA
"No discount" scenario	$0	$13,722	$3,115	$17,910	NA

a. Maintain existing soil cover, institutional controls, monitored natural attenuation
b. Removal, treatment, and disposal
c. Toxicity, mobility, or volume through treatment
d. NA = not applicable.

☑ Indicates the preferred alternative
☑ Yes, meets criterion
☐ No, does not meet criterion
◆ High: satisfies criterion
⟐ Moderate: partially meets criterion
◇ Low: least satisfies criterion

Table 8-3. Preferred Alternatives for the 216-B-46 Crib Analogous Waste Sites.

CRITERIA	ALTERNATIVES				
	❶ NO ACTION	❷ MESC, IC, MNA[a]	❸ RTD[b]	❹ CAPPING	❺ PARTIAL REMOVAL/ CAPPING
Analogous Sites 216-B-14 through 216-B-19 Cribs				☑	
Threshold Criteria					
Overall Protection	☐	☐	☑	☑	☑
Compliance with Laws	☐	☐	☑	☑[d]	☑[d]
Balancing Criteria					
Long-term effectiveness	◇	◇	◆	◈	◈
Short-term effectiveness	◇	◇	◇	◆	◇
Reduction in TMV[c]	◇	◇	◈	◈	◈
Implementability	◆	◆	◇	◆	◈
Cost (in thousands)					
Capital costs	$0	$20	$159,074	$2,408	$10,856
Operating and maintenance costs	$0	$7,424	$0	$18,119	$18,202
Present worth	$0	$1,470	$159,074	$6,136	$14,600
"No discount" scenario	$0	$7,444	$159,074	$20,527	$29,058
Analogous Site 200-E-14 Siphon Tank			☑		
Threshold Criteria					
Overall Protection	☐	☐	☑	☐	☑
Compliance with Laws	☐	☐	☑	☐	☑
Balancing Criteria					
Long-term effectiveness	◇	◇	◆	◇	◈
Short-term effectiveness	◇	◇	◆	◇	◆
Reduction in TMV[c]	◇	◇	◈	◈	◈
Implementability	◆	◆	◈	◆	◈
Cost (in thousands)					
Capital costs	$0	$20	$5,113	$561	$5,124
Operating and maintenance costs	$0	$4,420	$0	$2,522	$2,522
Present worth	$0	$950	$5,113	$1,087	$5,650
"No discount" scenario	$0	$4,440	$5,113	$3,083	$7,645

a. Maintain existing soil cover, institutional controls, monitored natural attenuation
b. Removal, treatment, and disposal
c. Toxicity, mobility, or volume through treatment
d. May not comply with groundwater protection requirements.

☑ Indicates the preferred alternative
☑ Yes, meets criterion
☐ No, does not meet criterion
◆ High: satisfies criterion
◈ Moderate: partially meets criterion
◇ Low: minimally satisfies criterion

Table 8-4. Sampling Before and After the Record of Decision.

Alternative	Confimatory Sampling						Design Sampling	Verification Sampling			O&M
	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 PRG Attainment	Monitor RAO Attainment
Alternative 1 – No Action								X	X	X	
Alternative 2 - Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation											
Representative site			X		X				X		X
Analogous site equal to representative site			X								X
Analogous site less than representative site	X	X	X	If an issue at Rep Site							X
Analogous site greater than representative site	X	X	X	If not an issue at Rep Site	X				X		X
Alternative 3 – Removal, Treatment, and Disposal											
Representative site						X			X	X	
Analogous site equal to representative site						X				X	
Analogous site less than representative site	X					X				X	
Analogous site greater than representative site						X			X	X	
Alternative 4 – Capping											
Representative site					X		X		X		X
Analogous site equal to representative site							X				X
Analogous site less than representative site	X						X				X
Analogous site greater than representative site					X		X		X		X
Alternative 5 – Partial Removal, Treatment, and Disposal with Capping											
Representative site						X	X		X	X	X
Analogous site equal to representative site						X	X			X	X
Analogous site less than representative site	X			X		X	X			X	X
Analogous site greater than representative site				X		X	X		X	X	X

O&M = operations and maintenance.
PRG = preliminary remediation goal.
RAO = remedial action objective.
X = assumed data needs.

