1231111
[0079991H]

DOE/RL-2010-49
Draft B

Remedial Investigation/Feasibility Study Work Plan 200-WA-1 and 200-BC-1 Operable Units

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

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

P.O. Box 550
Richland, Washington 99352

Attached to: 1231110

159

DOE/RL-2010-49
Draft B

Remedial Investigation/Feasibility Study Work Plan 200-WA-1 and 200-BC-1 Operable Units

Date Published
September 2015

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

U.S. DEPARTMENT OF ENERGY | Richland Operations Office
P.O. Box 550
Richland, Washington 99352

Executive Summary

This work plan describes the activities for conducting and developing the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*[1] (CERCLA) remedial investigation (RI)/feasibility study (FS) for the 200-WA-1 and 200-BC-1 Operable Units (OUs), located within the Inner Area of the Central Plateau at the Hanford Site. The work plan will serve as the basis for development of the RI/FS and baseline risk assessment (BRA) for the 200-WA-1 and 200-BC-1 OUs.

The RI determines the nature and extent of contamination and the fate and transport of contaminants in the environment to evaluate risks and select remedies and remedial treatment technologies.

The RI serves as the mechanism for collecting data to accomplish the following:

- Characterize site conditions
- Determine the nature of the waste
- Assess risk to human health and the environment (HHE)
- Assess potential threats to groundwater
- Conduct treatability testing to evaluate the potential performance and cost of the treatment technologies that may be considered
- Describe how remedial alternatives will be developed and evaluated in the FS

Appendix E of this work plan is a sampling and analysis plan (SAP) detailing the process of fulfilling the additional data needs described in this work plan.

The BRA will identify waste sites that pose a potential threat to groundwater or a potential unacceptable human health and/or ecological risk.

The FS is the process through which the development, screening, and detailed evaluation of alternative remedial actions will occur. The results will be documented in the RI/FS report. The RI/FS report also provides the basis for the development of a proposed plan

[1] *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et seq., Pub. L. 107-377, December 31, 2002. Available at: http://epw.senate.gov/cercla.pdf.

that describes the preferred remedy for each waste site. Following the public comment period, the selection of the final actions will be documented in a record of decision.

Background

In 2009, the U.S. Department of Energy, Richland Operations Office, developed a cleanup framework to reduce the size of the Hanford Site's active cleanup footprint to the area known as the Central Plateau. The Central Plateau is in the central portion of the Hanford Site and encompasses approximately 195 km^2 (75 mi^2). The two major geographic cleanup areas within the Central Plateau are the 170 km^2 (65 mi^2) Outer Area and the 25 km^2 (10 mi^2) Inner Area. The 200-WA-1 and 200-BC-1 OUs are located in the Inner Area (Figure ES-1).

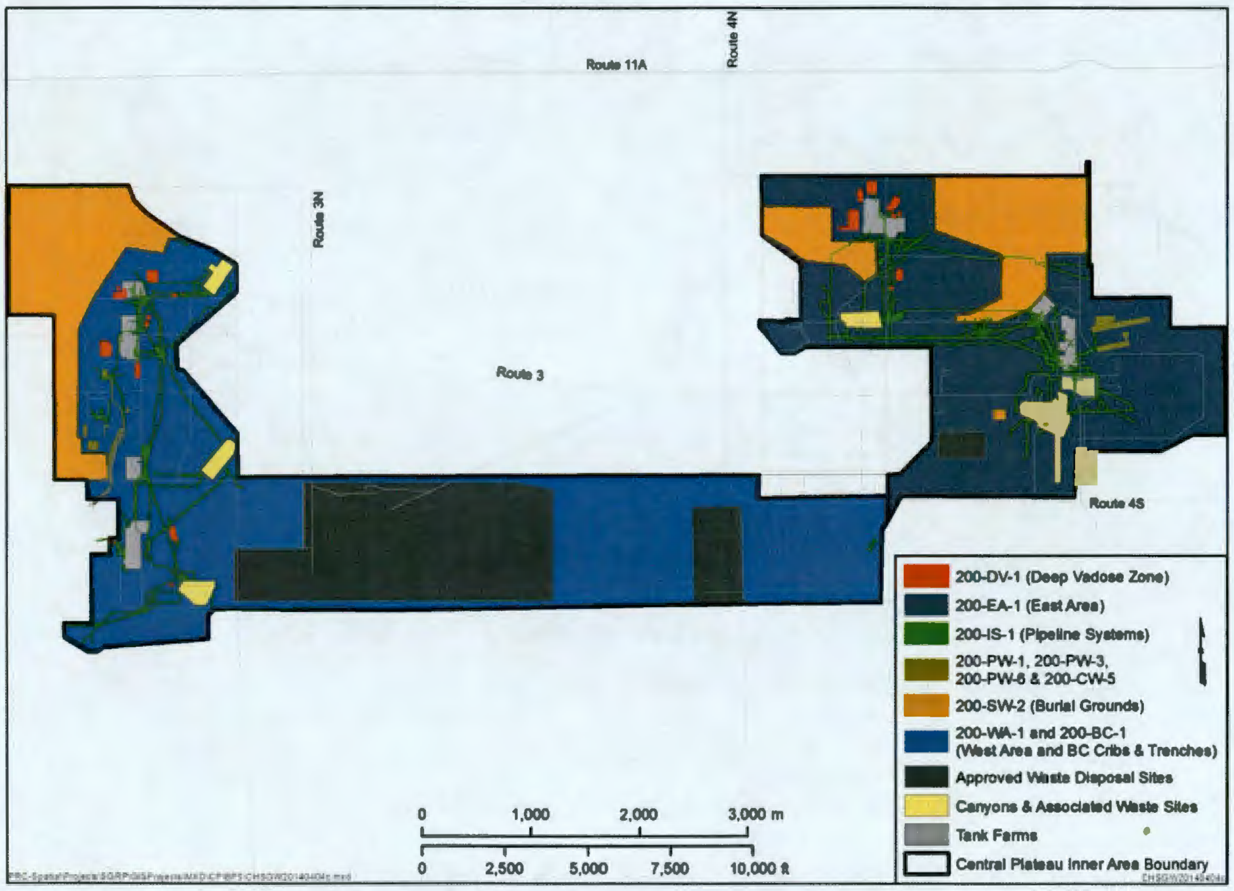


Figure ES-1. OUs in the Central Plateau Inner Area

Work Plan Scope—The scope of this work plan includes 145 sites in the 200-WA-1 OU and 27 sites in the 200-BC-1 OU. The types of waste sites in the 200-WA-1 and 200-BC-1 OUs are diverse but correspond to one of the following general categories:

Cribs are square- or rectangular-shaped below ground surface (bgs) infiltration structures. Cribs were initially constructed of a perforated discharge pipe installed within a gravel bed, with most supported by timber cribbing. Cribs were used to dispose of the largest volumes of liquid effluent from process facilities.

Trenches are typically V-shaped open excavations installed 3 to 6+ m (10 to 20+ ft) deep, with a perforated pipe in the bottom used for short-term or single-use discharges of liquid effluent.

Reverse Wells are injection wells used for infiltration of generally low-volume/higher concentration liquid effluents deeper into the vadose zone (usually 15.2 to 30.5 m [50 to 100 ft] bgs).

French Drains are shallow vertical structures used for infiltration of liquid waste into the vadose zone (generally 1.5 to 4.6 m [5 to 15 ft] bgs). French drains are often between 0.76 and 1.5 m (2.5 and 5.0 ft) in diameter and constructed of concrete or steel culvert pipe.

Retention Basins are generally concrete-lined open depressions used to store or convey process-related liquid effluents (e.g., cooling water and steam condensate).

Ditches are typically unlined, natural, or anthropogenic features, used to convey process-related effluents (e.g., cooling water).

Vaults are underground structures used to house process equipment or tanks. This category includes the 241-WR Vault.

Underground Storage Tank waste sites in the 200-WA-1 and 200-BC-1 OUs range from septic tanks to tanks storing high concentrations of process-related contaminants.

Septic Systems consist of septic tanks and associated drain fields that are used for liquid waste disposal from individual process facilities. Normally, septic systems handle only sanitary waste from bathrooms or showers, but some are connected to floor drains that potentially received radiological and/or chemical contaminants.

Unplanned Releases are unintentional releases and are areas of contamination associated with leaks, spills, or windblown contaminants. A large number of recent discoveries has been identified through surface radiological surveys (along roadways, rail spurs, or areas downwind of tank farms) or from periodic aerial radiologic surveys.

Solid Waste sites in the 200-WA-1 and 200-BC-1 OUs are nonengineered surface disposal areas (e.g., a construction laydown yard or general debris disposal area).

Pipelines convey process and waste liquids between the process facilities and the waste disposal sites (e.g., cribs and trenches).

Sand Filters received ventilation system exhaust and discharged the resulting condensate to a French drain.

Waste sites assigned to other Inner Area OUs, active facilities, tank farm facilities, or sites that do not contain CERCLA constituents are not assessed in this work plan.

200-WA-1 and 200-BC-1 OU RI Waste Sites Evaluation—The initial evaluation of the 200-WA-1 and 200-BC-1 OUs builds upon the operational history and environmental setting to describe what is known, or can be inferred, about waste sites to make remedial decisions. The evaluation integrates relevant site information, including contaminant data, physical structures, and the nature and extent of environmental impacts to assess whether the information is sufficient to characterize environmental risks and potential threats to groundwater, and to develop risk reduction strategies.

Relevant site information, including contaminant sources, process history, previous investigations, monitoring, and remediation activities, was integrated to create descriptions of each 200-WA-1 and 200-BC-1 OU waste site. More than 5,000 existing waste site records were reviewed as part of this evaluation to support the development of this work plan. The volume and diversity of historical records provide the basis for identifying data gaps and needs that will support the RI/FS evaluations.

Each waste site was evaluated to determine whether sufficient data exist to understand contaminant nature and extent, evaluate HHE risks and threat to groundwater, and develop appropriate preliminary remedial alternatives. Appendix D of this work plan provides a detailed summary of each waste site, including site description, release history, previous characterization, and nature and extent of contamination. Appendix D also summarizes the data needs identified for each waste site and provides a characterization approach to fulfill those data needs in accordance with the SAP in Appendix E. No additional characterization is proposed where existing site data are sufficient to evaluate the nature and extent of contamination, evaluate HHE risks and threat to groundwater, and develop appropriate preliminary remedial alternatives.

In the 200-WA-1 and 200-BC-1 OUs, a subset of waste sites with "nonsoil" features were identified as having separate data needs for the physical structure. These include vessels (and any waste contained therein) and other physical structures for which soil data are considered not adequately representative. These features include pipelines, underground storage tanks (USTs), building slabs, concrete basins, and vaults, but do not include timber structures within cribs or railroad tracks. Data needs for each of these sites are outlined in Appendix D. A specific approach for fulfilling these data needs is provided in the SAP (Appendix E). Generally, this approach includes the following:

- Sampling of solid and liquid waste contents from vessels (septic tanks, silos, solid waste vaults), if no data are available or existing data are of insufficient quality. Analytical data for these samples will be used to support evaluation of HHE risk and remedial action alternative development.

- Sampling of nonsoil features (pipelines, USTs, building slabs and foundations, basins, vaults) for which separate characterization data are required to support evaluation of HHE risk and remedial action alternative development.

200-BC-1 OU—The data needs evaluation resulted in 27 waste sites being placed into one of the following three categories:

1. **Sites that already have adequate vadose zone characterization to support evaluation of HHE risk and remedial alternative analysis.** Within the 200-BC-1 OU, one trench (216-B-26) was identified in this category.

2. **Sites for which characterization data at a similar site can be used to support evaluation of HHE risk and remedial alternative analysis.** Using similar site groups requires that the sites be sufficiently similar in design, primary waste source and volume, waste release scenario, hydrogeologic conditions, and contaminant migration. These similarities allow the characterized representative site to provide a comparable analysis or to provide bounding conditions for the uncharacterized similar sites to support evaluation of HHE risk and remedy analysis. Twenty-five of the

twenty-seven 200-BC-1 OU waste sites have been included in three similar site groupings. Three sites with ample vadose zone characterization, either currently (216-B-26) or once all data needs are addressed (216-B-14 and 216-B-58) in the 200-BC-1 OU, will serve as representative sites for 22 sites that are considered similar.

3. **Sites requiring additional data to support evaluation of HHE risk and remedial alternative analysis.** In the 200-BC-1 OU, four waste sites have been identified as having additional data needs. Two of these sites (216-B-14 and 216-B-58) require additional characterization and will serve as representative sites in their respective similar site groupings. The final two sites (200-E-14 and 216-B-53A) will be characterized independently.

200-WA-1 OU—The data needs evaluation resulted in each of the 145 waste sites in the 200-WA-1 OU being placed into one of the following three categories:

1. **Sites that have already received adequate vadose zone characterization sufficient to support evaluation of HHE risk and remedy analysis.** Within the 200-WA-1 OU, six waste sites were identified in this category. Five of the characterized sites are in the U Plant vicinity (216-U-1&2, 216-U-3, 216-U-4, 216-U-4A, and 241-U-361), with one in Z Plant (216-Z-7).

2. **Sites for which characterization data at a similar site can be used to support evaluation of HHE risk and remedial alternative analysis.** Using a similar site requires that it be sufficiently similar in design, primary waste source and volume, waste release scenario, hydrogeologic conditions, and contaminant migration. These similarities allow the characterized site to provide a comparable analysis or to provide bounding conditions for the uncharacterized site to support evaluation of HHE risk and remedy analysis. The 200-WA-1 OU has six groups of similar sites. Sites chosen to be representative for each group are 216-S-6, 216-T-28, 216-U-6, 216-T-34, 216-Z-16, and 216-Z-6. Of the 145 sites, 12 are included under the 6 groups of similar sites. However, each of the six group comparisons is contingent on execution of additional sampling and analysis for each of the six representative sites.

3. **Sites requiring additional data to support evaluation of HHE risk and remedial alternative analysis.** Additional data needs have been identified for 135 waste sites

in the 200-WA-1 OU. These sites include those where existing characterization data are inadequate for fulfilling RI/FS and BRA data needs and no similar site relationship to an adequately characterized representative site could be identified. In addition, two similar sites have some uncertainty in their dimension; therefore, some minimal shallow characterization will be performed on these two sites (216-S-5 and 216-U-5). Therefore, 216-S-5 and 216-U-5 are included in both the similar site and data needs categories.

Inputs to Support the BRA—The waste site data will be used as inputs to support the BRA. The BRA will support the determination of the need for action on the 200-WA-1 and 200-BC-1 OU waste sites, identify contaminants of potential concern, and support the development of preliminary remediation goals.

Remedial Alternatives—This work plan identifies general response actions for vadose zone contaminants to satisfy preliminary remedial action objectives. An initial screening of remedial technologies has also been performed, based on contaminant and site characteristics.

During the RI/FS process, waste sites within these OUs will be evaluated for the development of remedial alternatives. If it is determined that remedial alternatives cannot be evaluated with the existing characterization data, the SAP will be amended during the RI to collect the necessary data. This will occur before the remedy selection process.

This page intentionally left blank.

Contents

Appendices

Figures

Tables

This page intentionally left blank.

1 # Terms

amsl	above mean sea level
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
BRA	baseline risk assessment
CCU	Cold Creek unit
CEM	conceptual exposure model
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COC	contaminant of concern
COPC	contaminant of potential concern
CPP	CERCLA past-practice
CSM	conceptual site model
DOE	U.S. Department of Energy
DOE-RL	DOE Richland Operations Office
DPT	direct push technology
DQA	data quality assessment
DQO	data quality objective
DST	double-shell tank
DVZ	deep vadose zone
Ecology	Washington State Department of Ecology
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERDF	Environmental Restoration Disposal Facility
ESD	explanation of significant difference
FS	feasibility study
FSP	field sampling plan
GA	graded approach
GPL	geophysical logging

GRA	general response action
HAB	Hanford Advisory Board
HCP	Hanford Comprehensive Land Use Plan
HEAST	Health Effects Assessment Summary Tables
HEIS	Hanford Environmental Information System
HHE	human health and the environment
HHRA	Human Health Risk Assessment
HMS	Hanford Meteorological Station
HSU	hydrostratigraphic unit
HWIS	Hanford Well Information System
IDMS	Integrated Document Management System
IRIS	Integrated Risk Information System
K_d	distribution coefficient
MCL	maximum contaminant level
MNA	monitored natural attenuation
MTCA	"Model Toxic Control Act—Cleanup" (WAC 173-340)
NA	no data available
NAPL	nonaqueous-phase liquid
NCEA	National Center for Environmental Assessment
NCP	National Contingency Plan (40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan")
NEPA	*National Environmental Policy Act of 1969*
NPL	National Priorities List (40 CFR 300, Appendix B)
NTCRA	non-time-critical removal action
OU	operable unit
P&T	pump and treat
PFP	Plutonium Finishing Plant
PNNL	Pacific Northwest National Laboratory
POC	point of compliance
PPRTV	Provisional Peer-Reviewed Toxicity Values

PRG	preliminary remediation goal
PUREX	Plutonium and Uranium Extraction (Plant)
QAPjP	quality assurance project plan
RAGS	Risk Assessment Guidance for Superfund
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
RD/RA	remedial design/remedial action
REDOX	Reduction-Oxidation (Plant)
RFI/CMS	RCRA facility investigation/corrective measures study
RI	remedial investigation
ROD	record of decision
RTD	removal, treatment, and disposal
SALDS	State-Approved Land Disposal Site
SAP	sampling and analysis plan
SIM	Soil Inventory Model
SMDP	scientific-management decision point
SSL	soil screening level
SST	single-shell tank
TBC	to be considered
TBP	tributyl phosphate
TCRA	time critical removal action
TNC	The Nature Conservancy
TPA	Tri-Party Agreement
Tri-Parties	U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TRU	transuranic
TSD	treatment, storage, and disposal
UCL	upper confidence limit
UPR	unplanned release

UST	underground storage tank
VCP	vitrified clay pipe
VOC	volatile organic compound
WIDS	Waste Information Data System
WMA	Waste Management Area

1 Introduction

This document presents the work plan for a remedial investigation/feasibility study (RI/FS) that describes the approach to assess the nature and extent of contamination, characterize risks to human health and the environment (HHE) associated with exposure to site-related contaminants, and develop and evaluate remedial action alternatives to support selection of a final remedy for the 200-WA-1 and 200-BC-1 Operable Units (OUs) at the Hanford Site. This work is being performed for the U.S. Department of Energy (DOE) under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA).

The Hanford Site consists of approximately 1,517 km^2 (586 mi^2) in the Columbia River Basin of southeastern 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 National Priorities List (NPL) (40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan" [NCP], Appendix B, "National Priorities List") pursuant to CERCLA.[1] Each NPL (40 CFR 300, Appendix B) site is divided into multiple OUs, as outlined in the Tri-Party Agreement (TPA) (Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*). The 200-WA-1 and 200-BC-1 OUs are part of the 200 Area NPL (40 CFR 300, Appendix B) site.