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APPENDIX A

WASTE SITE PHOTOGRAPHS

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APPENDIX B

POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

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TERMS

ACM	asbestos containing material
ARAR	applicable or relevant and appropriate requirement
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
HEPA	high-efficiency particular air
LLW	low-level waste
MCL	maximum contaminant level
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 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

This appendix identifies and evaluates potential applicable or relevant and appropriate requirements (ARAR) for waste site remediation for the BC Cribs and Trenches Area waste sites. 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 ARAR to-be-determined 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 orders must be met.

Because the waste sites in the BC Cribs and Trenches Area 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. 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.* 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 (of Washington) requirement promulgated pursuant to a state (of Washington) 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.

Under this process, potential ARARs are classified into one of three categories: chemical-specific, location-specific, or action-specific. These categories are defined as follows.

- Chemical-specific requirements usually are 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 usually are technology- or activity-based requirements or limitations triggered by the remedial actions performed at the site.

When requirements in each category are identified, a determination must be made as to whether those requirements are ARARs. A requirement is applicable if the specific terms or jurisdictional prerequisites of the law or regulations directly address the circumstances at a site. Even if not applicable, a requirement may be relevant and appropriate if, based on best professional judgment, circumstances at the site are sufficiently similar to the problems or situations regulated by the requirement and the requirement's use is well suited to the site. Only the substantive requirements (e.g., use of control or containment equipment, compliance with numerical standards) associated with ARARs apply to CERCLA on-site activities. ARARs associated with administrative requirements, such as permitting, do not apply 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 BC Cribs and Trenches Area waste sites.

TBC information is nonpromulgated advisories or guidance issued by Federal and state (of Washington) 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 to protect human health and the environment. The TBCs complement the ARARs in determining protectiveness at a site or implementing 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 the following six circumstances in which the EPA may waive ARARs for on-site remedial actions.

- 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 through the use of another method or approach.
- The ARAR is a state (of Washington) 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.

B1.2 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS APPLICABLE TO REMEDIAL ACTIONS FOR BC CRIBS AND TRENCHES AREA WASTE SITES

Potential Federal and state (of Washington) ARARs are presented in Tables B-1 and B-2, respectively. The chemical-specific ARARs and TBCs likely to be most relevant to remediation of the BC Cribs and Trenches Area waste sites 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"). In addition, EPA/540/R-99/006, *Radiation Risk Assessment At CERCLA Sites: Q & A*, Directive 9200.4-31P, will assist as a TBC in regards to radiation risk assessment. The requirements of WAC 173-340-745 risk-based concentrations and EPA/540/R-99/006 help establish soil cleanup standards for nonradioactive and radioactive contaminants at waste sites. The several Federal and state of Washington air emission standards likely are 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 waste generated during remedial actions.

No location-specific ARARs have been identified for the waste sites considered in this focused feasibility study.

Action-specific ARARs that could be pertinent to remediation are state of Washington solid and dangerous waste regulations (for management of characterization and remediation waste and performance standards for waste left in place), *Atomic Energy Act of 1954* regulations (for performance standards for radioactive waste sites), and Federal and state regulations related to air emissions.

A variety of waste streams would be generated under the proposed remedial action alternatives. It is anticipated that most of the waste will be designated as low-level waste (LLW). However, quantities of dangerous or mixed waste, polychlorinated biphenyl (PCB)-contaminated waste, asbestos, and asbestos containing material (ACM) also could be generated. The majority of the waste will be in a solid form. However, some aqueous solutions might be generated.

The identification, storage, treatment, and disposal of hazardous waste and the hazardous component of mixed waste are governed by RCRA. The State of Washington, which

implements RCRA requirements under WAC 173-303, "Dangerous Waste Regulations," has been authorized to implement most elements of RCRA. The substantive requirements from the dangerous waste standards would apply to the generation and storage of any dangerous or mixed waste generated during the remedial action Treatment standards for dangerous or mixed waste 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 management and disposal of PCB wastes are governed by the *Toxic Substances Control Act of 1976* (TSCA), and regulations at 40 CFR 761, "Polychorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions." 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.

Removal and disposal of asbestos and ACM are regulated under the *Clean Air Act of 1990*; 40 CFR 61, Subpart M, "National Emission Standards for Asbestos"; and WAC 296-62, "General Occupational Health Standards"). These regulations provide for special precautions to prevent environmental releases or exposure to personnel of airborne emissions of asbestos fibers during the remedial action. Packaging requirements are identified in 40 CFR 61.52.