In 2009, the U.S. Department of Energy, Richland Operations Office (DOE-RL) developed a cleanup framework to reduce the size of the Hanford Site active cleanup footprint to the area known as the Central Plateau. The Central Plateau is in the central portion of the Hanford Site and encompasses approximately 195 km^2 (75 mi^2). The two major geographic cleanup areas within the Central Plateau are the 170 km^2 (65 mi^2) Outer Area and the 25 km^2 (10 mi^2) Inner Area (Figure 1-1). The 200-WA-1 and 200-BC-1 OUs are located in the Central Plateau's Inner Area.

This work plan was prepared in accordance with the following guidance documents:

- EPA/540/G-89/004, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (OSWER Directive 9355.3-01) (Note: Section 6.2.3.7 associated with cost estimating has been superseded by EPA 540-R-00-002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* [OSWER 9355.0-75])
- EPA/240/B-06/001, *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA QA/G-4)
- DOE/EH-94007658, *Remedial Investigation/Feasibility Study (RI/FS) Process, Elements and Techniques*

1.1 Scope and Objectives

The scope of this work plan includes the waste sites that have been assigned to the 200-WA-1 and 200-BC-1 OUs in Appendix C of the TPA (Ecology et al., 1989a). The goal of the remedial action is to implement response actions that will protect human health, the environment, and groundwater from unacceptable risks that may result from contamination from the waste sites in these two OUs. The decision process will include the following:

- Investigate the nature (type) and extent (spatial distribution) of contamination from the surface to the groundwater.

[1] The 1100 Area was removed from the NPL (40 CFR 300, Appendix B) in September 1996.

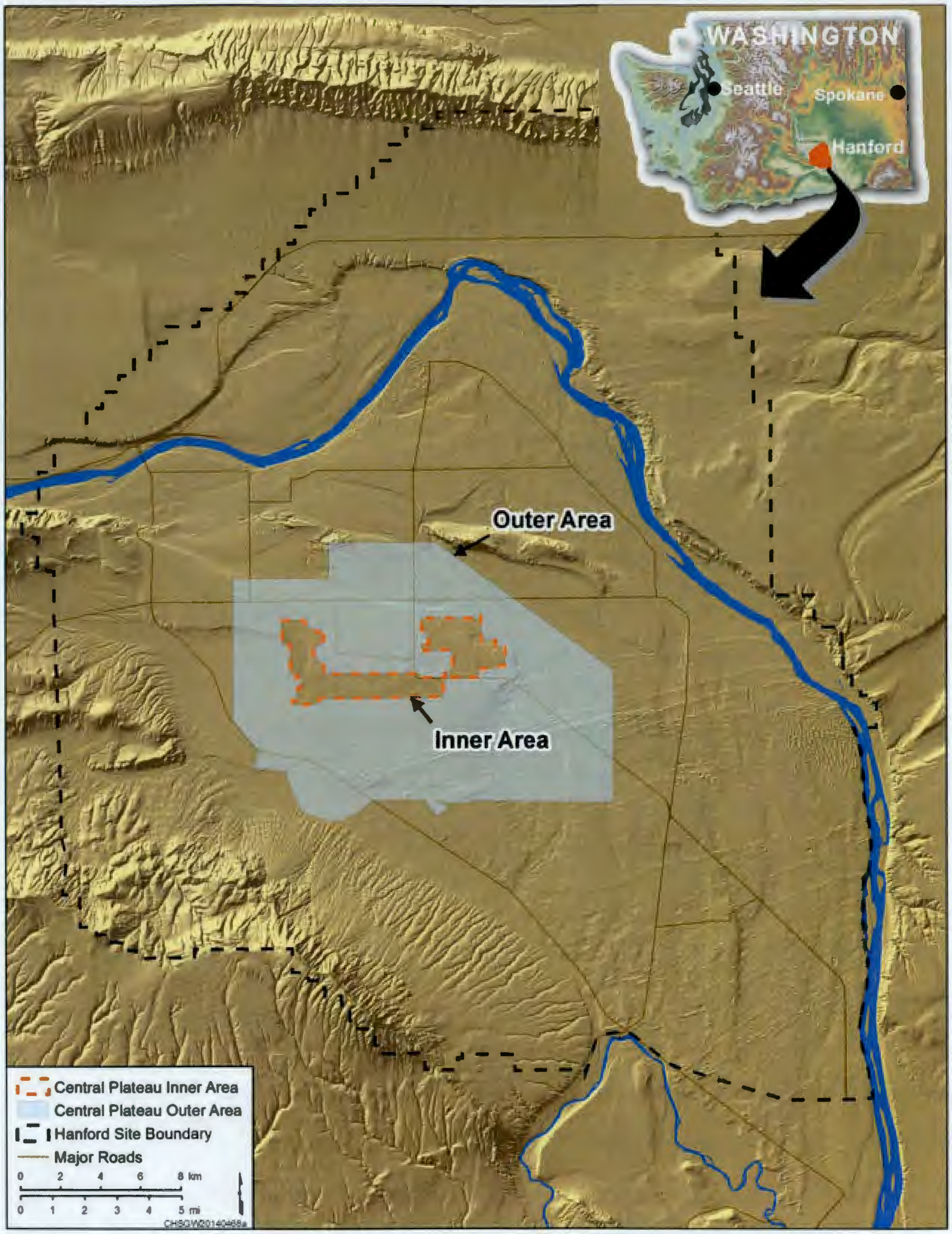


Figure 1-1. The Hanford Site

- Evaluate potential impacts to HHE.
- Evaluate potential impacts on groundwater and the Columbia River.
- Evaluate, select, and implement remedial solutions that protect human health, the environment, and groundwater from contamination in the vadose zone.

The following objectives for the work plan were developed during scoping meetings with DOE and EPA:

- Document the current state of knowledge and identify the activities needed to determine a preferred remedy(s) for the 200-WA-1 and 200-BC-1 OUs.
- Present the rationale and approach for the RI/FS.
- Present the available information on the OUs and applicable remediation technologies.
- Incorporate the Central Plateau Inner Area cleanup principles.
- Identify data gaps and a data collection strategy.
- Describe the tasks and schedule for the RI/FS.
- Achieve concurrence on the scope for the RI/FS.

Waste sites in the 200-WA-1 and 200-BC-1 OUs include cribs, trenches, reverse wells, retention basins, French drains, ditches, ponds, and unplanned releases (UPRs) associated with operations in the Central Plateau. The specific waste sites are described in the appendices. The OUs do not include the groundwater underlying the waste sites. The groundwater on the Central Plateau is addressed through the CERCLA RI/FS process for the 200-UP-1 and 200-ZP-1 OUs in the western Central Plateau and 200-BP-5 and 200-PO-1 OUs in the eastern Central Plateau.

1.1.1 Work Plan Organization

This work plan is organized as follows:

- **Chapter 1, Introduction,** describes the scope of work and identifies applicable OUs and waste site groupings in the Central Plateau. This chapter provides a general site overview and the regulatory basis for cleanup.
- **Chapter 2, Operable Unit Background and Environmental Setting,** presents information on the history of facility operations, descriptions of the waste sites, and the environmental setting for the 200-WA-1 and 200-BC-1 OUs.
- **Chapter 3, Initial Evaluation,** summarizes the available information for the waste sites within the 200-WA-1 and 200-BC-1 OUs, providing a basis for identifying key data gaps.
- **Chapter 4, Work Plan Approach and Rationale,** presents the methods used to assess data adequacy to support the remedial action decision-making process.
- **Chapter 5, Remedial Investigation/Feasibility Study Tasks,** describes the 12 standard RI/FS tasks, with special emphasis on the tasks related to the completion of the FS.
- **Chapter 6, Project Schedule,** indicates how project deliverables relate to enforceable milestones established in the TPA (Ecology et al., 1989a). The schedule will serve as a baseline for the work planning process.

- **Chapter 7, Project Management Considerations,** discusses project organization, project coordination, change control, and the dispute resolution process.
- **Chapter 8, References,** lists the works of others consulted in this work plan.

The appendices include supporting information used in the assessment of data needs for each waste site, and are provided in the following order:

- **Appendix A, Waste Information Data System Assessment Spreadsheet,** provides a summary of the waste sites within the 200-WA-1 and 200-BC-1 OUs, and presents the disposition of these waste sites into their appropriate OU.
- **Appendix B, Waste Site Supporting Information,** contains an overview of supporting waste site information consisting of historical waste streams from operating facilities, availability of analytical and geophysical data, indications of historical groundwater impacts, and a preliminary screening of remedial technologies.
- **Appendix C, Map Plates,** includes a map that shows locations of waste sites in this work plan. In addition, a series of plates presents historical groundwater effects for several of the key contaminant indicators.
- **Appendix D, Waste Site Summaries,** provides extensive information (more than 900 pages) on each waste site, including process history, potential contaminants, maps, drawings, previous investigations near the site, and nature and extent of contamination. Appendix D also summarizes data needs identified for each site and provides site–specific recommendations for characterization activities to satisfy those data needs, based on the sampling approaches provided in the sampling and analysis plan (SAP) (Appendix E).
- **Appendix E, 200-WA-1 and 200-BC-1 OU Sampling and Analysis Plan,** provides sampling approaches and protocols for additional characterization work proposed for 200-WA-1 and 200-BC-1 OU waste sites to fulfill the data needs required to support future RI/FS tasks.
- **Appendix F, Regulatory Applicable or Relevant and Appropriate Requirements,** identifies potential applicable or relevant and appropriate requirements (ARARs) and to-be-considered (TBC) criteria for the 200-WA-1 and 200-BC-1 OUs.

1.2 CERCLA Process

The TPA (Ecology et al., 1989a), which was originally published on May 15, 1989, identifies the responsibilities of DOE, EPA, and the Washington State Department of Ecology (Ecology) (hereinafter referred to as the Tri-Parties) under Section 120, "Federal Facilities," of CERCLA to jointly pursue remedial actions on the Hanford Site. The TPA (Ecology et al., 1989a) is a dynamic document that incorporates the remedial investigations (RIs), decisions, and actions agreed upon by the Tri-Parties. DOE is the lead agency responsible for conducting the response actions at the Hanford Site. Subsequent to 1989, the TPA (Ecology et al., 1989a) has been revised and will continue to be updated, as necessary, per agreements by the Tri-Parties. The most recent version of the TPA (Ecology et al., 1989a) can be found at the following link: www.hanford.gov.

The CERCLA process is clearly established and is addressed in detail on the EPA website available at: www.epa.gov/superfund. In brief, a remedial response is conducted at the completion of the assessment of an NPL (40 CFR 300, Appendix B) site. The remedial process involves planning and decision-making steps, including conducting an RI/FS, developing a proposed plan and a record of decision (ROD), and performing the actual remedial action. At any time in the response process, a removal action (e.g., a time-critical removal action [TCRA] or non-time-critical removal action [NTCRA]) may be implemented if warranted by site conditions. When conducting a CERCLA remedial action process, the TPA (Ecology et al., 1989a) requires that the technical requirements of the *Resource Conservation and Recovery Act* (RCRA) corrective action process be fulfilled. This work plan follows EPA guidance for the RI/FS activities, which are also intended to meet the RCRA facility investigation/corrective measures study (RFI/CMS) requirements.

The CERCLA process for the remediation and closure of the 200-WA-1 and 200-BC-1 OUs consists of the following major activities, as defined by CERCLA guidance documents:

- Develop an RI/FS work plan.
- Implement and complete work needed for the RI/FS.
- Develop a final RI report, including a baseline risk assessment (BRA).
- Develop a final FS report.
- Develop a final proposed plan.
- Provide the public with the opportunity to offer comments.
- Develop and approve a ROD.
- Develop a final remedial design/remedial action (RD/RA) work plan.
- Implement the final remedy.
- Achieve remedial action completion.
- Develop a remedial action report.
- Develop and implement a monitoring program (if required).
- Perform a cyclic 5-year review of the remedy effectiveness, as required by CERCLA.

This work plan identifies the activities needed to gather additional data (as determined by the systematic planning process) to make a remedial decision for the 200-WA-1 and 200-BC-1 OU waste sites. After the data have been gathered and analyzed, the conceptual site model (CSM) updated, and the risk assessment performed, an FS will be completed to identify and evaluate alternatives. A proposed plan containing a summary of the investigation and evaluation will be issued for public review and comment. The proposed plan will identify the preferred remedial alternative(s). The ROD will be issued by EPA and signed by the Tri-Parties.

1.3 Hanford Site Cleanup Completion Framework and Inner Area Principles

This section discusses the framework for completing cleanup on the Hanford Site, as well as the cleanup principles for the Central Plateau Inner Area.

1.3.1 Hanford Site Cleanup Completion Framework

DOE's overall Hanford Site cleanup strategy and approach to completing the remainder of the cleanup mission is described in DOE/RL-2009-10, *Hanford Site Cleanup Completion Framework*. The framework document defines the principal components of cleanup and provides the context for individual cleanup actions by establishing the approaches and common goals for those decisions needed to complete the cleanup mission.

The framework document (DOE/RL-2009-10) defines the overarching goals for cleanup, as shown in Table 1-1. These goals embody more than 20 years of dialogue among the Tri-Parties, Tribal Nations, State of Oregon, stakeholders, and the public. The goals consider key values captured in forums, such as the

Hanford Future Site Uses Working Group, Tank Waste Task Force, Hanford Summits, Tribal Nation values statements, and the Hanford Advisory Board (HAB). The goals serve as a guide for all aspects of Hanford Site cleanup and help set priorities to apply resources and sequence cleanup efforts for the greatest benefit.

Table 1-1. Overarching Goals for Hanford Site Cleanup

Goals for Hanford Site Cleanup
Goal 1: Protect the Columbia River.
Goal 2: Restore groundwater to its beneficial use to protect human health, the environment, and the Columbia River.
Goal 3: Clean up River Corridor waste sites and facilities to achieve the following objectives: • Protect groundwater and the Columbia River. • Shrink the active cleanup footprint to the Central Plateau. • Support anticipated future land uses.
Goal 4: Clean up Central Plateau waste sites and facilities to achieve the following objectives: • Protect groundwater and the Columbia River. • Minimize the footprint of areas requiring long-term waste management activities. • Support anticipated future land uses.
Goal 5: Safely mitigate and remove the threat of the Hanford Site's tank waste: • Safely store tank waste until it is retrieved for treatment. • Safely and effectively immobilize tank waste. • Close the tank farms and mitigate the impacts from past releases of tank waste to the ground.
Goal 6: Safely manage and transfer legacy materials scheduled for offsite disposition, including special nuclear material (e.g., plutonium), spent nuclear fuel, transuranic waste, and immobilized high-level waste.
Goal 7: Consolidate waste treatment, storage, and disposal operations on the Central Plateau.
Goal 8: Develop and implement institutional controls and long-term stewardship activities that protect human health; the environment; and Hanford's unique cultural, historical, and ecological resources after cleanup activities are completed.

To achieve these goals, Hanford Site cleanup is organized into three major components: the River Corridor, including the Hanford Reach National Monument; the Central Plateau; and tank farms/tank waste. Each component of the cleanup is complex and challenging, involving multiple projects and contractors and requiring many years and billions of dollars to complete. Environmental cleanup of waste sites and facilities in the River Corridor is nearing completion, with substantial progress made on groundwater remediation. Closure of the tanks and tank farms was evaluated in DOE/EIS-0391, *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)*, with a ROD issued in December 2013 (78 FR 240, "Record of Decision for the Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington").

The Hanford Site's environmental cleanup mission began in 1989, following a plutonium production era that lasted from 1943 to 1989. During plutonium production, the Hanford Site was divided into production areas, including the 200 East and 200 West Areas, which contain the major nuclear fuel processing, waste management, and disposal facilities. This work plan presents information related to the primary sources of contamination from plutonium production in the 200 East and 200 West Areas. The historical designations for the 200 East and 200 West Areas are used in context throughout this work plan, where appropriate.

The Central Plateau encompasses the 200 Area NPL (40 CFR 300, Appendix B) and includes two principal areas (Figure 1-1):

- **Inner Area:** Defined as the final footprint area of the Hanford Site, the Inner Area is required for permanent waste management and control of residual contamination. The boundary of the Inner Area is defined by waste disposal decisions already in place and the anticipated future decisions that will result in the requirement for continued waste management and control of residual contamination. The Inner Area is approximately 25 km^2 (10 mi^2) in size and will remain under federal ownership and control in perpetuity.

- **Outer Area:** The Outer Area is that portion of the Central Plateau beyond the boundary of the Inner Area. Contaminated soil and debris removed as part of Outer Area cleanup will be placed within the Inner Area for final disposal. Completion of cleanup for the approximately 170 km^2 (65 mi^2) Outer Area will shrink the active footprint of cleanup for the Central Plateau to the Inner Area.

The 200-WA-1 and 200-BC-1 OUs are located within the Inner Area.

1.3.2 Central Plateau Inner Area Cleanup Principles

In 2013 and 2014, the Tri-Parties undertook an initiative to develop a set of cleanup principles for the Inner Area of the Central Plateau. The outcome of this initiative is the establishment of an overarching and consistent set of cleanup principles that the Tri-Parties have agreed are the foundation for evaluating waste sites and making cleanup decisions in each of the OUs within the Inner Area pursuant to the TPA (Ecology et al., 1989a).

The overarching goals of the principles are to (1) provide a consistent approach for assessment of risks to HHE and evaluation of remedial alternatives within the Inner Area; and (2) identify and implement regulatory strategies that will optimize assessment resources, streamline documentation requirements, and promote consistency in decisions.

The substantive components of these principles related to land use, BRA, cleanup levels, points of compliance (POCs), and regulatory strategies are defined below. The principles, as they apply to the 200-WA-1 and 200-BC-1 OUs, are reflected in the appropriate sections of this work plan.

1.3.2.1 Land Use

- Inner Area land use is industrial.
- The agencies are in agreement that the current 25.9 km^2 (10 mi^2) Inner Area footprint will not be reduced further.

1.3.2.2 Baseline Risk Assessment

- The BRA will use the default EPA industrial scenario (multiple pathway) to determine the need for action at a cumulative cancer risk level of 1 in 10,000 and 1 in 100,000 and a hazard index of 1 for noncarcinogenic effects.

- State requirement for cumulative cancer risks under WAC 173-340, "Model Toxic Control Act—Cleanup" (MTCA) Method C at 1 in 100,000 will be considered because of future corrective action requirements.

- Once a basis for action is determined, cleanup standards for chemicals will be based on MTCA (WAC 173-340) Method C industrial cleanup levels for direct contact.
- The only institutional control is industrial land use.
- The BRA will not include residential or unrestricted scenarios. Tribal scenarios will be evaluated, and results will be provided in the RI reports.
- The BRA will be done on an OU-by-OU basis (each work plan).
- DOE will develop RI/FS work plan sections that describe the principles and specific parameters on BRAs that will serve as guiding principles for all work plans.

1.3.2.3 Cleanup Levels

- Preliminary remediation goals (PRGs) for human health direct contact with radionuclides will be risk-based.
- PRGs for chemicals will be based on MTCA (WAC 173-340) Method C (direct contact).
- The approach to ecological cleanup will be the same as for the River Corridor, as applied for the 100-D/H RI/FS (DOE/RL-2010-95, *Remedial Investigation/Feasibility Study for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*).
- Groundwater protection modeling will be based on natural recharge and will not consider irrigation.
- Groundwater protection modeling and PRG development will be based on the process defined in DOE/RL-2011-50, *Regulatory Basis and Implementation of a Graded Approach to Evaluation of Groundwater Protection*. DOE will identify specific parameters in DOE/EIS-0391 that will be applied or make adjustments, where appropriate.
- Groundwater protection PRGs will be developed, discussed, and approved through a single process to develop PRGs applicable to each of the five unique areas of the Central Plateau.

1.3.2.4 Conditional Point of Compliance for Groundwater

- FSs will present an evaluation of groundwater protection at the standard POC immediately beneath each waste site or facility under consideration. DOE may also choose to perform an analysis in the first Inner Area FS to evaluate a conditional POC at the boundary of the Inner Area for groundwater protection. The resulting decision will serve as the basis for the justification for the remainder of the OUs in the Inner Area.
  - The basis for the decision will be developed in the first FS, but all OUs will need to justify the decision. The subsequent OU discussions will reference the first evaluation and include an overview of similarities and differences between the first and subsequent OUs to ensure the approach is justified.

1.3.2.5 Human Health and Ecological Depth Point of Compliance

- FSs will present an alternative that will evaluate compliance with human health (direct contact) and ecological PRGs at the standard POC of 4.6 m (15 ft) below ground surface (bgs). DOE may also choose to perform an analysis in the first Inner Area FS to evaluate a conditional POC at 3 m (10 ft) bgs for direct contact and ecological protection. The resulting decision will serve as the basis for the justification for the remainder of the OUs in the Inner Area.

  - The basis for the decision will be developed in the first FS, but all OUs will need to justify the decision. The subsequent OU discussions will reference the first evaluation and include an overview of similarities and differences between the first and subsequent OUs to ensure the approach is justified.

- Unlike in the River Corridor, engineered structures and/or mass of contamination will not be removed unless it is a risk management decision.

1.3.2.6 Regulatory Strategies

- Similar site approaches can be used with proper analysis and use of available information, data, and process knowledge.
- Characterization strategies will consider multiple remedial technologies, risk reduction, regulatory requirements, and cost avoidance. The observational approach can also be a valid strategy where removal, treatment, and disposal (RTD) is appropriate.
- The regulatory agencies are willing to consider a plug-in approach. They generally believe that it applies primarily to RTD sites but could be applied to other potential remedies if justified.
- Post-ROD characterization (meaning limited pre-ROD characterization) is a valid approach but may result in interim action RODs.

1.4 Integration with Other Activities

To facilitate consistent remedial decisions across the Central Plateau Inner Area, the Tri-Parties modified the TPA (Ecology et al., 1989a) in 2010 to restructure Central Plateau remediation activities. Restructuring included consolidating some of the Inner Area waste sites into geographical area-based OUs, resulting in the creation of the 200-EA-1 and 200-WA-1 OUs, and retention of the 200-BC-1 OU. An additional OU, 200-DV-1, was created to include waste sites in the Inner Area with deep vadose zone (DVZ) contamination. On the Central Plateau, the DVZ is defined as the region below the practical depth of surface remedy influence (e.g., shallow excavation or barriers) and above the regional aquifer. The Tri-Parties created the 200-DV-1 OU to support investigation and remedy selection for this challenging type of DVZ waste site.

Figure 1-2 illustrates the CERCLA OUs that are currently assigned in the Central Plateau Inner Area. The existing groundwater OUs in the Central Plateau remained unchanged.

This RI/FS work plan and subsequent decision documents must be closely integrated with the overall Hanford Site closure strategy. Integration with other regulatory programs and other OUs in the Inner Area is discussed in the following subsections. Specific ongoing sampling, analysis, and remedial action activities that are critical to the 200-WA-1 and 200-BC-1 OU decision process are also discussed.

1.4.1 RCRA/CERCLA Integration

The TPA (Ecology et al., 1989a) designates the 200-WA-1 and 200-BC-1 OUs as CERCLA Past Practice (CPP) OUs with EPA as the lead regulatory agency. There are no RCRA treatment, storage, and disposal (TSD) units in these OUs. CERCLA addresses the uncontrolled releases of hazardous substances to the environment and the cleanup of inactive waste sites. In accordance with the TPA (Ecology et al., 1989a), remediation activities for CPP OUs are governed by CERCLA. Other environmental laws, such as RCRA, *Clean Air Act of 1990*, and *Clean Water Act of 1977*, are incorporated into the CERCLA process as ARARs with which selected remedies must comply.

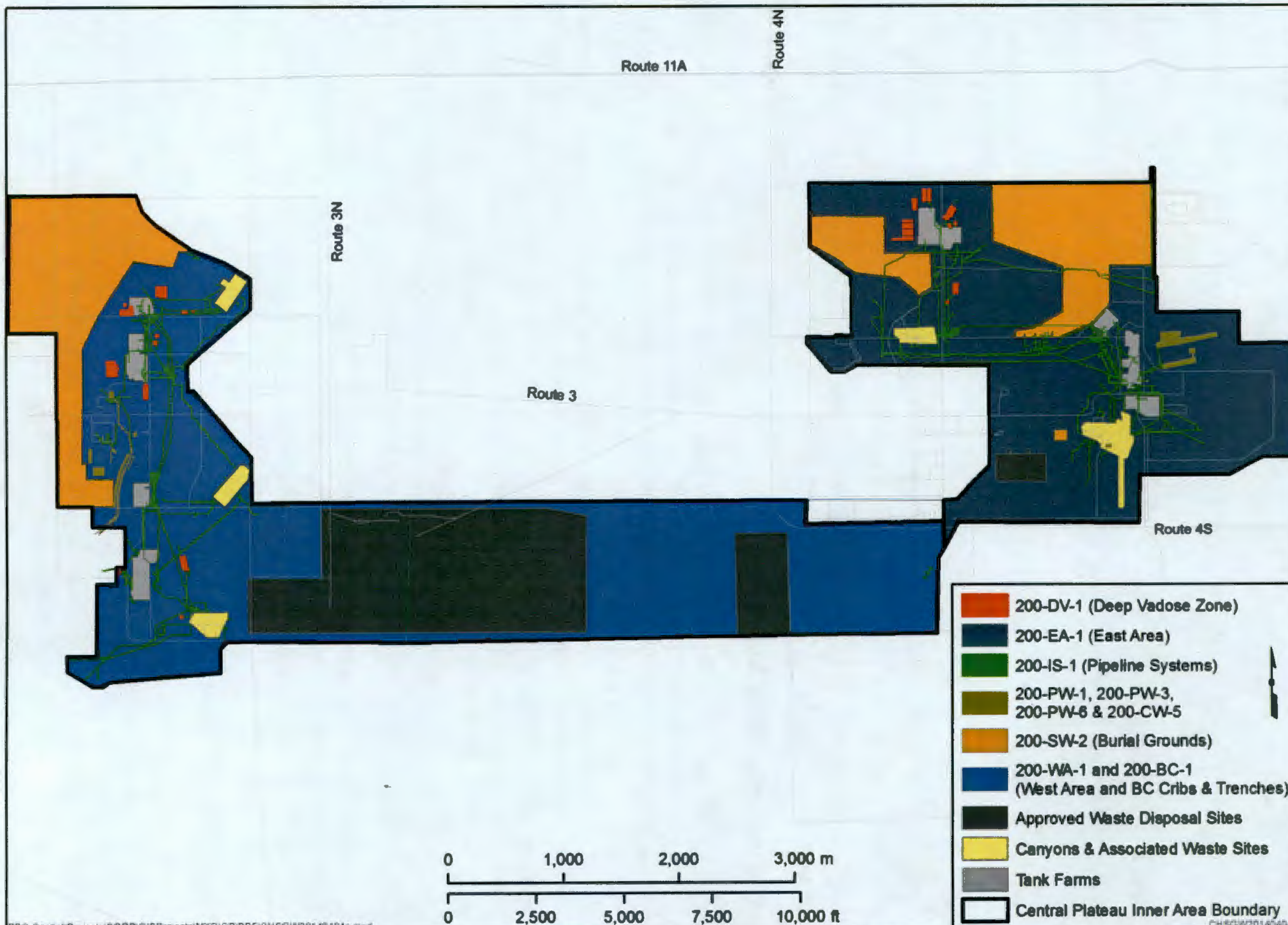


Figure 1-2. OUs in the Central Plateau Inner Area

1.4.2 Tank Farm Waste Management Areas

The single-shell tanks (SSTs) are grouped into waste management areas (WMAs), which will be closed following a defined closure process. Each WMA contains part of the SST RCRA TSD unit that includes tanks and ancillary equipment. Closure of the tanks and tank farms was evaluated in DOE/EIS-0391, with a *National Environmental Policy Act of 1969* (NEPA) ROD issued in December 2013 (78 FR 240). WMAs are not included in the 200-WA-1 and 200-BC-1 OUs.

1.4.3 Central Plateau Source Operable Units

The current OUs in the Central Plateau Inner Area contain waste sites that received liquid wastes (200-EA-1 OU; 200-WA-1 and 200-BC-1 OUs; 200-PW-1, 200-PW-3, 200-PW-6, and 200-CW-5 OUs; and 200-DV-1 OU); waste sites that received solid wastes (200-SW-2 OU); and waste sites associated with inactive waste transfer pipelines (200-IS-1 OU). The Inner Area also contains OUs for former processing plants (canyons) and associated waste sites. The OUs are shown in Figure 1-2.

In 1989, waste sites in the Central Plateau were initially grouped into 42 OUs (32 source OUs, 6 tank farm OUs, and 4 groundwater OUs) that were primarily geographically based (DOE/RL-96-67, *200 Areas Soil Remediation Strategy – Environmental Restoration Program*).

In 1997, the Tri-Parties regrouped the waste sites for characterization purposes according to discharge type (e.g., tank waste or process water) followed by waste site type (e.g., crib or ditch). The process-based grouping reduced the number of source OUs from 32 to 23.

The process-based waste site groupings facilitated the use of the analogous site approach to characterization. This approach allowed data collected from representative sites to be extrapolated to similar, or analogous, sites in the early stages of assessment to support remedial alternative evaluation and selection, as provided in DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*. 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*, was prepared and implemented for the 200-TW-1 and 200-TW-2 OUs in 2001 to characterize one representative site for the 200-TW-1 OU (216-T-26 Crib) and two representative sites for the 200-TW-2 OU (216-B-7A and 216-B-38 Cribs). The other representative site in the 200-TW-1 OU (216-B-46 Crib) was characterized as part of the 200-BP-1 OU investigation, and the other representative site in the 200-TW-2 OU (200-B-5 Reverse Well) was characterized in 1979. One of the representative sites for the 200-PW-5 OU (216-B-57 Crib) also was characterized as part of the 200-BP-1 OU investigation.

In 2002, the Tri-Parties agreed to consolidate the 23 process-based source OUs into 12 OU groups based on similarities between contaminant sources. As a result, the 200-PW-5 OU was consolidated with the 200-TW-1 and 200-TW-2 OUs (DOE/RL-2002-42, *Remedial Investigation Report for the 200-TW-1 and 200-TW-2 Operable Units (Includes the 200-PW-5 Operable Unit)*.

The Tri-Parties conducted a supplemental data quality objective (DQO) evaluation in 2005 and 2006 to review all of the process and characterization data available for the Central Plateau waste sites and to identify residual data needs. The elements of the DQO were integrated into the supplemental work plan issued in 2007 (DOE/RL-2007-02, *Supplemental Remedial Investigation/Feasibility Study Work Plan for the 200 Areas Central Plateau Operable Units*). The supplemental work plan included a SAP (*Volume II: Site-Specific Field-Sampling Plan Addenda*), for the collection of additional data at those waste sites for which existing data were determined to be insufficient for decision making purposes. Integration of this supplemental information with this RI is presented in Section 3.2.2.

The following sections describe OUs that contain structures, waste sites, or WMAs that are in physical proximity to 200-WA-1 and 200-BC-1 OU waste sites.

1.4.3.1 200-PW-1, 200-PW-3, 200-PW-6, and 200-CW-5 Operable Units

The plutonium- and organic-rich group process-based OUs include the 200-PW-1, 200-PW-3, 200-PW-6, and 200-CW-5 OUs. Waste sites in the 200-PW-1 and 200-PW-6 OUs primarily received plutonium- and organic-rich waste streams from the Plutonium Finishing Plant (PFP) process operations. The 200-CW-5 OU received cooling water from the PFP and U Plant. The 200-PW-3 OU waste sites received process discharge directly or indirectly derived from Plutonium and Uranium Extraction (PUREX) Plant operations that contained fission products (primarily cesium-137), and both aqueous- and nonaqueous-phase organics. The ROD was issued in September 2011 (EPA et al., 2011, *Record of Decision Hanford 200 Area Superfund Site 200-CW-5 and 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*).

1.4.3.2 200-IS-1 Operable Unit Pipelines

The 200-IS-1 OU consists of waste sites that are associated with inactive, buried waste-transfer pipelines and pipeline components (e.g., diversion boxes, catch tanks, valve pits, vaults, and control structures) located within the Inner Area of the Central Plateau. The 200-IS-1 OU also includes the contaminated soil that is the result of previously identified UPRs from the pipeline and pipeline components.

Part of the coordination of activities across OU waste sites is to understand and define specific interface conflict points. Interface conflict points are defined as the boundary location(s) where a waste site in one OU physically exists within the geographic boundary of another OU waste site or tank farm WMA. Boundary interface points are predominantly associated with pipeline waste sites in the 200-IS-1 OU that extend into or are adjacent to soil waste sites, canyons, and WMAs. A few boundary interface points exist between soil waste sites and canyons and WMAs. Pipeline boundary interface points are associated with the following:

- 200-PW-1, 200-PW-3, 200-PW-6, and 200-CW-5 OU soil waste sites (as defined in the ROD [EPA et al., 2011])
- 200-DV-1, 200-WA-1, 200-BC-1, and 200-EA-1 OU soil waste sites
- All canyons
- All WMAs

The existence of interface points can create conflicts in cleanup decision and remedy implementation processes across OUs. The following criteria and process have been developed to define interface boundary point conflicts and mitigate the impact of the conflicts for the 200-DV-1, 200-WA-1, 200-BC-1, and 200-EA-1 OU soil waste sites:

- Each soil waste site will be evaluated to identify the presence of pipelines in and/or adjacent to it. An interface conflict will be considered to exist under the following conditions:
    1. A pipeline[2] is located within the boundary of the soil waste site as defined in the Waste Information Data System (WIDS) waste site mapping overlay and not included as being part of the waste site in WIDS.

---

[2] Pipeline is inclusive of the pipeline and pipeline auxiliary components such as encasements, support structures, valve boxes, manholes, and diversion boxes.

2. A pipeline is located outside of the boundary of the soil waste site and within 7.6 m (25 ft)[3] of the boundary. This criterion is inclusive of the segment of pipeline that extends into the waste site.

- For soil waste sites identified to have interface conflicts, specific coordinates of the interface points will be established and referenced. DOE intends to redefine and update the WIDS summary sheets to be inclusive of all pipelines located within the waste site boundary and all pipeline segments outside of the boundary up to a distance of 7.6 m (25 ft).
- The updated WIDS summary sheets will be circulated to EPA and Ecology for information.
- The RI/FS and RFI/CMS process will address the portion of pipeline waste sites defined by the interface conflict points and updated in WIDS.
- DOE does not anticipate any new pipeline or soil waste sites to be created by this process.

DOE intends to develop similar criteria to define and mitigate pipeline interface conflicts between 200-IS-1 and canyon OUs and tank farm WMAs.

An additional coordination of activities across OU waste sites includes maintaining consistency in characterization approaches. Certain types of structures (for example, pipelines and tanks) are common to both the 200-IS-1 and 200-WA-1 OUs. These structures may require characterization of the physical structure and the vadose zone to characterize risk in the RI or to evaluate remedial options in the FS. Currently under development, the 200-IS-1 OU work plan includes a characterization approach for pipelines and tanks. Pending completion and approval of the work plan, a similar approach for investigation of pipeline and tank structures may be incorporated into the 200-WA-1 OU work plan and SAP with EPA acceptance.

1.4.3.3 200-SW-2 Operable Unit Burial Grounds

The 200-SW-2 OU consists of 24 landfills located in the Central Plateau Inner Area. In addition, portions of the 200-SW-2 OU are associated waste sites located within the footprint of the 200-SW-2 OU landfills. These sites include the Semiworks swamp (216-C-9 Pond), which lies directly beneath the 218-C-9 Burial Ground, and the T Pond system (collocated in the 218-W-2A and 281-W-3AE Landfills). The remedial action alternatives for 200-WA-1 and 200-BC-1 OU waste sites adjacent to the burial grounds will take into consideration the proximity of the burial ground.

1.4.3.4 200-DV-1 Deep Vadose Zone Operable Unit

The DVZ is defined as the region below the practical depth of the surface remedy's influence (e.g., excavation or barrier). Based on a depth greater than 4.6 m (15 ft) bgs, DVZ contamination is not considered to pose human health or ecological risks through direct exposure or uptake by biota; however, waste sites in the DVZ may represent a potential source of groundwater contamination. Data collection for the 200-DV-1 OU waste sites will be conducted under DOE/RL-2011-102, *Remedial Investigation/Feasibility Study and RCRA Facility Investigation/Corrective Measures Study Work Plan for the 200-DV-1 Operable Unit*. Data from 200-DV-1 OU investigations will be integrated with 200-WA-1 OU waste site data, where appropriate, during the RI/FS evaluation.

1.4.4 Central Plateau Groundwater Operable Units

Groundwater impacts resulted from discharges to waste sites and, in some cases, vertical transport was enhanced by poorly sealed nearby wells. Contaminants present in three groundwater OUs were affected

[3] 7.6 m (25 ft) is a general distance criterion, and actual distances may vary slightly based on waste site characteristics and pipeline components such as nearest manhole or junction.

by historical discharges to the 200-WA-1 and 200-BC-1 OU waste sites. These OUs are underlain by the 200-ZP-1, 200-UP-1, and 200-PO-1 Groundwater OUs. A groundwater pump-and-treat (P&T) remediation system was constructed to address contaminated groundwater present in the 200-ZP-1 and 200-UP-1 Groundwater OUs. The ROD for the 200-ZP-1 OU was issued in 2008 (EPA, 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*). The interim ROD for the 200-UP-1 OU was issued in 2012 (EPA et al., 2012, *Record of Decision for Interim Remedial Action, Hanford 200 Area Superfund Site 200-UP-1 Operable Unit*). The RI report for the 200-PO-1 OU has been issued (DOE/RL-2009-85, *Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit*). The RI report for the 200-BP-5 OU (DOE/RL-2009-127, *Remedial Investigation Report for the 200-BP-5 Groundwater Operable Unit*) and the combined FS report for the 200-BP-5 and 200-PO-1 OUs are in preparation.

Chapter 3 discusses the potential contaminant migration from 200-WA-1 and 200-BC-1 OU vadose zone waste sites to the underlying groundwater, which will be more fully evaluated in the RI/FS report. Chapter 5 presents additional information on the approach that will be used.

1.4.5 Major Plant Operations

Several major processing plant complexes are located within the Inner Area. These complexes are the U Plant, Reduction-Oxidation (REDOX) Plant (S Plant), T Plant, and PFP, formerly known as Z Plant. CERCLA response actions for cleanup of these facilities have been initiated or will be conducted in the future.