Waste that is designated as LLW that meets Environmental Restoration Disposal Facility (ERDF) acceptance criteria is assumed to be disposed of at the ERDF, which is engineered to meet appropriate performance standards under 10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste." Alternate potential 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 for appropriate performance standards to ensure that it is adequately protective of human health and the environment.

Waste designated as dangerous or mixed waste would be treated as appropriate to meet land-disposal restrictions and ERDF waste acceptance criteria and disposed of at the 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 during the remedial action would be identified and implemented before movement of any waste.

Some of the aqueous waste designated as LLW, dangerous, or mixed waste would be transported to the 200 Area Effluent Treatment Facility for treatment and disposal. The Effluent Treatment Facility is a RCRA-permitted facility authorized to treat aqueous waste streams generated on the Hanford Site and to dispose of these streams at a designated state-approved land disposal facility in accordance with applicable requirements.

Waste designated as PCB remediation waste likely would be disposed at ERDF, depending on whether it is LLW 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 and disposal at an appropriate disposal facility.

Asbestos and ACM would be removed, packaged as appropriate, and disposed of in the ERDF.

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 to the environment, the facilities can be treated as one for purposes of CERCLA response actions. Consistent with this, the BC Cribs and Trenches Area remedial action and the ERDF would be considered to be on site for purposes of CERCLA Section 104, and waste may be transferred between the facilities without requiring a permit.

All alternatives 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 emissions.

The Federal *Clean Air Act of 1990* and the "Washington Clean Air Act" (RCW 70.94) require regulation of air pollutants. Under Federal implementing regulations, the 40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities," requires that radionuclide airborne emissions from the facility 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. The same regulation addresses point sources (i.e., stacks or vents) that emit radioactive airborne emissions, requiring monitoring of such sources with a major potential for radioactive airborne emissions, and requiring periodic confirmatory measurement sufficient to verify low emissions from such sources with a minor potential for emissions. Under Washington State implementing regulations, the Federal regulations are paralleled by adoption, and in addition require added control of radioactive airborne emissions where economically and technologically feasible (WAC 246-247-040(3) and –040(4), "Department of Health," "Radiation Protection - Air Emissions," "General Standards," and associated definitions). To address the substantive aspect of these requirements, best or reasonable control technology will be addressed by ensuring that applicable emission control technologies (those reasonably operated in similar applications) will be used when economically and technologically feasible (i.e., based on cost/benefit). Additionally, the substantive aspect of the requirements for monitoring of fugitive or non-point sources that emit radioactive airborne emissions (WAC 246-247-075(8), "Monitoring, Testing and Quality Assurance") will be addressed by sampling the effluent streams and/or ambient air 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).

B2.0 REFERENCES

10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste," Title 10, *Code of Federal Regulations*, Part 61, as amended.

40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," Title 40, *Code of Federal Regulations*, Part 61, as amended.

40 CFR 61.52, "Emission Standard," Title 40, *Code of Federal Regulations*, Part 6152, as amended.

40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities," Title 40, *Code of Federal Regulations*, Part 61, as amended.

40 CFR 61, Subpart M, "National Emission Standards for Asbestos," Title 40, *Code of Federal Regulations*, Part 61, Subpart M, as amended.

40 CFR 141, "National Primary Drinking Water Standards," Title 40, *Code of Federal Regulations*, Part 141, as amended.

40 CFR 268, "Land Disposal Restrictions," Title 40, *Code of Federal Regulations*, Part 268, as amended.

40 CFR 761, "Polychorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions," Title 40, *Code of Federal Regulations*, Part 761, as amended.

Atomic Energy Act of 1954, 42 USC 2011, et seq.

Clean Air Act of 1990, 42 USC 7401, et seq., Pub. L. 101-549.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601, et seq.

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RCW 70.94, "Public Health and Safety," "Washington Clean Air Act," Title 70, Chapter 94, *Revised Code of Washington*, as amended, Washington State, Olympia, Washington.

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

Superfund Amendments and Reauthorization Act of 1986, 42 USC 103, et seq.

Toxic Substances Control Act of 1976, 15 USC 2601, et seq.

WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-303-140, "Land Disposal Restrictions," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-303-665, "Landfills," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-304, "Minimum Functional Standards for Solid Waste Handling," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-340, "Model Toxics Control Act -- Cleanup," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-350, "Solid Waste Handling Standards," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-400, "General Regulations for Air Pollution Sources," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 173-460, "Controls for New Sources of Toxic Air Pollutants," *Washington Administrative Code*, as amended, Washington State Department of Ecology, Olympia, Washington.

WAC 246-247, "Department of Health," "Radiation Protection - Air Emissions," *Washington Administrative Code*, as amended, Washington State Department of Health, Olympia, Washington.

WAC 296-62, "General Occupational Health Standards," *Washington Administrative Code*, as amended, Washington State Department of Labor and Industries, Olympia, Washington.

Table B-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and To-Be-Considered for Remedial Action Sites. (2 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"National Primary Drinking Water Standards," 40 CFR 141			
"Maximum Contaminant Levels for Organic Contaminants," 40 CFR 141.61	ARAR	Establishes MCLs that are drinking water criteria designed to protect human health from the potential adverse effects of organic contaminants in drinking water.	The groundwater associated with the BC Cribs and Trenches Area waste sites currently is not used for drinking water. However, 200 Area groundwater may be considered a potential drinking water source and, because the groundwater is hydraulically connected to the Columbia River (which is used for drinking water), the substantive requirements in 40 CFR 141.61 for organic contaminants are relevant and appropriate.
"Maximum Contaminant Levels for Inorganic Contaminants," 40 CFR 141.62	ARAR	Establishes MCLs that are drinking water criteria designed to protect human health from the potential adverse effects of inorganic contaminants in drinking water.	The groundwater associated with the BC Cribs and Trenches Area waste sites currently is not used for drinking water. However, 200 Area groundwater may be considered a potential drinking water source and, because the groundwater is hydraulically connected to the Columbia River (which is used for drinking water), the substantive requirements in 40 CFR 141.62 for inorganic contaminants are relevant and appropriate.
"Maximum Contaminant Levels for Radionuclides," 40 CFR 141.66	ARAR	Establishes MCLs that are drinking water criteria designed to protect human health from the potential adverse effects of radionuclides in drinking water.	The groundwater associated with the BC Cribs and Trenches Area waste sites currently is not used for drinking water. However, 200 Area groundwater may be considered a potential drinking water source and, because the groundwater is hydraulically connected to the Columbia River (which is used for drinking water), the substantive requirements in 40 CFR 141.66 for radionuclides are relevant and appropriate.
"Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions," 40 CFR 761			
"Applicability," Specific Subsections: 40 CFR 761.50(b)(3) 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 or relevant and appropriate to the storage and disposal of PCB liquids, items, remediation wastes, and bulk product waste at >50 ppm. The specific subsections identified from 40 CFR 761.50(b) reference the specific section for the management of PCB waste type. The disposal requirements for radioactive PCB waste are addressed in 40 CFR 761.50(b)(7).
"National Emission Standards for Hazardous Air Pollutants," 40 CFR 61			
"Standard," 40 CFR 61.92	ARAR	Requires that emissions of radionuclides to the ambient air from DOE facilities shall not exceed amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr.	The substantive requirements of this standard are applicable to remedial action activities in the BC Cribs ands Trenches Area, such as excavation of contaminated soils and the operation of exhausters and vacuum systems handling radioactively contaminated airborne effluent, each which may result in the release of radioactive particulates into unrestricted areas. As a result, requirements limiting emissions apply. This is a risk-based standard for human health and the environment.

Table B-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and To-Be-Considered for Remedial Action Sites. (2 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Emission Monitoring and Test Procedures," 40 CFR 61.93	ARAR	Establishes the methods for monitoring emissions rates from existing point sources.	The substantive requirements of this standard are applicable, because emissions of radionuclides to the ambient air may result from remediation activities performed in the BC Cribs and Trenches Area, or from related use of temporary sources such as exhausters or HEPA-filtered vacuum systems.
"National Emission Standard for Asbestos," 40 CFR 61 Subpart M; "Applicability," 40 CFR 61.140			
"Standard for Demolition and Renovation," 40 CFR 61.145	ARAR	Specifies that facilities are to be inspected for the presence of asbestos before demolition. The standard defines regulated asbestos-containing materials and establishes removal requirements based on quantity present and handling requirements. These requirements also specify handling and disposal requirements for regulated sources having the potential to emit asbestos. Specifically, no visible emissions are allowed during handling, packaging, and transport of asbestos-containing materials.	Although asbestos-containing materials are not anticipated, the substantive requirements of this standard are applicable should asbestos-containing materials be located during remedial action activities associated with pipelines and buried asbestos.
"Standard for Waste Disposal for Manufacturing, Fabricating, Demolition, Renovation, and Spraying Operations," 40 CFR 61.150	ARAR	Identifies the requirements for the removal and disposal of asbestos during demolition and renovation activities.	Although asbestos-containing materials are not anticipated, the substantive requirements of this standard are applicable should asbestos-containing materials be located during remedial action activities associated with pipelines and buried asbestos.
Regulations pursuant to the *Resource Conservation and Recovery Act of 1976* and implemented through WAC 173-303, "Dangerous Waste Regulations" (see Table B-2).			