1.4.5.1 Canyons

The U Plant, REDOX, and T Plant Canyons are located in the 200 West Area. The canyons will be closed under their own specific decision documents:

- **U Plant (200-CU-1):** The 221-U Facility ROD (EPA et al., 2005, *Record of Decision 221-U Facility (Canyon Disposition Initiative) Hanford Site, Washington*) selected partial demolition of the canyon, void filling to stabilize contamination and mitigate subsidence potential, and placement of a surface barrier as a final remedy. Waste sites adjacent to the U Plant are likely to be covered by the barrier footprint. The barrier will be considered when identifying data needs and potential remedies for adjacent 200-WA-1 OU waste sites. The barrier footprint may be evaluated during remedial design to consider consolidation with adjacent 200-WA-1 OU waste site remedial action.

- **REDOX (200-CR-1):** REDOX has been shut down for more than 40 years. The final remedy is expected to be similar to the remedy selected for the U Plant. Based on the similarities between REDOX and the U Plant, the selected remedy at REDOX is anticipated to include a surface barrier. The data needs and potential remedies for adjacent 200-WA-1 OU waste sites are based on collecting information that will support integration with the REDOX remedial action.

- **T Plant:** The T Plant is currently operational and has not yet been assigned to an OU. The final remedy is also expected to be similar to the remedy selected for the U Plant. The anticipated remedy will be considered when identifying data needs and potential remedies for adjacent 200-WA-1 OU waste sites.

1.4.5.2 Structures

Remedial action alternatives developed in the RI/FS report for waste sites adjacent to major plant facilities will consider the proximity of the complex and potential facility remedies. Coordination with structures is discussed in the following sections.

Structures on the Central Plateau that are not RCRA units or part of an OU are generally deactivated and demolished under CERCLA NTCRAs. The structure site may be characterized following removal if contamination is suspected. The area characterized will be evaluated under the procedural steps for adding, updating, classifying, and reclassifying sites, in accordance with the TPA-MP-14, *Maintenance of Waste Information Data System (WIDS)*, process and added to the appropriate OU if designated as a waste site. This may result in waste sites that will be assigned to the 200-WA-1 OU in the future. Newly assigned waste sites will be evaluated in accordance with the path forward described in Section 2.2.2.

1.4.5.3 PFP Closure Project Area

In accordance with DOE/RL-2011-03, *Removal Action Work Plan for the Deactivation, Decontamination, Decommissioning, and Demolition of the Plutonium Finishing Plant Complex*, the PFP Closure Project will collect characterization data to document the condition of the remaining slabs, belowgrade areas, and surrounding soils at the completion of closure activities. The characterization data will be evaluated using the TPA-MP-14 process to identify any potential new waste sites and OUs they would be assigned to.

1.4.6 Development of 200-WA-1 and 200-BC-1 Operable Units

In 2010 the Tri-Parties realigned the Central Plateau OUs into 10 groups. The 200-WA-1 OU was established per TPA (Ecology et al., 1989a) Change Package M-15-09-02, *Federal Facility Agreement and Consent Order Change Control Form: Modify Tri-Party Agreement M-15 Series Milestones for Central Plateau Waste Sites and Groundwater*. Waste sites were assigned in Change Packages C-09-07, *Federal Facility Agreement and Consent Order Change Control Form: Revise Tri-Party Agreement Appendix C to Align Operable Unit Assignments with Proposed Central Plateau Decisions*, and C-11-05, *Federal Facility Agreement and Consent Order Change Control Form: Reassignment of 216-S-14 Waste Site from 200-DV-1 Operable Unit to 200-WA-1 Operable Unit*. Waste sites from the 200-LW-1/2, 200-MG-1/2, 200-MW-1, 200-PW-2/4, 200-SC-1, 200-TW-1/2, 200-UR-1, and 200-UW-1 OUs were assigned to the 200-WA-1 OU. This realignment assigned many waste sites located in the 200 West Area to the 200-WA-1 OU. The 200-BC-1 OU is grouped with the 200-WA-1 OU for the RI/FS decision process per TPA Milestone M-015-91B, *Submit FS Report & Proposed Plan for the 200-BC-1/200-WA-1 operable units (200 West Inner Area) to EPA.*

Waste site evaluations in the 200-WA-1 OU are reported in the following documents:

- DOE/RL-2003-23, *Focused Feasibility Study for the 200-UW-1 Operable Unit*
- DOE/RL-2003-24, *Proposed Plan for the 200-UW-1 Operable Unit*
- DOE/RL-2005-71, *Action Memorandum for the Time-Critical Removal Action for Support Activities to the 200-UW-1 Operable Unit*
- DOE/RL-2008-44, *Engineering Evaluation/Cost Analysis for the 200-MG-1 Operable Unit Waste Sites*
- DOE/RL-2008-45, *Engineering Evaluation/Cost Analysis for the 200-MG-2 Operable Unit Waste Sites*
- DOE/RL-2009-86, *Action Memorandum for Non-Time-Critical Removal Action for 37 Waste Sites in the 200-MG-1 Operable Unit*
- DOE/RL-2009-37, *Action Memorandum for Non-Time-Critical Removal Action for 200-MG-2 Operable Unit*

The data needs assessment conducted as part of this work plan was carried out independently of the conclusions of these previous decision documents.

This work plan also considers the following SAPs that have been approved:

- DOE/RL-2007-02 (Volume II)
- DOE/RL-2009-60, *Sampling and Analysis Plan for Selected 200-MG-1 Operable Unit Waste Sites*
- DOE/RL-2009-94, *216-U-8 Crib and 216-U-12 Crib Vadose Zone Characterization Sampling and Analysis Plan*

The data needs identified in these documents are considered in the data needs assessment (Chapter 4) for the corresponding 200-WA-1 OU waste sites and characterization approaches, where appropriate, and are integrated into the 200-WA-1 and 200-BC-1 OU SAP (Appendix E).

2 Operable Unit Background and Environmental Setting

This chapter summarizes the background and historical information for the waste sites in the 200-WA-1 and 200-BC-1 OUs and describes the environmental setting in the 200 West Area.

2.1 History of Operations

The operational history for the 200 West Area is organized around the major processing plants and disposal facilities described in the following paragraphs. Discussion of the operations focuses on the waste streams and the potential for the waste stream contributions to waste sites. Tables B-1 through B-4 in Appendix B of this work plan summarize plant waste streams, estimated volumes, disposal sites, and the chemical composition of wastes generated at the major processing plants. Appendix C provides maps of waste site locations, and Appendix D provides individual waste site descriptions and history.

T Plant—The 221-T Building, also known as the T Plant or T Canyon Building, housed the first operational, full-scale plutonium separations facility in the world. This building is one of five Hanford Site canyon buildings, a reference to their large size and the canyon-like appearance of their upper galleries. The T Plant has been reprogrammed from its original mission to be an active decontamination and repair facility, where radioactive and hazardous wastes are processed and packaged. It is the only processing canyon that remains in operation at the Hanford Site. During plutonium separation operations, waste streams generated at T Plant were disposed of at nearby locations, including some 200-WA-1 OU waste sites. DOE/RL-91-61, *T Plant Source Aggregate Area Management Study Report*, provides a detailed discussion of T Plant history.

Plutonium Finishing Plant (PFP or Z Plant)—The PFP was the location of the final step associated with plutonium metal production at Hanford. The plant is a complex consisting of more than 60 buildings, all of which are undergoing or slated for deactivation and demolition. Waste streams generated during Z Plant operations were disposed of at numerous nearby locations, including some 200-WA-1 OU waste sites. A detailed discussion of Z Plant history is presented in DOE/RL-91-58, *Z Plant Source Aggregate Area Management Study Report.*

U Plant—The U Plant was constructed in 1944 as a plutonium separations facility, but it was never used for that purpose. It was retrofitted for uranium recovery from selected waste streams. A final remedy was selected for disposition of U Plant through a CERCLA process in 2005. Waste streams generated during U Plant operations were disposed of at numerous nearby locations, including some 200-WA-1 OU waste sites. Detailed discussions of U Plant history are presented in DOE/RL-91-52, *U Plant Source Aggregate Area Management Study Report*, and DOE/RL-2003-23, *Focused Feasibility Study for the 200-UW-1 OU.*

REDOX (S Plant)—The REDOX Plant was in operation from 1953 through 1972 and processed approximately 24,000 tons of uranium fuel rods. Waste streams generated during REDOX operations were disposed of at nearby locations, including some 200-WA-1 OU waste sites. A detailed discussion of REDOX history is presented in DOE/RL-91-60, *S Plant Aggregate Area Management Study Report.*

BC Cribs and Trenches—The BC Cribs and Trenches were used in the 1950s to dispose of an estimated 140 million L (38 million gal) of tank waste supernatant from the B, BX, BY, and C Tank Farms. Four trenches received smaller quantities of liquid wastes that were generated in the 300 Area and transferred by tanker truck to the Central Plateau. The largest volume of waste at the BC Cribs and Trenches was disposed of in 6 cribs and 16 trenches and was conveyed by underground pipeline from the B, BX, BY, and C Tank Farms. Information on the BC Cribs and Trenches waste history is presented in DOE/RL-2004-66, *Focused Feasibility Study for the 100-BC Cribs and Trenches Area Waste Sites.*

2.1.1 Liquid Waste Handling

Various liquid waste streams were generated at the processing plants located within the 200-WA-1 OU, including process wastes, process wastewaters, and sanitary wastewater. During the early period of nuclear fuel reprocessing, the basis for segregating liquid wastes was established. Wastes were segregated into streams that contained radioactive materials (called contaminated waste streams) and those that did not contain radioactive materials (or uncontaminated waste streams).

Liquid Waste Classification. The liquid wastes were identified as either radioactive or nonradioactive. The radioactive liquid waste streams were divided into three general categories:

- **High-Activity Liquid Wastes**—High-activity wastes contained fission products, unrecovered uranium, transuranic (TRU) elements, and nonradioactive residuals from the chemical separation processes. The waste was stored as it was created, first in SSTs built between 1943 and 1964, then in double-shell tanks (DSTs) constructed between 1968 and 1986. The high-activity wastes were generally aqueous liquids with a high solids content. The waste was typically made alkaline before transfer, to prevent corrosion of the tanks and transfer lines. During the 1950s, some of these waste streams were disposed of in the vadose zone when the available tank capacity was exceeded.

- **Intermediate-Level or Intermediate-Activity Liquid Wastes**—Intermediate-level wastes were generally aqueous liquids that contained varying amounts of fission products, uranium, and TRU elements, as well as varying amounts of organic and inorganic process chemicals, ranging from strongly alkaline to strongly acidic. These wastes were generally disposed of directly to the vadose zone through engineered structures such as cribs, trenches, French drains, and injection (or reverse) wells. The injection wells discharged the wastes at depths typically greater than 4.6 m (15 ft). All of these discharge structures were designed to promote infiltration of the liquid wastes into the vadose zone, thereby minimizing the potential for direct exposure to site workers. Intermediate-level wastes were generated in large volumes (that is, billions of liters).

- **Low-Level or Low-Activity Liquid Wastes**—Low-level wastes typically contained low to variable radioactive content, fission products with relatively small amounts of uranium, and few TRU elements. These wastes generally consisted of steam condensate and cooling water. Although normally uncontaminated, they occasionally became contaminated through system upsets or equipment failure. In general, these waste streams were managed using the same systems and processes used for disposal of noncontaminated liquids (i.e., discharge directly to surface ditches and ponds). Low-activity wastes constituted the largest volume of liquid wastes discharged to the vadose zone in the Central Plateau. The primary effect of these discharges was groundwater elevation mounding beneath the waste sites, which affected horizontal and vertical groundwater flow gradients until the discharges were stopped, and the mounding subsided.

Nonradioactive Liquid Wastes—Nonradioactive wastes may have contained low levels of chemical constituents. The nonradioactive streams were generally managed with less stringent disposal and exposure controls, and most were discharged to surface ditches or ponds where they infiltrated the vadose zone.

Liquid Waste Transfer. Liquid waste transfer methods used at the Hanford Site included process lines, tanker trucks, railcars, and localized pumping. Examples include high-activity waste piped to underground tanks, transfer of liquid wastes by tanker truck or by railcar via unloading stations, and uncontaminated to slightly contaminated liquids and cooling water pumped to local ditches and ponds.

Within each operation, waste transfer lines (also called process lines) connected the major processing facilities with the various waste disposal and storage facilities. Most waste transfer lines were 7.6 cm (3 in.) diameter stainless steel pipes with welded joints. These lines were generally enclosed in steel-reinforced concrete encasements and set belowground. Transfer lines to liquid effluent disposal facilities (e.g., cribs) were constructed from a variety of materials, including vitreous clay and galvanized metal.

Diversion boxes housed the valving equipment facilities used to route waste from one process line to another. The diversion boxes were typically constructed from concrete and designed to contain leaks from waste transfer line connections. The diversion boxes generally drained by gravity to nearby catch tanks where spilled liquid was collected.

Diverter stations are generally rectangular, two-tiered reinforced concrete vaults constructed belowground that allowed waste streams flowing into the diverter station to be routed to waste receiving tanks in the tank farms. The diverter station vaults have floor drains that lead to the common catch tank or sump located directly below the diverter station.

Valve pits are concrete structures that house valves associated with the transfer of waste between tanks in the tank farms. A valve pit, sometimes referred to as a control structure, is a belowground, reinforced concrete structure. Valve pits also were used to distribute flow evenly over both halves of very long cribs (up to 427 m [1,400 ft]). These structures were most commonly associated with gravity flow pipelines that discharged waste streams to cribs, ponds, or ditches.

2.1.2 Liquid Waste Storage/Disposal

Liquid waste was either transferred to large underground radioactive waste storage tanks for storage or discharged directly to surface or subsurface soils or structures, as described in the following text:

- **Tanks:** Large underground radioactive waste storage tanks (SSTs and DSTs) were constructed to store high-activity liquid waste streams. Because of waste leakage in a small number of SSTs and the potential for additional leakage, no new waste was added to the SSTs after 1980. All pumpable liquid has been transferred to DSTs with known integrity. The DSTs, which have exceeded or are expected to exceed their design life, are managed under a comprehensive integrity management program.

- **Direct Discharge:** Direct discharge sites were constructed to receive varying volumes of uncontaminated and low- to intermediate-level/activity radioactive liquid waste. When storage tank capacity was exceeded, high-activity wastes were diverted to direct-discharge sites for a time in the 1950s. Open ditches and percolation ponds allowed infiltration of liquid waste to the vadose zone. Reverse wells, cribs, and French drains were all designed to percolate wastewater into the ground without exposing the wastewater to the atmosphere. Open trenches were used to dispose of fixed volumes of low- to intermediate-level radioactive liquid waste. The types of direct discharge structures in the 200-WA-1 and 200-BC-1 OUs include the following:

  - **Cribs:** Cribs are excavations, typically less than 10 m (30 ft) deep, that were backfilled with granular material or held open by wood cribbing, and overlain by a vapor barrier. Many cribs were equipped with perforated drain piping that distributed the waste over a larger area. Most cribs were designed to receive liquid via a pipeline from the waste-generating facility on a batch or semi-continuous basis until the crib's specific retention or radionuclide adsorption capacity was met. Following discharge of the specified volume of liquid, the crib was removed from service.

  - **Trenches:** Trenches are linear excavations, typically less than 10 m (30 ft) deep, that were used to dispose of contaminated liquid wastes by direct discharge, normally via a temporary pipeline. Trenches generally did not have any permanent engineered features associated with them. They were commonly used on a specific-retention basis, with a fixed volume of liquid identified for discharge. When the planned volume was discharged, the liquid was allowed to percolate, and then the trench was backfilled. Trenches, particularly those with specific-retention design basis, were expected to retain residual contamination within the vadose zone immediately below the trench. Some trenches received only small quantities of wastewater; these trenches were used as vehicle and equipment cleaning and decontamination sites. A shallow excavation was opened, and then vehicles or equipment were placed into the trench where they were cleaned, typically with water or steam.

- **Reverse wells:** Also known as injection wells, reverse wells were disposal sites for liquid wastes. They featured drilled and cased holes with the lower end of the casing perforated or open to allow liquid to be injected into the vadose soil at depths greater than cribs and French drains. Reverse wells were used for the disposal of intermediate-level liquid wastes in the early phases of Hanford Site operations.

- **French drains:** French drains were designed to percolate wastewater into the ground without exposing it to the atmosphere. French drains were generally constructed of vertically oriented, large-diameter steel or concrete pipe with an open bottom that may have included perforations along a portion of the pipe length. The inside of the pipe was open or filled with gravel and covered with an impermeable layer. The service life of the French drains varied. French drains were designed to receive relatively small liquid flow rates or volumes, although the total volume discharged over a particular site's service life may have been upward of hundreds of thousands of liters. Most French drains received waste volumes ranging from thousands to tens of thousands of liters. French drains typically exhibit residual contamination beneath the structure within the upper portion of the vadose zone.

- **Retention basins, ditches, and ponds:** Retention basins, ditches, and ponds were components of a larger system or were autonomous waste sites. The pond systems were designed to receive large volumes of low-level or radiologically uncontaminated wastewater (e.g., steam condensate, cooling water, and chemical sewer discharge) that percolated the wastewater into the vadose zone. Ponds were typically fed by ditches that originated near the various waste-generating facilities.

  - **Retention basins** were open-topped concrete structures where liquid waste was held before it was discharged to ditches and ponds. The retention basins were associated with specific process plants (for example, T, U, S, and Z Plants each have at least one retention basin). Some of the retention basins were lined with synthetic material during later periods of operation. Some retention basins were equipped to allow diversion of unacceptably high-level contaminated wastewater to alternative discharge points (for example, a crib); however, most wastewater was discharged directly to ditches and, subsequently, to the receiving pond. Some retention basins were removed from service after becoming grossly contaminated.

  - **Ditches** were shallow, open excavations, usually less than 3.0 m (10 ft) deep, often following natural surface topography and drainage pathways that conveyed wastewater to ponds. Ditches were typically unlined; therefore, a percentage of the wastewater infiltrated the vadose zone beneath the ditch before reaching a pond.

  - **Ponds** were typically located in topographically low areas and were subsequently modified to increase their surface area to enhance wastewater infiltration. Modifications included excavation to deepen the ponds, construction of berms or dikes to increase pond volume or contain wastewater, and excavation of accessory ditches to expand surface area and to divert excessive flows to other ponds. The discharge of high volumes (that is, hundreds of millions of liters per year) to the ditch and pond systems in the 200 Areas at the Hanford Site resulted in creation of large groundwater mounds beneath the site that influenced horizontal and vertical groundwater flow gradients. The only pond in the 200-WA-1 and 200-BC-1 OUs is 216-Z-21.

2.1.3 Solid Waste Management Practices

Solid waste disposal areas at the Hanford Site ranged from engineered landfills to shallow debris disposal sites. No engineered landfills are present in the 200-WA-1 and 200-BC-1 OUs. The shallow debris disposal sites present in the 200-WA-1 OU include laydown yards or general dumping areas that are known or suspected to contain nonliquid radioactive materials and wastes containing hazardous substances (e.g., paint, solvents, batteries, creosote-treated wood poles, or lead-tipped bolts).