40 CFR 61, "National Emission Standards for Hazardous Air Pollutants."
40 CFR 141, "National Primary Drinking Water Standards."
40 CFR 761, "Polychorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions."
Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq.
WAC 173-303, "Dangerous Waste Regulations."

ARAR = applicable or relevant and appropriate requirement.
CFR = *Code of Federal Regulations.*
DOE = U.S. Department of Energy.
HEPA = high-efficiency particular air.
MCL = maximum contaminant level.
PCB = polychlorinated biphenyl.
TBC = to be considered.
WAC = *Washington Administrative Code.*

Table B-2. Identification of Potential State Applicable and Relevant or Appropriate Requirements and To-Be-Considered for Remedial Action Sites. (5 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 waste.	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.
"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.
"Designation of Dangerous Waste," WAC 173-303-070	ARAR	Establishes the method for determining whether or not a solid waste is 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.
"Excluded Categories of Waste," WAC 173-303-071	ARAR	Describes those categories of waste that are excluded from the requirements of WAC 173-303 (excluding WAC 173-303-050).	The conditions of this requirement are applicable to remediation of the BC Cribs and Trenches Area waste sites, should wastes identified in WAC 173-303-071 be encountered.
"Conditional Exclusion of Special Wastes," WAC 173-303-073	ARAR	Establishes the conditional exclusion and the management requirements of special waste, as defined in WAC 173-303-040.	The conditions of this requirement are applicable to remediation of the BC Cribs and Trenches Area waste sites, should special waste be encountered.
"Requirements for Universal Waste," WAC 173-303-077	ARAR	Identifies those waste types exempted from regulation under WAC 173-303-140 and WAC 173-303-170 through 173-303-9907 (excluding WAC 173-303-960). These waste types 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 special waste are applicable to the interim management of certain waste that will be generated during the remedial action.

Table B-2. Identification of Potential State Applicable and Relevant or Appropriate Requirements and To-Be-Considered for Remedial Action Sites. (5 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	There regulations define the requirements for the recycling of 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 are not otherwise subject to CERCLA as hazardous substances can be recycled and/or conditionally excluded from certain dangerous waste requirements.
"Land Disposal Restrictions," WAC 173-303-140	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).	Substantive requirements of these regulations 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 ARAR to this remedial action, but would instead be subject to all applicable laws and regulations.
"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 intermit 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 173-330-200 by reference. WAC 173-303-200 further includes certain substantive standards from WAC 173-303-630 and -640 by reference.
"Model Toxics Control Act – Cleanup," WAC 173-340			
"Soil Cleanup Standards for Industrial Properties," WAC 173-340-745(5)(b)	ARAR	Identifies the methods used to identify risk-based concentrations and their use in the selection of a cleanup action. Cleanup and remediation levels are based on protection of human health and the environment, the location of the site, and other regulations that apply to the site. The standard specifies cleanup goals that implement the strictest Federal or state cleanup criteria.	The state-established risk-based concentrations for soils and protection of groundwater are relevant and appropriate to the BC Cribs and Trenches Area waste sites remedial actions, because no Federal standard exists.

Table B-2. Identification of Potential State Applicable and Relevant or Appropriate Requirements and To-Be-Considered for Remedial Action Sites. (5 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Minimum Functional Standards for Solid Waste Handling," WAC 173-304			
"On-Site Containerized Storage, Collection and Transportation Standards for Solid Waste," WAC 173-304-200(2)	ARAR	Establishes the standards for the on-site storage of solid wastes that are not radioactive or dangerous wastes.	Substantive requirements of these regulations are applicable to materials encountered during the remedial action. Specifically, nondangerous, nonradioactive solid wastes (i.e., hazardous substances that are only regulated as solid waste) that will be containerized for removal from the CERCLA site would be managed on site according to the substantive requirements of this standard.
"Solid Waste Handling Standards," WAC 173-350			
"On-Site Storage, Collection and Transportation Standards," WAC 173-350-300	ARAR	Establishes the requirements for the temporary storage of solid waste in a container on site and the collecting and transporting of the solid waste.	The substantive requirements of this newly promulgated rule are relevant and appropriate to the on-site collection and temporary storage of solid waste at the BC Cribs and Trenches Area waste sites. Compliance with this regulation is being implemented in phases for existing facilities.
"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 waste. 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 waste at the BC Cribs and Trenches Area waste sites. Construction of additional groundwater monitoring wells is anticipated as part of the overall remedial actions.
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.	

Table B-2. Identification of Potential State Applicable and Relevant or Appropriate Requirements and To-Be-Considered for Remedial Action Sites. (5 Pages)

ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
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.	
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.	
"General Regulations for Air Pollution Sources," WAC 173-400			
"General Standards for Maximum Emissions," WAC 173-400-040	ARAR	Establishes the general emission standards for emission units. Emission standards identified in other chapters for specific emission units will take precedence over the general emission standards of this section.	The substantive requirements of this standard are relevant and appropriate to remedial actions performed at the site that could result in the emission of criteria air pollutants (i.e., fugitive dust). Substantive standards established for the control and prevention of air pollution under this regulation are applicable to remedial actions that may be proposed at a site.
"Controls for New Sources of Toxic Air Pollutants," WAC 173-460			
"Control Technology Requirements," WAC 173-460-030 WAC 173-460-060 WAC 173-460-070	ARAR	Emissions of toxic air contaminants shall be quantified and ambient impacts evaluated. Best available control technology for toxics shall be used as determined by the lead agency to protect human health and the environment.	Substantive requirements of these standards are relevant and appropriate to this remedial/removal action, because there is the potential for toxic air pollutants to become airborne as a result of decontamination, demolition, and excavation activities. As a result, standards established for the control of toxic air contaminants may be relevant and appropriate.
"Department of Health," "Radiation Protection - Air Emissions," WAC 246-247			
"Standards," WAC 246-247-040(3) WAC 246-247-040(4)	ARAR	These standards specify emission monitoring requirements and the application of best available radionuclide technology requirements found in WAC 246-247-120, Appendix B; and the application of "as low as reasonably achievable control technology" requirements found in WAC 246-247-130, Appendix C.	Substantive requirements of this standard are applicable, because fugitive and non-point source emissions of radionuclides to the ambient air may result from activities performed during excavation of contaminated soils in the BC Cribs and Trenches Area. This standard exists to ensure compliance with emission standards.

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ARAR Citation	ARAR or TBC	Requirement	Rationale for Use
"Monitoring, Testing, and Quality Assurance," WAC 246-247-075	ARAR	Establishes the monitoring, testing, and quality assurance requirements for radioactive air emissions. Adopts 40 CFR 61, Subpart H, monitoring, testing, and quality assurance requirements. Measurement techniques may include, but are not limited to, sampling, calculation, smears, or other reasonable methods for identifying emissions, as determined by the lead agency.	The substantive requirements of this regulation are considered applicable as fugitive, non-point source emissions of radionuclides to the ambient air that may result from the excavation of contaminated soils in the BC Cribs and Trenches Area. This standard exists to ensure compliance with emission standards.

40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities."

Comprehensive Environmental Response, Compensation, and Liability Act of 1980,42 USC 9601, et seq.

WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells."

WAC 173-303, "Dangerous Waste Regulations."

WAC 173-304, "Minimum Functional Standards for Solid Waste Handling."

WAC 173-340, "Model Toxics Control Act -- Cleanup."

WAC 173-350, "Solid Waste Handling Standards."

WAC 173-400, "General Regulations for Air Pollution Sources."

WAC 173-460, "Controls for New Sources of Toxic Air Pollutants."

WAC 246-247, "Department of Health," "Radiation Protection - Air Emissions."

ARAR = applicable or relevant and appropriate requirement.

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

CFR = *Code of Federal Regulations.*

TBC = to be considered.

WAC = *Washington Administrative Code.*