Several waste sites resulted from airborne particulate waste generated during facility operations. Airborne particulates were removed by pollution control equipment (e.g. sand filters) upstream of facility stacks or dispersed from facilities through unplanned or intentional releases from facility stacks, waste handling storage, or disposal facilities, and subsequently deposited on the ground surface.

2.1.4 Unplanned Releases in Waste Handling

Locations of UPRs of chemical and radiological materials also are designated as waste sites. Available information such as the release history, location, and quantities of chemicals released are documented in WIDS. This information is based primarily on historical operating records and descriptions of incident responses. Typical examples of UPR types include the following:

- Waste transfer pipeline failure and discharges to the surface or subsurface
- Contamination spread from a burial box or process equipment in transit
- Fire in a 200 West burial ground that spread contamination near the Z Plant
- Contaminated equipment hauled to the 200 West burial ground from the T Plant that contaminated an area near the railroad tracks
- Potentially contaminated surface soil that was eroded and transported by wind to an adjacent site

UPRs vary in magnitude, extent, and description. The overall effectiveness of UPR response actions has not always been well documented. Most radiologically contaminated UPR sites have been covered with gravel or soil stabilization material.

2.2 200-WA-1 and 200-BC-1 Operable Unit Waste Sites

A total of 145 waste sites are assigned to the 200-WA-1 OU, and 27 waste sites are assigned to the 200-BC-1 OU in Appendix C of the TPA (Ecology et al., 1989a). If new waste sites are discovered or changes are proposed for existing waste site OU assignments, the TPA-MP-14 process will be followed to assign waste sites. A TPA (Ecology et al., 1989a) change package will be prepared to update Appendix C of the TPA Action Plan (Ecology et al., 1989b).

2.3 Environmental Setting

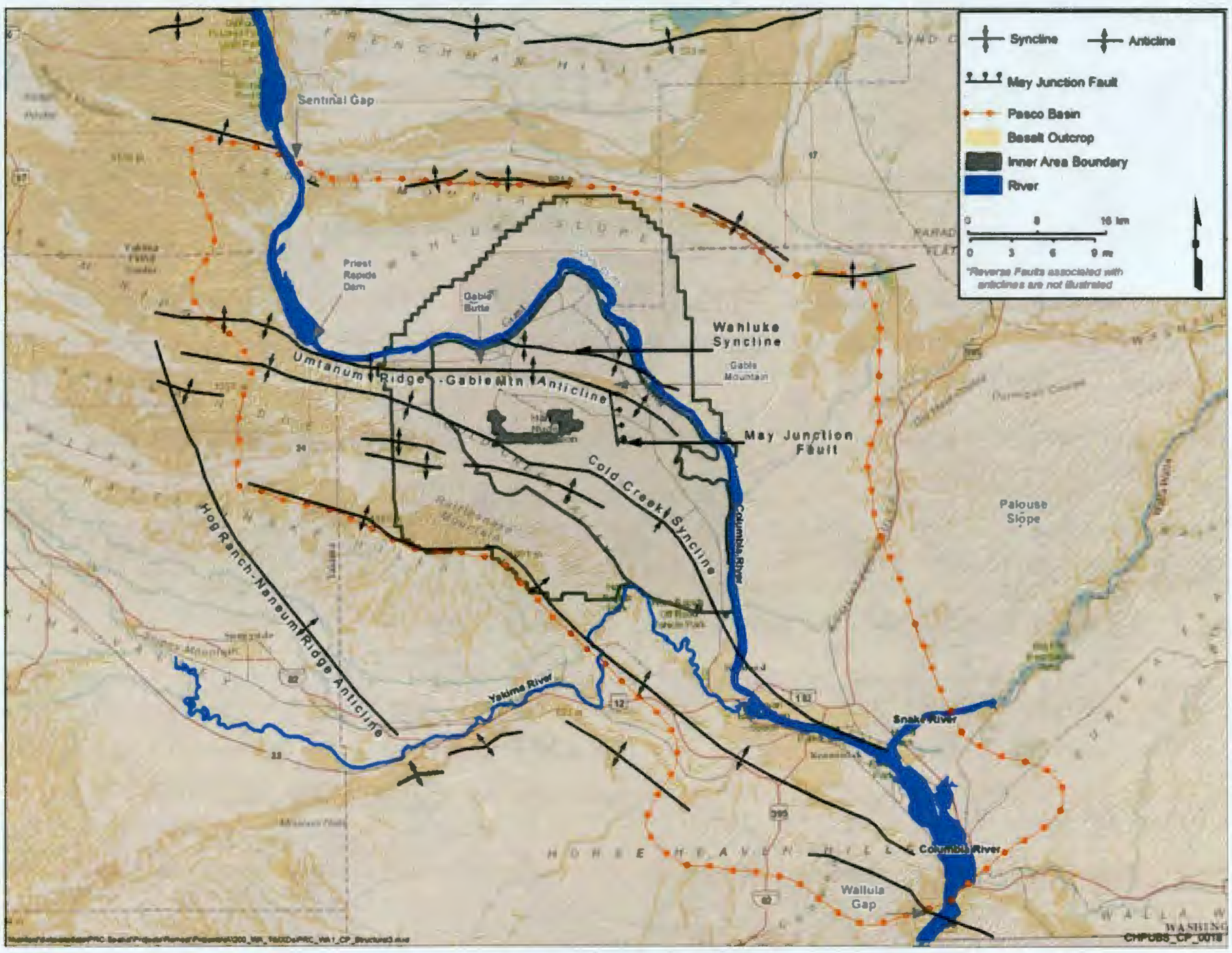
This section describes the environmental setting for the Central Plateau's Inner Area. The description includes characteristics of surface and subsurface features and processes that are relevant to developing a preliminary understanding of contaminant distribution for each 200-WA-1 and 200-BC-1 OU waste site. This understanding provides the foundation for identifying data needs and investigation approaches to address specific data gaps.

2.3.1 Physiography and Topography

The Hanford Site lies within the Pasco Basin, as shown on Figure 2-1. The physiographic setting of the Hanford Site is relatively low relief, resulting from river and stream sedimentation filling the synclinal valleys and basins between the anticlinal ridges. The elevation in the 200 West Area ranges from approximately 221 m (725 ft) along the eastern part of T Plant to around 197 m (647 ft) above mean sea level (amsl) in the western part of U Plant and S Plant. No natural surface water drainage channels are located within the area.

2.3.2 Climate and Meteorology

The Pacific Ocean moderates temperatures throughout the Pacific Northwest. The Cascade Mountain Range (located approximately 113 km [70 mi] west of the Hanford Site) generates a rain shadow that decreases rain and snowfall totals in the eastern half of Washington State. The Site is located within the driest part of that rain shadow. The Cascade Range also serves as a source of cold (more dense) air drainage. The Rocky Mountains to the north and east of the region shield the area from most of the severe winter storms and cold air masses that move south from Canada.



Note: Modified from PNNL-6415, *Hanford Site National Environmental Policy Act (NEPA) Characterization*.

Figure 2-1. Generalized Geologic Structure Map of the Pasco Basin

Climatological data for the Hanford Site are compiled at the Hanford Meteorological Station (HMS), which is located on the Central Plateau just outside the northeastern corner of the 200 West Area .

2.3.2.1 Wind

The Cascade Mountains have a considerable effect on the wind regime at the Hanford Site by serving as a source of cold (more dense) air drainage. This orographic drainage from the Cascade Mountain Range results in a northwest to west-northwest prevailing wind direction. Summertime winds from the northwest frequently exceed 13 m/s (30 mi/h), although the fastest wind speeds at the HMS are usually associated with flow from the southwest. Monthly average wind speeds recorded 15.2 m (50 ft) above the ground surface are slower during the winter months, averaging 2.7 to 3.1 m/s (6 to 7 mi/h), and faster during the spring and summer months, averaging 3.6 to 4.0 m/s (8 to 9 mi/h). The maximum speed of the drainage winds (and their frequency of occurrence) tends to decrease as they move southeast across the Site.

2.3.2.2 Temperature and Humidity

The average monthly temperatures at the HMS range from a low of -0.4°C (31.2°F) in January to a high of 24.9°C (76.8°F) in July, based on data collected from 1945 through 2013. Daily maximum temperatures at the HMS vary from an average of 2°C (35°F) in late December and early January to 36°C (96°F) in late July.

From mid-November through early March, the average daily minimum temperature is below freezing, with a daily minimum in late December and early January averaging -6°C (21°F). The annual average relative humidity at the HMS is 55 percent. It is highest during the winter months, averaging about 76 percent, and lowest during the summer, averaging about 36 percent.

2.3.2.3 Precipitation

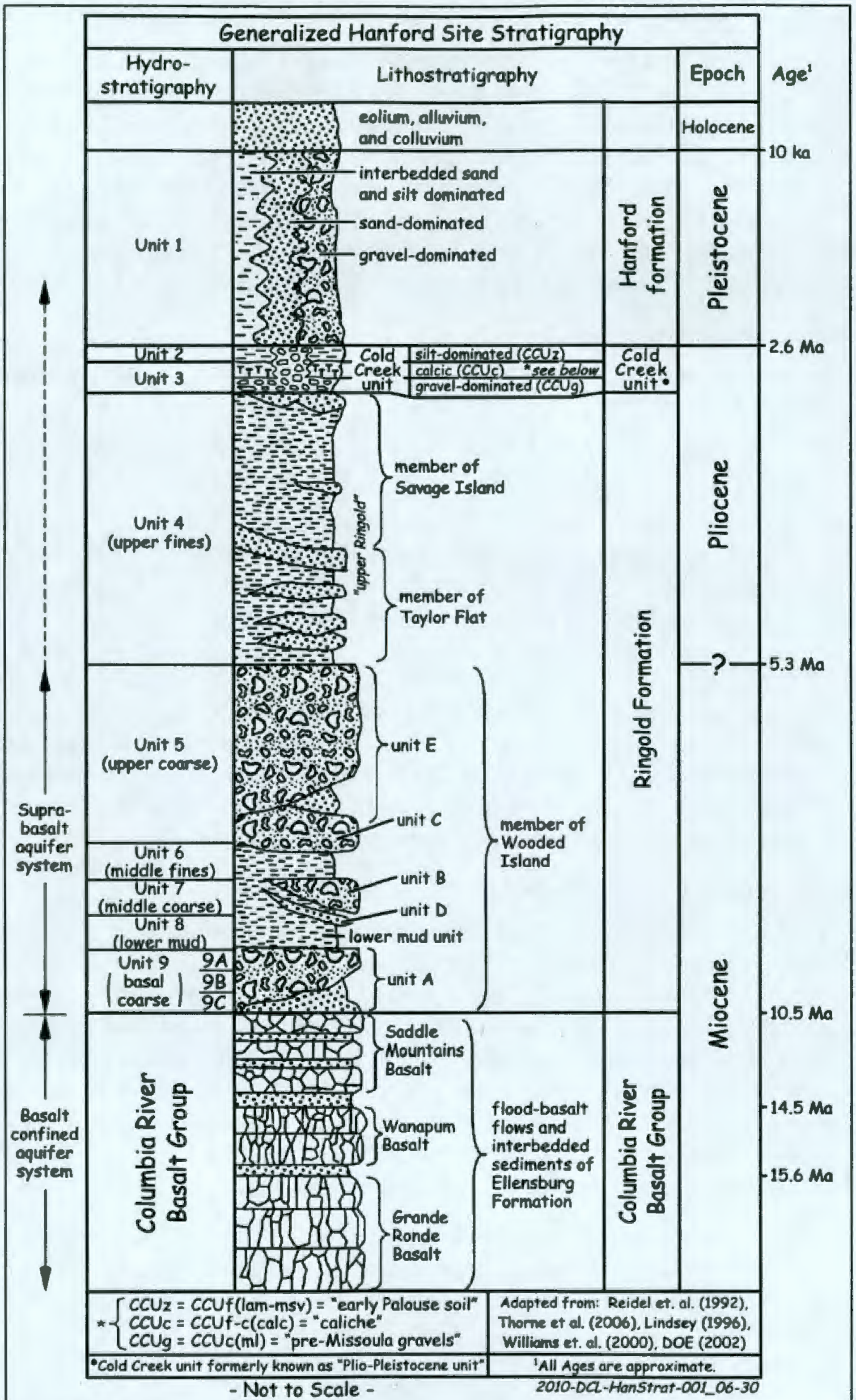
Average annual precipitation at the HMS is 17 cm (6.8 in.). Most precipitation occurs during the late fall and winter months, with more than half of the annual amount occurring from November through February. Average snowfall ranges from 0.25 cm (0.1 in.) during October to a maximum of 13.2 cm (5.2 in.) during December, decreasing to 1.3 cm (0.5 in.) in March. Snowfall accounts for about 38 percent of all precipitation from December through February.

2.3.3 Geologic Setting

The geology of the Hanford Site is well characterized through past investigation activities. The Central Plateau Inner Area is located in the central part of the Pasco Basin. Over the last 16 million years, the basin filled with flood basalts (i.e., lava flows) that formed bedrock and sediments (e.g., silt, sand, and gravel). Unconsolidated and partly consolidated fluvial (river-derived), lacustrine (lake), and cataclysmic flood sediments of the Miocene through Holocene ages (about 10.5 million years to the present) overlie the basalts. Beneath the ground surface, the major geologic units of interest (from oldest to youngest) include the following: (1) the Elephant Mountain Member of the Saddle Mountains Basalt Formation (a part of the Columbia River Basalt Group), (2) the Ringold Formation, (3) the Cold Creek unit (CCU), (4) the Hanford formation, and (5) recent Holocene surficial deposits.

A generalized geological structure of the Pasco Basin and a stratigraphic column containing the hydrogeologic nomenclature of the Hanford Site are presented in Figures 2-1 and 2-2. The following previous studies contain geologic interpretations, related maps, and cross sections pertaining to the 200-WA-1 and 200-BC-1 OUs:

- DOE/RL-92-16, *200 West Aggregate Area Management Study Report*
- DOE/RL-2009-122, *Remedial Investigation/Feasibility Study for the 200-UP-1 Groundwater Operable Unit*
- DOE/RL-2009-85, *Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit*



Note: Modified from PNNL-6415, *Hanford Site National Environmental Policy Act (NEPA) Characterization*. Complete citations for figure references are provided in Chapter 8.

Figure 2-2. Generalized Stratigraphic and Hydrostratigraphic Column for the Central Plateau

The hydrogeologic interpretations for the 200-WA-1 and 200-BC-1 OU waste sites are based on PNNL-13858, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-West Area and Vicinity, Hanford Site, Washington*, and PNNL-12261, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington*. The 200-WA-1 and 200-BC-1 OU RI focuses on the sedimentary units above the basalt surface because they comprise the vadose zone and uppermost unconfined aquifer system within the OUs.

2.3.3.1 Columbia River Basalt

Basalt is an igneous rock ejected from the earth during volcanic events. The basalt flows of the Columbia River Basalt Group were deposited during Miocene time (23.7 to 10.5 million years ago) from source vents in southeastern Washington, northern Oregon, and western Idaho. These basalt flows form the basement rock for much of the overlying sedimentary deposits. Beneath the Hanford Central Plateau, the youngest and uppermost basalts belong to the Saddle Mountains Basalt Formation (RHO-BWI-ST-4, *Geologic Studies of the Columbia Plateau: A Status Report*). The Saddle Mountains Basalt Formation is divided into the Ice Harbor, Elephant Mountain, Pomona, Esquatzel, Asotin, Wilbur Creek, and Umatilla Members. The Elephant Mountain Member is the uppermost basalt unit present beneath the 200 WA-1 and 200-BC-1 OUs and is approximately 35 m (115 ft) thick. The Rattlesnake Ridge interbed of the Ellensburg Formation is present between the Elephant Mountain Member and the underlying Pomona Member and comprises the uppermost basalt confined aquifer beneath the Central Plateau. Near the 300 Area, the overlying Ice Harbor Member is present and forms the top of the Saddle Mountains Basalt.

In the central portion of the Pasco Basin, the Ellensburg Formation interbed ranges from 1.5 to 15 m (5 to 50 ft) thick and is composed of clayey basalt conglomerates, fluvial floodplain deposits, and ash tuffs and tuffites (RHO-RE-ST-12P, *An Assessment of Aquifer Intercommunication in the B Pond-Gable Mountain Pond Area of the Hanford Site*).

Within the 200-WA-1 and 200-BC-1 OUs, the basalt surface is interpreted as the basal hydrogeologic boundary for the overlying sedimentary aquifer system that has been affected by historical liquid effluent disposal practices.

2.3.3.2 Ringold Formation

The Ringold Formation is an unconsolidated to semiconsolidated sedimentary sequence of clay, silt, sand, and granule- to cobble-sized gravel deposited unconformably on the basalt (PNNL-12261; PNNL-13858). The Ringold Formation forms the lower portion of the vadose zone and the entire suprabasalt aquifer system in the 200-WA-1 and 200-BC-1 OUs.

Underlying the 200 West Area and vicinity are up to four distinct Ringold Formation hydrostratigraphic units (HSUs) informally designated, from youngest to oldest, as units 4, 5, 8, and 9 (Figure 2-2). These units generally correspond to, from youngest to oldest: the Ringold Formation member of Taylor Flat (Rtf [unit 4]), which is composed of predominantly fine-grained silt and sand; the Ringold Formation member of Wooded Island – unit E (Rwie [unit 5]), which is a fluvial deposit composed of silty, sandy, gravel; the Ringold Formation member of Wooded Island – lower mud unit (Rlm [unit 8]), which is composed predominantly of fine-grained lacustrine silt and clay; and the Ringold Formation member of Wooded Island – unit A (Rwia [unit 9]), which is a fluvial deposit composed of silty, sandy, gravel (PNNL-13858).

2.3.3.3 Cold Creek Unit

The CCU includes several post-Ringold Formation and pre-Hanford formation units beneath portions of 200-WA-1 (DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for Post-Ringold-Formation Sediments Within the Central Pasco Basin*) (Figure 2-2). Three different facies deposits generally comprise the CCU within the Central Plateau: a fine-grained silt-dominated deposit (CCUz), a variably cemented calcium carbonate fine- to coarse-grained deposit (caliche) (CCUc-), and a coarse-grained (gravel) deposit (CCUg).

The fine-grained (CCUz) and the underlying carbonate-cemented (CCUc) units are present in the vadose zone throughout the 200-WA-1 OU. The CCUc (caliche) is a subaerial paleo-surface deposit that developed in situ atop the exposed Ringold Formation and extended partially into the underlying Ringold Formation (PNL-6820, *Hydrogeology of the 200 Areas Low Level Burial Grounds—An Interim Report: Volume 1: Text*). The CCUc is a secondary deposit (mineral coating or cement) that accumulated on and within older sediment, it is composed of calcium carbonate that precipitated in available pore spaces between sediment grains (sand, silt, or gravel). The caliche binds the sediment grains together, forming one or more hardpan layers; the location and amount of calcium carbonate cement are variable, so the physical properties of this unit vary from soil-like to rock-like.

The CCUz is a fine-grained silt to sand facies that overlies the CCUc in the 200-WA-1 OU. This unit grades laterally from fluvial to eolian deposits ranging from a sandy silt to a silt; where silt content dominates, perched water horizons have been found (e.g., beneath the 241-B-BX Tank Farms). Calcium carbonate in this sequence varies from a few percent to absent. Where higher calcium carbonate content is found, clumps of semi-consolidated silt and sand are generally reported.

Within the 200-WA-1 OU, the relatively thin CCU sequence (CCUz +CCUc) forms a significant liquid flow barrier (perching horizon) within the deep vadose zone because of relatively low hydraulic properties. Both of these CCU units have unique geophysical properties that allow easy identification and correlation. The CCU is not present beneath the 200-BC-1 OU.

2.3.3.4 Hanford Formation

The Hanford formation is the informal stratigraphic name given to the Pleistocene cataclysmic flood deposits in the Pasco Basin (DOE/RL-2002-39). The Hanford formation overlies the Ringold Formation, CCU, and/or basalt within the Central Plateau. The cataclysmic floodwaters eroded or reworked much of the pre-existing Ringold Formation and CCU sediment across the Gable Gap area and unconformably deposited thick unconsolidated, basalt-rich sediments known as the Hanford formation. The Hanford formation is divided into three representative facies associations that are referred to as the gravel-dominated, sand-dominated, and silt-dominated intervals. These lithologic units are not laterally continuous, but can be correlated if present within the area. The floodwaters deposited a thick sand and gravel bar (Cold Creek bar) that constitutes the Central Plateau, which is the location of the 200-WA-1 and 200-BC-1 OUs. Remnant erosional channels, preserved during waning stages of the paleo-floods, created large-scale surface features visible north of the Central Plateau near West Lake and the former Gable Mountain Pond.

The Hanford formation is the primary geologic unit comprising about half of the vadose zone thickness in the 200 West Area and nearly all of the vadose zone thickness in the 200 East Area and lies directly beneath the waste sites that contaminants must pass through to reach groundwater. Under the 200-WA-1 OU on the Central Plateau, the Hanford formation consists predominantly of gravel- and sand-dominated facies, depending on the depositional location within the Cold Creek flood bar. The gravel-dominated facies is typically poorly sorted and may contain sand with lesser amounts of silt. In some areas, the gravel-dominated facies may be open framework, containing no fine-grained sediment (sand or silt). The sand-dominated sequence is fairly well sorted and contains distinct, limited lateral extent silt stringers or thin beds marking sand bed depositional boundaries. In most areas on the Cold Creek flood bar (Central Plateau), the coarse-grained gravel sequence overlays a much thicker Hanford sand sequence.

2.3.3.5 *Holocene Surficial Deposits*

Overlying the Hanford formation are recently deposited surficial deposits of eolian (windblown) silt and sand. Only about 6 percent of the Hanford Site has been disturbed or is actively used by DOE. These surficial materials within the Central Plateau, and particularly those areas that constitute most of the 200-WA-1 and 200-BC-1 OUs, have been removed or reworked extensively by construction activities.

2.3.4 Hydrogeology

This section describes the hydrogeology of the Hanford Site with specific reference to the Inner Area.

2.3.4.1 *Hydrostratigraphy*

The Inner Area hydrogeologic designations were determined through an evaluation of available borehole and geophysical logs and integration of these data with hydrostratigraphic correlations from existing reports (e.g., PNNL-12261 and PNNL-13858). The HSUs of interest in the Inner Area include the following:

- Recent surficial deposits and the Hanford formation (HSU 1) - primarily vadose zone
- The CCU (HSUs 2 and 3) - vadose zone only
- The Ringold Formation
  - Rtf (HSU 4) - primarily vadose zone
  - Rwie (HSU 5) - lower vadose zone and unconfined aquifer in 200 West Area
  - Rlm (HSU 8) - primarily confining unit
  - Rwia (HSU 9) - unconfined to confined aquifer
- The Elephant Mountain Basalt Member (HSU 10) - confining horizon
- The Rattlesnake Ridge interbed - a confined water-bearing aquifer

2.3.4.2 *Vadose Zone*

The thickness and stratigraphy of the vadose zone vary between the 200-WA-1 and 200-BC-1 OUs. The vadose zone thickness ranges from about 55 m (180 ft) beneath the western portion of 200-WA-1 OU to about 104 m (340 ft) near 200-BC-1 OU. In the 200-WA-1 OU the vadose zone is composed of the Hanford formation, the CCU_z (silt) and CCU_c (caliche) units, the Ringold Formation upper fines (Rtf), and part of the Ringold Formation unit E (Rwie). The unconfined aquifer water table lies within the Rwie in the 200-WA-1 OU and within the Hanford formation near the 200-BC-1 OU.

2.3.4.3 *Uppermost Aquifer*

The uppermost aquifer in the 200-WA-1 and 200-BC-1 OUs occurs primarily within the sediments of the Ringold Formation where groundwater occurs under unconfined conditions.

The depth to groundwater in the uppermost aquifer underlying the Inner Area ranges from approximately 55 m (180 ft) beneath the former U Pond in the 200 West Area to approximately 104 m (340 ft) in the southwestern corner of the 200 East Area (near 200-BC-1 OU). The saturated thickness of the unconfined aquifer thins considerably between the 200-WA-1 and the 200-BC-1 OUs, ranging from approximately 67 to 112 m (220 to 368 ft) in the 200-WA-1 OU to approximately 21 m (68 ft) beneath the 200-BC-1 OU. The uppermost aquifer is important to the assessment of the 200-WA-1 and 200-BC-1 OUs because it is the first groundwater to be potentially affected by contaminants originating in the OU waste sites.

The water table elevation and, subsequently, the groundwater gradient, flow direction, and flow velocity within the uppermost aquifer underlying the 200-WA-1 and 200-BC-1 OUs have been historically altered by discharges of wastewater to the vadose zone within the Central Plateau. Historically, large groundwater mounds formed beneath 13 high-volume wastewater discharge sites. Although these large-volume discharges have been discontinued, the groundwater mounds have not completely dissipated, particularly in the 200 West Area, where the aquifer occurs in the lower hydraulic conductivity deposits of the Ringold Formation. The groundwater elevation mounds historically present in the 200 East Area (i.e., those associated with B Pond and Gable Mountain Pond), where the water table is typically found within the Hanford formation, have generally dissipated. The resulting water table surface illustrates a generally west-to-east groundwater flow direction between the 200-WA-1 and 200-BC-1 OUs.

2.3.4.4 Perched Groundwater

Two hydrogeologic units beneath the Inner Area have the soil-water retention capacity to create local temporary to pseudo long-term perched conditions under high liquid recharge conditions, the CCUz and c and the Rlm. Over the long term, the historical moderate- to high-volume contaminated liquid waste discharged to areas overlying these two perching intervals created localized groundwater perching and lateral spreading of the liquid waste that most likely mixed effluent from various disposal sources in the vadose zone before it reached the groundwater. During operations these perching areas persisted, but most eventually drained or moved laterally downgradient to the unconfined aquifer following cessation of waste disposal operations. Continued perched zone drainage is known to occur and impacts the unconfined aquifer at the B Complex in the 200 East Area as a result of multiple sources that may continue to impact the perched interval.

Cold Creek Unit—Where present above the water table, primarily within the 200-WA-1 OU, the CCUc and z consists of fine sandy silt to silt and/or caliche-rich intervals. These intervals exhibit very low hydraulic properties (relative to the overlying coarse unconsolidated Hanford formation deposits) that result (depending on the infiltration rate) in impeded downward liquid migration, which have led to temporary saturation or perching conditions and lateral spreading along and/or within the low-permeability CCU sediment horizons. Data show that, over time, the perched water conditions diminish when the liquid source is reduced or stopped, but that some areas take many years to decades to drain. Residual elevated moisture and contamination have continued to exist in these intervals long after active liquid disposal ceased. While the perching CCUc is present as a continuous mapped unit that dips to the south beneath most of the western Inner Area, it has variable thickness and the hydraulic properties, while generally very low, vary laterally.

Within the 200-WA-1 OU perched water conditions have occurred on the CCUc and have been documented from the northernmost liquid disposal waste sites (e.g., State-Approved Land Disposal Site [SALDS] and the 216- T Ponds and Ditches) to the southernmost liquid disposal waste sites (U Pond and the 216-S-10 Pond and Ditch). These legacy waste sites, with the exception of the SALDS, are no longer operational and the perched water conditions have dissipated. Several wells were completed and monitored conditions within the perched interval above the CCUc near the 216-S-10 Ditch and farther north near the U Ditches.

Ringold Formation Lower Mud Unit—The second prominent perching horizon, the Rlm (Figure 2-2), consists of a relatively continuous, very fine-grained silt- to clay-rich interval that is located in most areas below the water table. However, on the eastern margin of the eastern Inner Area, the Rlm unit is positioned above the regional water table, due to structurally uplifted basalt and other related suprabasalt sediments associated with geologic formation of the Gable Mountain structural lineament (PNNL-12261). It will not be discussed further in this section because it does not influence the 200-WA-1 and 200-BC-1 OUs.

Overall, the CCUc and z have demonstrated to be significant perching intervals beneath the 200-WA-1 OU.

2.3.5 Surface Water Hydrology

There are no naturally occurring surface water features present within the 200-WA-1 and 200-BC-1 OUs. Primary surface water features associated with the Hanford Site are the Columbia and Yakima Rivers and the Columbia River's other major tributaries: the Snake and Walla Walla Rivers. West Lake, about 4 ha (10 ac) in size and less than 0.9 m (3 ft) deep, is the only natural ephemeral lake within the Hanford Site (DOE/RW-0164, *Site Characterization Plan: Reference Repository Location, Hanford Site, Washington*). It is a playa formed by local discharge of groundwater.

The Columbia River flows through the northern and eastern margins of the Hanford Site. Routine water quality monitoring of the Columbia River is conducted by DOE for radiological and nonradiological parameters. This information has been compiled and reported by Pacific Northwest National Laboratory (PNNL) since 1973 and then Mission Support Alliance since 2011. In general, the Columbia River water is characterized by a very low suspended load, a low nutrient content, and an absence of microbial contaminants (DOE/RW-0164).

Approximately one-third of the Hanford Site is drained by the Yakima River system. Cold Creek and its tributary, Dry Creek, are ephemeral streams on the Hanford Site that are within the Yakima River drainage system. Both streams drain areas along the western part of the Hanford Site and cross the southwestern part of the Hanford Site toward the Yakima River. Surface flow, which may occur during spring runoff or after heavier than normal precipitation, typically infiltrates and disappears into the surface sediments before reaching the Yakima River. Rattlesnake Springs, located on the western part of the Hanford Site, forms a small surface stream that flows for about 2.9 km (1.8 mi).

2.3.6 Environmental Resources

The Hanford Site is surrounded by agricultural and residential development. Because of the long-standing management practices of DOE, most of the land on the Hanford Site is relatively undisturbed, and the Site is one of the last large areas of relatively undisturbed shrub-steppe habitats in Washington.

The ecological setting has been characterized using a compilation of data from many biological inventories of plant and wildlife species and ecological characterizations from the following reports:

- The Nature Conservancy (TNC) of Washington's sitewide geographic information system-based plant community mapping for all areas outside the Hanford Site boundaries and biodiversity surveys of mammals, birds, reptiles, amphibians, insects, and plants between 1994 and 1998. There are three annual reports (Pabst, 1995, *Biodiversity Inventory and Analysis of the Hanford Site, 1994 Annual Report*; Soll and Soper, 1996, *Biodiversity Inventory and Analysis of the Hanford Site, 1995 Annual Report*; and Hall, 1998, *Biodiversity Inventory and Analysis of the Hanford Site, 1997 Annual Report*), and a final report in 1999 (Soll et al., 1999, *Biodiversity Inventory and Analysis of the Hanford Site Final Report 1994-1999*).

- 200 Areas Ecological Data Compilation (PNNL-13230, *Hanford Site Environmental Report for Calendar Year 1999*; PNNL-13331, *Population Characteristics and Seasonal Movement Patterns of the Rattlesnake Hills Elk Herd—Status Report 2000*; PNNL-13487, *Hanford Site Environmental Report for Calendar Year 2000*; PNNL-13745, *Hanford Site Ecological Quality Profile*).

- Characterization of vegetative communities associated with the 200 Area facilities at the Hanford Site (WHC-SD-EN-TI-216, *Vegetation Communities Associated with the 100-Area and 200-Area Facilities on the Hanford Site*).

- Vascular Plants of the Hanford Site (PNNL-13688, *Vascular Plants of the Hanford Site*).
- Hanford Biological Resources Management Plan (using TNC and other characterization reports), identifying four levels of habitat value and appropriate management strategies for the Site (DOE/RL-96-32, *Hanford Site Biological Resources Management Plan*).

The Hanford Site is characterized as a cool desert or a shrub-steppe and supports a biological community typical of this environment. The Hanford Central Plateau contains a number of plant, mammal, bird, reptile, amphibian, and insect species, as discussed in the following sections.

2.3.6.1 Vegetation of the Central Plateau

The vegetation of the Central Plateau is characterized by native shrub-steppe interspersed with large areas of disturbed ground with a dominant annual grass component. The native stands are classified as an *Artemisia tridentata/Poa sandbergii-Bromus tectorum* community (PNL-2253, *Ecology of the 200 Area Plateau Waste Management Environs: A Status Report*), meaning that the dominant shrub is big sagebrush (*Artemisia tridentata*), and the understory is dominated by the native Sandberg's bluegrass (*Poa sandbergii*) and the introduced annual cheatgrass (*Bromus tectorum*). Other shrubs that are typically present include gray rabbitbrush (*Chrysothamnus nauseosus*), green rabbitbrush (*C. viscidiflorus*), spiny hopsage (*Grayia spinosa*), and occasional antelope bitterbrush (*Purshia tridentata*). Other native bunchgrasses that are typically present include bottlebrush squirreltail (*Sitanion hystrix*), Indian ricegrass (*Achnatherum hymenoides*), needle-and-thread (*Stipa comata*), and prairie junegrass (*Koeleria cristata*). Common and important herbaceous species include turpentine cymopteris (*Cymopteris terebinthinus*), globemallow (*Sphaeralcea munroana*), balsamroot (*Balsamorhiza careyana*), several milk vetch species (*Astragalus caricinus*, *A. sclerocarpus*, *A. succumbens*), long-leaf phlox (*Phlox longifolia*), the common yarrow (*Achillea millifolium*), pale evening-primrose (*Oenothera pallida*), thread-leaf phacelia (*Phacelia linearis*), and several daisy/fleabane species (e.g. *Erigeron poliospermus*, *E. Filifolius*, and *E. pumilus*). In all, more than 100 plant species have been documented to occur in native stands on the Central Plateau.

Disturbed communities on the Central Plateau are primarily the result of mechanical disturbance or range fires. Mechanical disturbance, construction activities, soil borrow areas, road clearings, and firebreaks can result in changes to the plant community and surface soil. Revegetation of remediated waste sites in the River Corridor (as described in DOE/RL-2011-116, *Hanford Site Revegetation Manual*) has been successful with replanting of suitable native species in the 100 Areas following remediation activities. Examples are provided in annual issues of the *River Corridor Closure Contractor Revegetation and Mitigation Monitoring Report*, such as WCH-288 (2008), WCH-362 (2009), WCH-428 (2010), WCH-512 (2011), and WCH-554 (2012).

The vegetation in and around the ponds and ditches on the Central Plateau is significantly different from that of the surrounding dry land areas. Several tree species are present, especially cottonwood (*Populus trichocarpa*) and willows (*Salix* spp.). Wetland species are also present, including several sedges (*Carex* spp.), bulrushes (*Scirpus* spp.), cattails (*Typha latifolia* and *T. angustifolia*), and pondweeds (*Potamogeton* spp.).

2.3.6.2 Mammals

Although mule deer (*Odocoileus hemionus*) are much more common to riparian sites along the Columbia River, they are frequently observed foraging throughout the Central Plateau. The largest mammal living on the Central Plateau is the elk (*Cervus elaphus*). A herd of 772 elk also occur on the Hanford Site, with a herd of 22 regularly occupying areas around the northern portion of the central Hanford Site (HNF-54666, *Elk Monitoring Report for Calendar Year 2012*). Other mammal species common to the Central Plateau include badgers (*Taxidea taxus*), coyotes (*Canis latrans*), blacktail jackrabbits

(*Lepus californicus*), Townsend ground squirrels (*Spermophilus townsendii*), Great Basin pocket mice (*Perognathus parvus*), pocket gophers (*Thomomys talpoides*), and deer mice (*Peromyscus maniculatus*). Badgers are known for their digging capability and have been implicated several times for tunneling into inactive burial grounds throughout the Central Plateau. Most badger excavations in the Central Plateau are a result of badgers searching for prey (mice and ground squirrels). Coyotes are the principal predators, consuming such prey as rodents, insects, rabbits, birds, snakes, and lizards. The Great Basin pocket mouse, which thrives in sandy soils and lives entirely on seeds from native and revegetated plant species, is the most abundant small mammal. Townsend ground squirrels are not abundant in the Central Plateau, but they have been seen at several different sites.

Other small mammals that live in low numbers include the western harvest mouse (*Reithrodontomys megalotis*) and the grasshopper mouse (*Onychomys leucogaster*). Mammals associated more closely with buildings and facilities include Nuttall's cottontails (*Sylvilagus nuttallii*), house mice (*Mus musculus*), Norway rats (*Rattus norvegicus*), and some bat species. Nine bat species have been identified at the Hanford Site (HNF-53759, *Summer Bat Monitoring Report for Calendar Year 2012*). Five locations for the 2012 summer survey were within the Inner Area, some with bats observed. Mammals such as skunks (*Mephitis mephitis*), raccoons (*Procyon lotor*), weasels (*Mustela* spp.), porcupines (*Erethizon dorsatum*), and bobcats (*Lynx rufus*) have only been observed on very few occasions.

2.3.6.3 Birds

More than 235 species of birds have been documented to occur at the Hanford Site (WHC-EP-0402, *Status of Birds at the Hanford Site in Southeastern Washington*). At least 100 of these species have been observed in the Central Plateau. The most common passerine birds include starlings (*Sturnus vulgaris*), horned larks (*Ermophila alpestris*), meadowlarks (*Sturnella neglecta*), western kingbirds (*Tyranus verticalis*), rock doves (*Columba livia*), barn swallows (*Hirundo rustica*), cliff swallows (*Hirundo pyrrhonota*), black-billed magpies (*Pica pica*), and ravens (*Corvus corax*). Common raptors include the northern harrier (*Circus cyaneus*), American kestrel (*Falco sparvarius*), and red-tailed hawk (*Buteo jamaicensis*). Swainson's hawks (*Buteo swainsoni*) sometimes nest in the trees at some of the army bunker sites used in the 1940s. Golden eagles (*Aquila chrysaetos*) are observed infrequently. Burrowing owls (*Athene cunicularia*) nest at several locations throughout the Central Plateau. The most common upland game birds found in the Central Plateau are California quail (*Callipepla californica*) and Chukar partridge (*Alectoris chukar*); however, ring-necked pheasants (*Phasianus colchicus*) and gray partridges (*Perdix perdix*) may be found in limited numbers. The only native game bird common to the Central Plateau is the mourning dove (*Zenaida macroura*), which migrates south each fall. Other species of note that nest in undisturbed sagebrush habitats in the Central Plateau include sage sparrows (*Amphispiza belli*) and loggerhead shrikes (*Lanius ludovicianus*). Long-billed curlews (*Numenius americanus*) also use the sagebrush areas and revegetated burial grounds for nesting and foraging.

Waterfowl and aquatic birds formerly inhabited the 216-B-3 and 216-U-10 Ponds, and other areas with running or standing water. However, these areas have been removed through stabilization and remedial action cleanup activities. No substantial bodies of open water remain in the Central Plateau.

2.3.6.4 Reptiles and Amphibians

Common reptiles include gopher snakes (*Pituophis melanoleucus*) and side-blotched lizards (*Uta stansburiana*). Other reptiles and amphibians that are infrequently observed include sagebrush lizards (*Sceloporus graciosus*), horned toads (*Phrynosoma douglassii*), western spadefoot toads (*Scaphiopus intermontana*), yellow-bellied racers (*Coluber constrictor*), Pacific rattlesnakes (*Crotalus viridis*), and striped whipsnakes (*Masticophis taeniatus*). Both lizards and snakes are prey for mammalian and avian predators.

2.3.6.5 Insects

Hundreds of insect species inhabit the Central Plateau. Two of the most common groups of insects include several species of darkling beetles and grasshoppers. Harvester ants are also common and have been implicated in the uptake of radionuclides from some of the burial grounds in the Inner Area. The maximum documented burrowing depth of harvester ants at the Hanford Site, and depth from which ants can excavate and bring up material, is 270 cm (8.9 ft) (Sample et al., 2015, "Depth of the Biologically Active Zone in Upland Habitats at the Hanford Site, Washington: Implications for Remediation and Ecological Risk Management"; PNL-2774, *Characterization of the Hanford 300 Area Burial Grounds: Task IV – Biological Transport*). Other major groups of insects include bees, butterflies, and scarab beetles. Insects affect the surrounding plant community and serve as the prey base for many species of birds, reptiles, and mammals.

3 Initial Evaluation

The 200-WA-1 and 200-BC-1 OU initial evaluation builds on the operational history and environmental setting to describe what is known, or can be inferred, about the waste sites to help identify the data gaps to be filled by the RI. The descriptions integrate relevant site information including contaminants, physical structures, future land use, and potential exposure pathways to develop a preliminary CSM. The initial evaluation results create a basis on which to estimate the nature and extent of environmental impacts, identify exposure pathways and receptors, assess effect on groundwater, and develop strategies to reduce risk. The initial waste site evaluations and site descriptions generated in Chapter 3 will be used to identify the key additional data needs that are input to the DQO process presented in Chapter 4.

3.1 Contaminant Sources Based on Process History and Process Knowledge

Environmental effects in the Inner Area are primarily the result of facility processes, waste disposal practices, and UPRs. The process chemistry and waste-generating operations at these facilities were evaluated to identify the primary contaminant sources and release locations.

3.1.1 Primary Contaminant Sources

Liquid effluent, solid waste, and airborne particulates that were discharged to the environment during facility operations were the primary contaminant sources in the Inner Area.

The waste sites within the 200-WA-1 and 200-BC-1 OUs are representative of a variety of primary waste sources and release mechanisms. The following general categories of primary contaminant sources are associated with the 200-WA-1 and 200-BC-1 OU waste sites:

- Liquid process wastes were generated during facility operations and released to the environment either intentionally (e.g., to engineered structures such as cribs or trenches) or during UPRs via spills or leaks from tanks, pipelines, or other storage or conveyance components. Process wastes may be aqueous or nonaqueous but are generally identified as exhibiting relatively high concentrations of known process-related contaminants (e.g., radionuclides or chemicals). This source category also includes wastes that were initially sent to the tank farms and later decanted with the decanted liquid diverted to a vadose zone engineered structure.

- Process wastewater was generated during facility operations and released to the environment either intentionally (e.g., to cribs, trenches, ponds, and ditches) or during UPRs via spills or leaks from tanks, pipelines, or other storage or conveyance components. Process wastewater generally consisted of aqueous liquids that contained nominal or no apparent radionuclides and variable concentrations of chemical constituents. Examples of process wastewater include noncontact cooling water, steam condensate, wash water from housekeeping in uncontaminated facilities, and sanitary wastewater. Some process wastewater streams (e.g., process cooling water and steam condensate from process heat exchangers) were subject to contamination in the event of plant upset conditions. These streams may also contain constituents such as corrosion control chemicals that were added to the water as part of normal use. Process wastewater was generated and discharged to the environment in small (hundreds of thousands of liters) to very large (billions of liters) quantities at various locations within and adjacent to the 200-WA-1 and 200-BC-1 OUs. Sanitary wastewater was generated during historical and ongoing plant operations and typically discharged to the vadose zone via sanitary sewerage systems that included septic tanks and drain fields. The septic system sizes and the volume of sanitary wastewater that was received varied by location and number of employees present at each facility. Normally, septic systems handled only sanitary waste from bathrooms/showers or similar facilities, but some were connected to floor drains that potentially received radiological and/or chemical contaminants.

- Solid wastes were generated during facility operations and placed in shallow debris disposal sites, including laydown yards or general dumping areas. Solid waste may have included solid chemical or process waste, contaminated equipment and hardware, and nonhazardous materials. Airborne particulate waste was generated during facility operations and was removed by pollution control equipment (e.g., sand filters) upstream of facility stacks or dispersed from facilities through unplanned or intentional releases from facility stacks, waste handling storage, or disposal facilities, and subsequently deposited on the ground surface.

Some waste sites received more than one type of primary source material.

3.1.2 Secondary Sources of Contamination

Secondary sources of contamination, which developed from the release of primary contaminant source materials to the environment, typically included contaminated environmental media. The secondary contaminant sources may contribute to ongoing or future contaminant release, transport, and exposure, away from the initial point of release of the primary source(s). For the 200-WA-1 and 200-BC-1 OU waste sites, the secondary sources are solid and liquid phase contaminants associated with vadose zone soil.

The identification and assessment of secondary sources is an important element in the characterization of risks to HHE posed by site conditions, and the development and evaluation of remedial action alternatives. At the 200-WA-1 and 200-BC-1 OU waste sites, secondary sources related to residual mobile contaminants within the vadose zone are particularly important to the assessment of the potential future threat to groundwater.

3.2 Previous Investigations, Monitoring, and Remediation Activities

A substantial volume of information on 200-WA-1 and 200-BC-1 OU waste site conditions has been assembled over the life of investigations conducted at the Hanford Site. The data reviewed in preparation of this work plan are organized by waste, site and a summary of the information is included in Appendix D.

3.2.1 Evaluation of Existing Data

Data pertaining to 200-WA-1 and 200-BC-1 OU waste sites exist in a variety of forms and are evaluated as follows:

- Identification of data sources and types
- Compilation and organization of data by waste site
- Data quality assessment (DQA)
- Evaluation of existing indirect data to support vadose zone contamination assessment

3.2.1.1 Identification of Data Sources and Types

The overall data assessment strategy integrates information on waste site design and process operations history, with information obtained from previous, ongoing, and planned investigations, or prior remedy decisions, to build a dataset that supports the characterization of risks necessary for remedial action decision making. To support this strategy, the following data reference sources were queried for 200-WA-1 and 200-BC-1 OU waste site information:

- Hanford Well Information System (HWIS)—A web-based interface that provides access to well information for the Hanford Site. HWIS is not a database but an interface to the Integrated Document

Management System (IDMS), containing well history information such as drilling dates, construction dates, decommissioning status, survey information, well activity information (e.g., sampling and maintenance), construction details, and borehole and well records (e.g., as-built construction drawings, geologic logs).

- Hanford Environmental Information System (HEIS)—The official data repository for Hanford Site environmental data. It contains a variety of chemical and physical data for various sample media that include water and soil samples. Analytical data from these waste sites, generated through June 2014, comprise the dataset that is subject to initial evaluation in this work plan.
- HEIS Geophysical Logging (GPL)—Hanford Site-specific database containing electronic GPL data.
- Sampling and analysis laboratory reports for waste characterization and environmental assessment samples available in HEIS.
- Automated Water Level Network—Hanford Site-specific database containing water level measurements for selected onsite groundwater monitoring wells.
- Effluent Volumes and Discharges—Hanford Site-specific database that contains information on the effluent volumes released to the soil disposal sites in the Central Plateau (200 Area).
- Historical reports and information, including technical reports available from IDMS, the Administrative Record, the Public Information Repository, and declassified documents; waste site figures and engineering drawings (as-built drawings were used to verify site location and construction of engineered features and dimensions, where available; design drawings were used if as-built drawings were not available). Many studies and evaluations of waste sites, waste sources, and response actions have been published. These documents include the technical manuals for major operating facilities at the Hanford Site.
- Hanford Soil Inventory Model (SIM) (PNNL-16940, *Hanford Soil Inventory Model (SIM), Revision 2, Software Documentation – Requirements, Design, and Limitations*)—Hanford Site-specific model that quantifies contaminant inventories and uncertainties for waste sites based on approximately 50 years of process knowledge.
- Routine environmental monitoring activities and site-specific and Hanford Sitewide groundwater monitoring reports.
- The Hanford WIDS database contains the history and status of individual waste sites at the Hanford Site. Files may contain photographs, maps, and selected reference documents, either extracted pages or the entire document associated with the waste site.
- Remote imagery and data including aerial photographs, light detection and ranging data, and aerial radiological surveys.
- Extrapolation or inference of subsurface geologic conditions and contaminant distribution measured at representative waste sites to nearby, or operationally similar, waste sites that have not been investigated.

3.2.1.2 Compilation and Organization of Data by Waste Site

After the available data were assembled, the information was compiled by waste site and reviewed. Appendix D provides summaries of data available for each 200-WA-1 and 200-BC-1 OU waste site.

3.2.1.3 Data Quality Assessment

Because waste site information comes from a broad range of sources and periods, a preliminary DQA was performed to determine the extent to which existing data provided representative measurements of specific site conditions. Figure 3-1 shows the DQA process followed. The most rigorous level of DQA was performed on older laboratory analytical data. Recent samples were typically collected in accordance with approved SAPs and their accompanying quality assurance projects plans (QAPjPs), and were subsequently subjected to a less rigorous usability assessment. For these contemporary data, the DQA was conducted in accordance with the DQOs described in the SAP and QAPjP (see Appendix E).

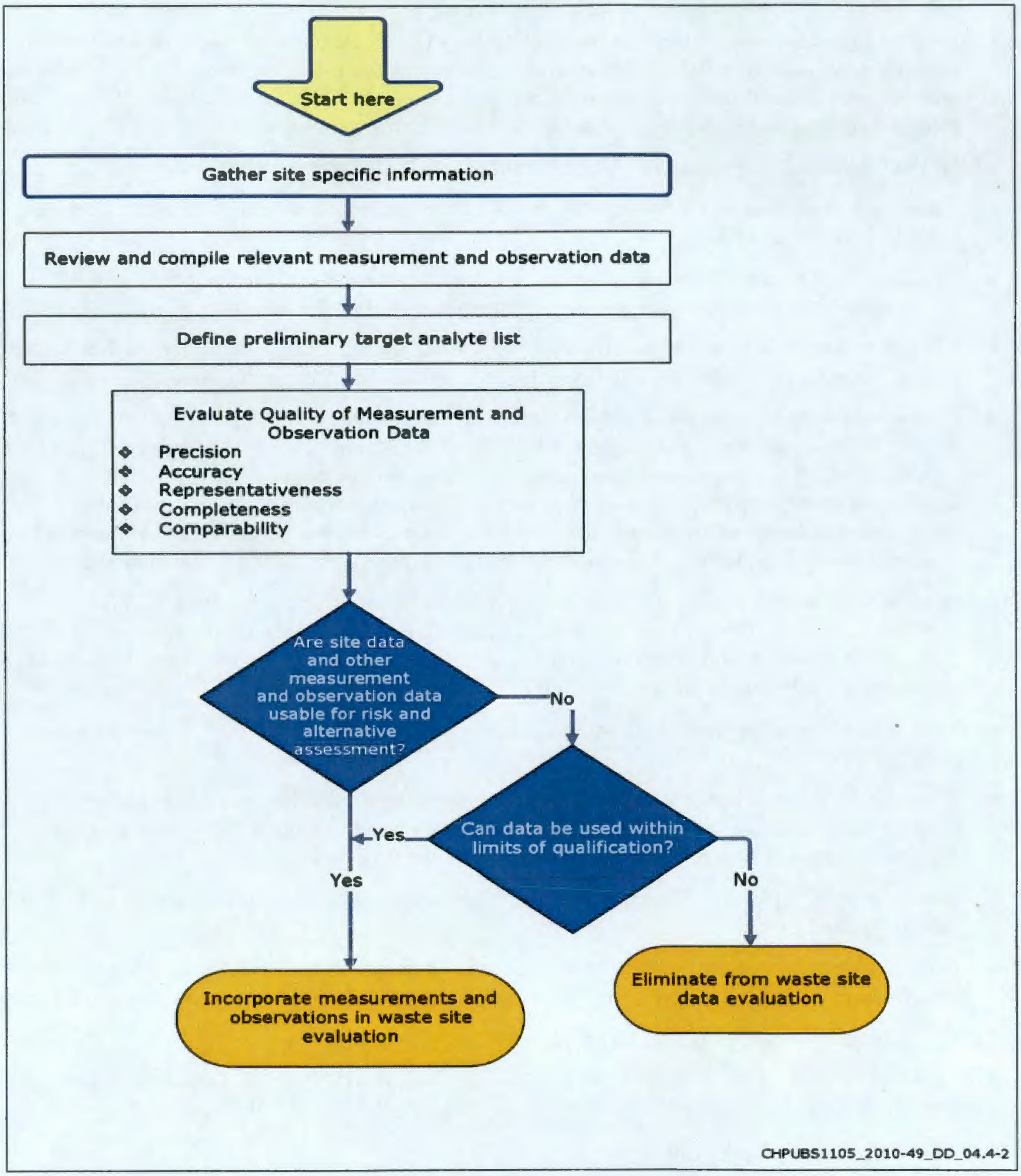


Figure 3-1. Data Quality Assessment Flowchart

Data for which DQAs have already been performed were accepted as reported, and no additional data review was performed, unless specific data quality issues were discovered during the initial evaluation.

A majority of the data was deemed usable for 200-WA-1 and 200-BC-1 OU waste sites RI/FS preliminary CSM and conceptual exposure model (CEM) development and data needs assessment.

3.2.1.4 Existing Soil Sampling and Analysis Data

The highest-quality data for defining the nature and extent of residual contaminant concentrations in vadose zone soil are obtained from laboratory analysis of soil samples collected at multiple depths within or beneath the waste site footprint. Collection of representative subsurface soil samples from waste disposal sites can be complicated by anisotropic (nonuniform) movement of wastewater within the vadose zone soil. As a result, a clear understanding of vadose zone lithology (the primary influence of anisotropic wastewater movement) is critical to accurate interpretation of analytical data. Appendix D includes available data for individual waste sites.

3.2.1.5 Existing Geophysical Survey Measurement Data

Various geophysical survey measurement techniques have been applied to the waste sites in the 200-WA-1 and 200-BC-1 OUs. These are divided into two general categories: surface geophysical techniques that are applied at or above (in the case on airborne radiation surveys) the ground surface, and downhole geophysical techniques that are applied to boreholes and provide depth-vertical profile information.

The following techniques provided information for this RI/FS work plan:

- Aerial gamma radiation surveys were conducted using helicopter-based sensors. These measurements provide a wide-area identification and assessment of significant gamma radiation sources and some quantification of specific nuclides that account for the radiation detected. Two aerial survey reports were reviewed during preparation of this work plan (EGG-1183-1661, *An Aerial Radiological Survey of the U.S. Energy Research and Development Administration's Hanford Reservation (Survey Period: 1973-1974)*, and DOE-0335, *An Aerial Radiological Survey of the Hanford Reservation Richland Washington: Date of Survey: February 29 to March 21, 1996*).
- Surface soil electrical resistivity surveys were conducted at several locations. The most notable application of this technology was at the BC Cribs and Trenches, where a broad area was surveyed and selected locations subsequently examined by sampling and analysis of vadose samples collected from optimally located boreholes (PNNL-17821, *Electrical Resistivity Correlation to Vadose Zone Sediment and Pore-Water Composition for the BC Cribs and Trenches Area*). A soil resistivity survey was also conducted at the 216-U-8 and 216-U-12 Crib locations in 2010.
- Downhole radiation measurements were obtained, including gross gamma logs using scintillation counting equipment. More recently, downhole spectral gamma measurements provided a quantitative measurement of gamma-emitting radionuclides (predominantly uranium, cobalt-60, and cesium-137) in subsurface soil.
- Neutron moisture determinations were made that provide quantitative estimates of soil moisture content in the subsurface. Passive neutron measurements provide gross detection of neutrons emitted by spontaneous fission of some TRU radionuclides in the subsurface soil.

3.2.1.6 Evaluation of Existing Indirect Data to Support Vadose Zone Contamination Assessment

Indirect data gathered for the 200-WA-1 and 200-BC-1 OU waste sites include radiation surveys that measure gross radiation conditions, civil surveys that provide waste site elevation and location information, and measurements and observations collected during spill or release response activities in the past. Historical photographs provide another element of indirect data by providing visible indication of site conditions.

3.2.2 Previously Proposed 200 West Area Data Collection

In addition to existing historical investigations, supplementary environmental investigations have been planned for selected waste sites and are in various stages of implementation. The completed results of these investigations will be incorporated into the 200-WA-1 and 200-BC-1 OU RI/FS report. These planned investigations include the following:

- Supplemental RI of selected waste sites in the 200 Area that will generate site-specific characterization information (DOE/RL-2007-02, Rev. 0, Vol. II)
- Vadose characterization of 216-U-8 and 216-U-12 Cribs
- 200-MG-1 OU SAP

The portions of these planned investigations that have not been completed are considered in the data needs assessment, and where appropriate, data collection activities required to fulfill RI/FS data needs are incorporated into the 200-WA-1 and 200-BC-1 OU SAP (Appendix E). Where additional data collection activities are proposed outside the specific data needs of the 200-WA-1 and 200-BC-1 OU RI/FS (e.g., 216-U-8 and 216-U-12 treatability study), coordination with the entities responsible for those studies provides the opportunity for that opportunistic sampling to fulfill those other purposes may occur during the 200-WA-1 and 200-BC-1 OU characterization efforts. 216-U-8 Crib characterization fieldwork began in August 2015 and is expected to be completed by the end of October 2015. This investigation involves the drilling and sampling of a total of six boreholes adjacent to the south edge of the crib within the upper 24 m (80 ft) of the vadose zone. The analytical results from this investigation will be used to support the final design and implementation of the uranium sequestration field test as described in DOE/RL-2010-87 ("Field Test Plan for the Uranium Sequestration Pilot Test").

Existing data have been incorporated into the preliminary understanding of contaminant distribution presented in the following sections. The relevant results from independently scoped characterization activities may be integrated into the 200-WA-1 and 200-BC-1 OU RI/FS report.

3.3 Preliminary Understanding of the Nature and Extent of Contamination

This section describes the current understanding of the nature (type of contamination, including contaminants of interest and chemical and physical properties) and the extent of contamination (spatial distribution) as it currently exists in the OUs. The nature and extent of contamination is evaluated on a waste site-by-waste site basis to support characterization of potential risks, assess potential impact to groundwater, provide initial identification of remedial technologies and development of potential remedial alternatives for each waste site, and identify data needs.

3.3.1 200-WA-1 and 200-BC-1 OU Waste Site-Specific Contamination Conditions

The waste sites within the 200-WA-1 and 200-BC-1 OUs exhibit a variety of design, primary waste source, waste volume, and waste release scenarios. The waste sites range from those suspected of exhibiting low concentrations with limited shallow contamination in small discrete areas to waste sites that received large volumes of liquid effluent that migrated downward through the soil column to groundwater. Section 3.3.2 discusses how an additional line of evidence (i.e., detection of relatively immobile radionuclides in groundwater near a waste site) was also used to identify waste sites with potential groundwater effects.

In addition, there is a subset of the waste sites within the 200-WA-1 OU that contain structures such as underground storage tanks (USTs), pipelines, building slabs, concrete basins, and vaults. These structures in some cases may represent contaminated media as the result of spills, leaks, or discharges associated with the operation or use of the site. A portion of these waste sites that contain tanks, vaults, septic tanks, retention basins, silos, or other vessels may also retain solid or liquid residuals that may represent a continuing source of contamination. The following sections discuss these features as a source of potential contamination.

An overview of waste site contamination conditions was developed based on the measurements and observation data sources described in the preceding sections. To simplify the discussion and presentation of waste site contaminant distribution within the 200-WA-1 and 200-BC-1 OUs, the waste sites were grouped by site geography and type. The following sections present waste site groupings and their characteristics, including apparent contaminant distribution, by geography.

The preliminary contaminants of potential concern (COPCs) include a broad range of radionuclide and chemical constituents. The chemical constituents include metals, other inorganic and organic cations, volatile organics, and semivolatile organics. Details on the contaminants associated with each respective waste site grouping are provided in Appendix B. Additionally, the Waste Site Summaries in Appendix D include information on potential contaminants and summary-level information on existing characterization data for each waste site.

The 200-WA-1 and 200-BC-1 OU waste sites were segregated into the following five geographic and operation-based units:

1. BC Cribs and Trenches vicinity (200-BC-1 OU)
2. U Plant vicinity (200-WA-1 OU)
3. S (REDOX) Plant vicinity (200-WA-1 OU)
4. Z (PFP) Plant vicinity (200-WA-1 OU)
5. T Plant vicinity (200-WA-1 OU)

The assignment of sites to geographic- and operation-based areas allows for the assessment of data needs (Chapter 4) to be focused on groups of sites with similar underlying geologic setting as well as similar plant process, geochemistry, and expected contaminants. The 200-WA-1 and 200-BC-1 OU waste sites are identified by geographic/operational unit, waste site type, waste, and primary source type in Table B-5, located in Appendix B.

The 200-WA-1 and 200-BC-1 OU waste sites were further subdivided into three groups based on relative depth of vadose zone contamination, estimated using the following pore volume calculation:

Pore Volume = liquid discharge volume/(structure bottom area [vadose zone thickness] 30% porosity).

The depth groupings provide consistency in the data needs analysis supporting HHE risk and groundwater protection evaluations, as well as consistency in the characterization approaches proposed in the SAP (Appendix E). The three vadose zone depth groupings are described as follows:

- **Shallow:** Sites with little or no liquid discharge volumes (0 pore volumes), where contamination is believed to reside within the top 4.6 m (15 ft) bgs, that are not suspected to have affected groundwater.
- **Intermediate:** Sites that received less than 0.5 pore volumes of liquid discharge, where contamination is believed to reside deeper than the top 4.6 m (15 ft) bgs, but are not suspected to have affected groundwater.

- **Deep:** Sites that received greater than 0.5 pore volume of liquid discharge and/or are known or suspected to have affected groundwater (see Table B-6 in Appendix B).

3.3.1.1 BC Cribs and Trenches

The BC Cribs and Trenches (Figure 3-2) were previously evaluated in DOE/RL-2000-38. These waste sites are further separated based on waste site configuration, primary waste source, and relative volume of waste received. Site groupings for BC Cribs and Trenches are described as follows.

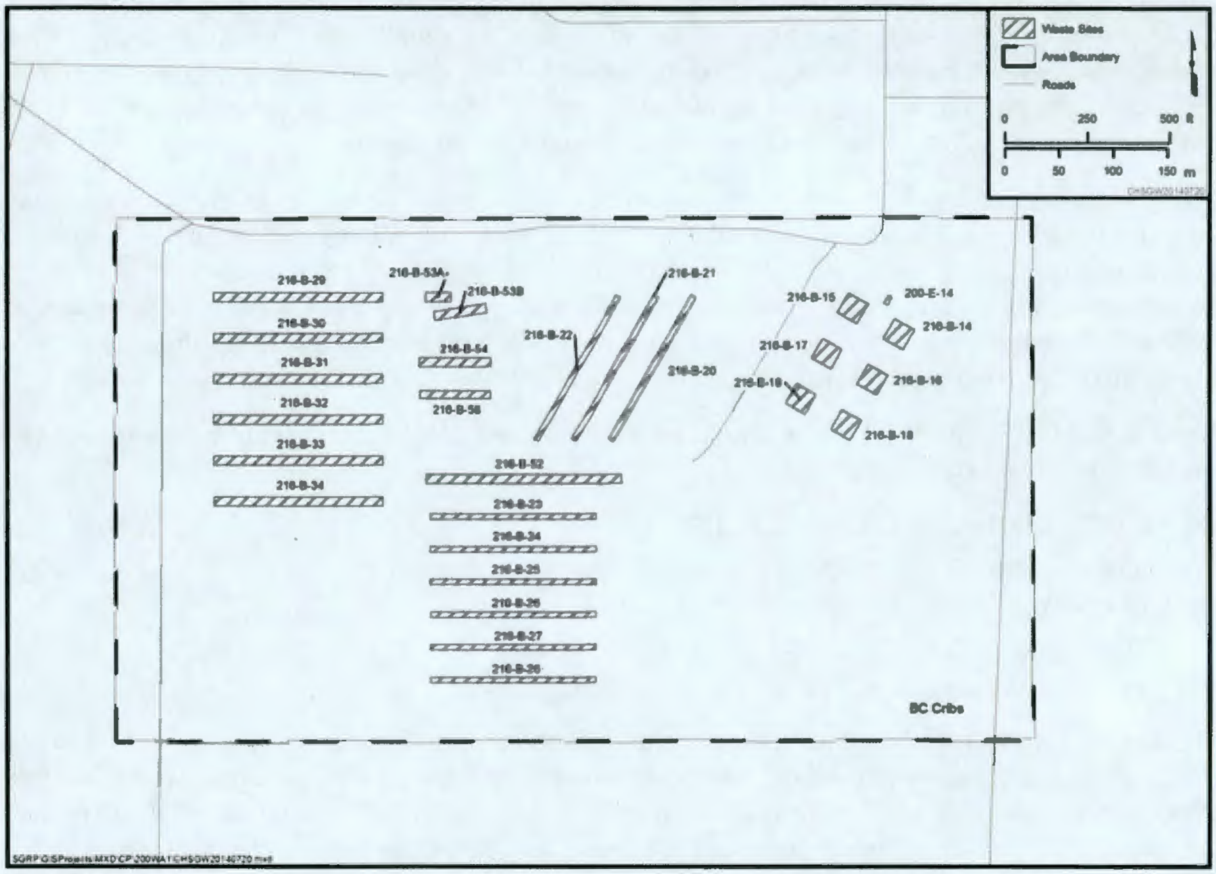


Figure 3-2. 200-BC-1 OU Waste Sites

High-Volume Scavenged Waste Cribs (216-B-14 through 216-B-19 Cribs)

These sites are included in the deep vadose zone depth grouping based on pore volume estimates between 0.8 and 2. Groundwater analytical results indicate that these waste sites likely affected groundwater during their operation (see Section 3.3.2). Cesium-137 and strontium-90 have been detected in groundwater near these waste sites (see Appendix D). Consequently, the cribs are known or suspected to exhibit full thickness vadose zone contamination. The scavenged waste discharged to these waste sites originated from the B, BX, BY, and C Tank Farms, where high-level waste was reacted with nickel ferrocyanide to enhance precipitation of cesium and strontium. The resulting supernatant, with reduced cesium-137 and strontium-90 activity, was then pumped to the BC Cribs for disposal.

Specific Retention Scavenged Waste Trenches (216-B-20 through 216-B-34 and 216-B-52 Trenches)

These waste sites received moderate volumes of the same scavenged tank waste supernatant; however, the waste volume was distributed along the trench bottoms and in a total volume that was intended to prevent the waste from migrating to groundwater. These sites are included in the intermediate vadose zone depth grouping based on pore volume estimates between 0.3 and 0.5.

- The pore volume estimates and historical detections of cesium-137 and strontium-90 suggest that contamination may have reached groundwater at the 216-B-20, 216-B-21, and 216-B-22 Trenches.
- The pore volume estimates combined with no evidence of historical groundwater radionuclide detections (see Section 3.3.2) suggest that the resulting contamination was likely retained within the upper portion of the vadose zone at the 216-B-23 through 216-B-34 and 216-B-52 Trenches.

Specific Retention 300 Area Waste Trenches (216-B-53A, 216-B-53B, 216-B-54, and 216-B-58 Trenches)

These waste sites received aqueous liquid waste that was generated in the 300 Area and transferred to the trenches in tanker trucks. The waste was generally neutral or alkaline and was collected in bulk in the 304 Building before shipment to the 200 Areas for disposal to cribs. The 216-B-53A Crib is unique in that it received aqueous decontamination wastewater generated during cleanup of the Plutonium Recycle Test Reactor in the 300 Area following a fuel failure event. These sites are included in the intermediate vadose zone depth grouping based on pore volume estimates between 0.005 and 0.3. The pore volume estimates suggest that the resulting contamination was likely retained within the upper portion of the vadose zone. No groundwater monitoring wells are associated with these sites.

Underground Storage Tank 200-E-14 Siphon Tank

This tank received scavenged tank waste supernatant and distributed it to the six BC Cribs in 38,000 L (10,000 gal) batches via an automatic siphon action when the tank liquid level reached 1.6 m (5.5 ft). This underground tank likely contained about 3,800 L (1,000 gal) of scavenged tank waste supernatant, its minimum design heel. The waste was alkaline with a pH between 10 and 11. Because the potential for contamination from historical leaks is uncertain and the tank bottom depth is 8.2 m (27.5 ft), this site is conservatively included in the intermediate vadose zone depth grouping.

Table 3-1 summarizes the waste sites in each site type within the 200-BC-1 OU. Figure 3-3 is a schematic drawing that illustrates the inferred distribution of contaminants in the vadose zone for the 200-BC-1 OU waste site groups.

Table 3-1. Summary of Waste Site Types within the 200-BC-1 OU

Site Type	Associated Waste Sites[a]	Estimated Number of Pore Volumes[b]	Indicator Parameters Historically Detected in Groundwater?[c]	Conceptual Model of Potential Vadose Zone Contamination
High-Volume Scavenged Waste Cribs	216-B-14, 216-B-15, 16-B-16, 216-B-17, 216-B-18, 216-B-19	0.8 to 2	Yes	Full thickness vadose zone impacts based on pore volume >0.5 and historical groundwater detections.
Specific Retention Scavenged Waste Trenches	216-B-20, 216-B-21, 216-B-22	0.3	Yes	Partial thickness vadose zone impacts based on pore volume <0.5. Uncertainty based on historical groundwater detections, which suggests a potential for full vadose zone impacts.

Table 3-1. Summary of Waste Site Types within the 200-BC-1 OU

Site Type	Associated Waste Sites[a]	Estimated Number of Pore Volumes[b]	Indicator Parameters Historically Detected in Groundwater?[c]	Conceptual Model of Potential Vadose Zone Contamination
	216-B-23, 216-B-24, 216-B-25, 216-B-26, 216-B-27, 216-B-28, 216-B-29, 216-B-30, 216-B-31, 216-B-32, 216-B-33, 216-B-34, 216-B-52	0.3 to 0.5	No	Partial thickness vadose zone impacts based on pore volume <0.5 and no detections of indicator parameters in groundwater
Specific Retention 300 Area Waste Trenches	216-B-53A, 216-B-53B, 216-B-54, 216-B-58	0.005 to 0.3	No data	Partial thickness vadose zone impacts based on pore volume <0.5. No groundwater data available.
UST	200-E-14	Unknown	No	Residual waste in tank. Potential for contamination from historical leaks is uncertain. Bottom depth is 8.4 m (27.5) ft.

a. DOE intends to redefine and update the WIDS summary sheets to be inclusive of all pipelines located within the waste site boundary and all pipeline segments outside of the boundary up to a distance of 7.6 m (25 ft).

b. One pore volume is the calculated soil pore volume between the structure bottom and groundwater based on an assumed porosity of 30 percent. Estimated Number of Pore Volumes (PV) is the number of times the volume of liquid discharged to the structure could fill one pore volume, and is determined as follows: PV = Liquid discharge volume / [structure bottom area * vadose zone thickness * 0.3].

c. Indicator parameters include cesium-137 and strontium-90, see Table B-6.

UST = underground storage tank

WIDS = Waste Information Data System

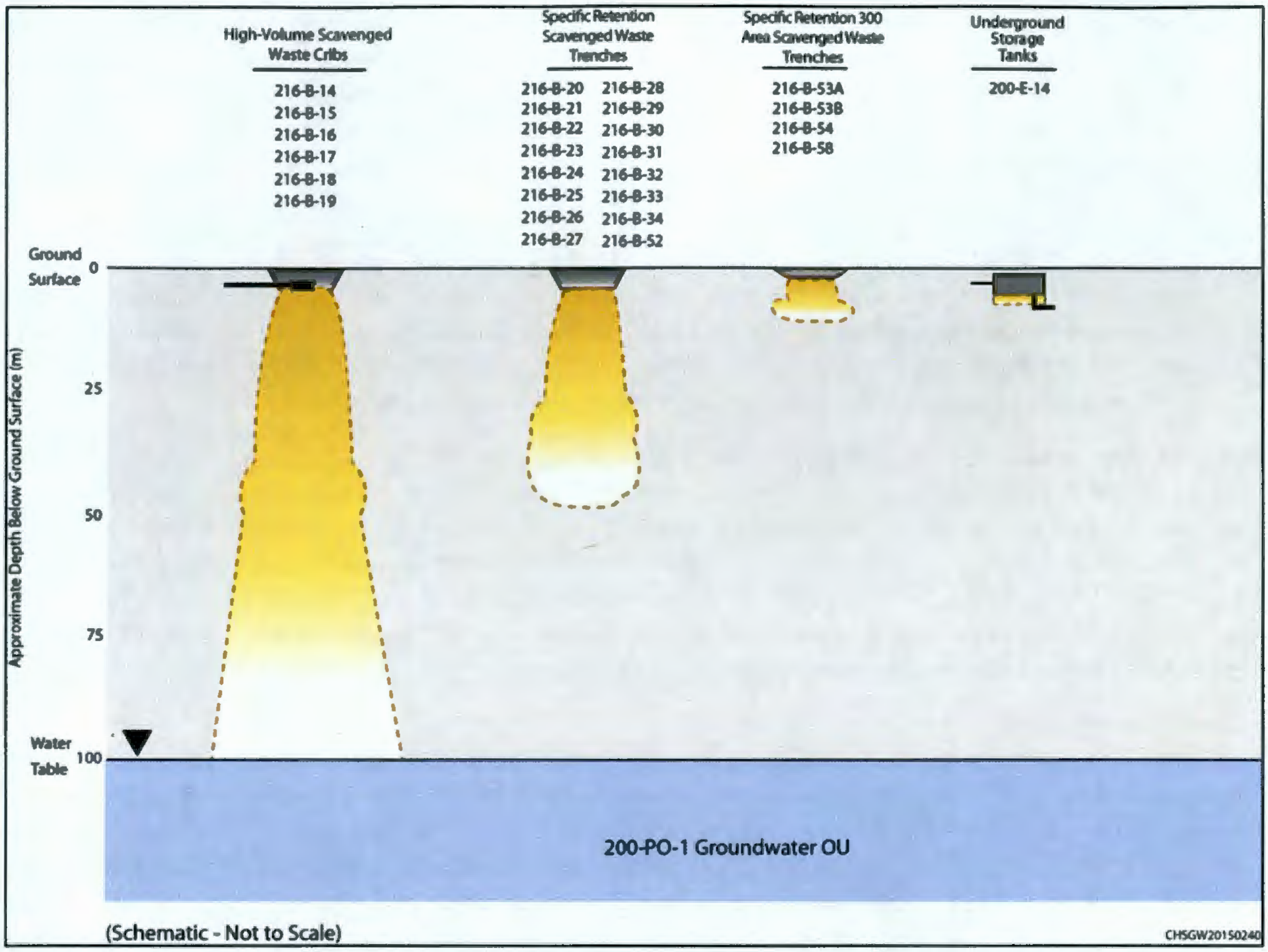


Figure 3-3. Schematic Representation of Contaminant Distribution at the 200-BC-1 OU Waste Sites Based on Process Knowledge

3.3.1.2 Waste Sites near the U Plant

Waste site locations in the 200-WA-1 OU near the U Plant are shown in Figure 3-4. These sites are divided into 11 groups, based on waste site configuration, primary waste source, and relative volume of waste received. The groupings for the U Plant vicinity waste sites are described as follows.

High-Volume Process Waste Cribs

Six high-volume process waste cribs are located near the U Plant. These sites are included in the deep vadose zone depth grouping based on pore volume estimates (between 0.6 and 78 pore volumes).

- **216-U-8, 216-U-12, and 216-U-1&2 Cribs:** Based on pore volume estimates, these sites could exhibit full thickness vadose zone contamination. In addition, historical groundwater data indicate discharges to these cribs affected groundwater during facility operations and, therefore, are likely to exhibit full thickness vadose zone contamination. The 216-U-8 Crib received radiologically contaminated process condensate from the 221-U and 224-U Buildings that was pH-adjusted to near neutral by passing the waste stream through the 270-W Tank limestone bed. Radionuclides (strontium-90, iodine-129, tritium, and uranium) and nitrate have historically been detected in groundwater wells associated with the 216-U-8 Crib (see Appendix D). The 216-U-12 Crib received strongly acidic process condensate from the 224-U Building that was not pH adjusted. Radionuclides (cesium-137, strontium-90, and tritium), nitrate, chromium, and carbon tetrachloride have historically been detected in groundwater wells associated with the 216-U-12 Crib (see Appendix D). The 216-U-1&2 Crib received solvent recovery waste from the 274-U Building after passage through the 241-U-361 Settling Tank. (Note: In previous documents, 216-U-1 and 216-U-2 were considered/ counted as two cribs.) Radionuclides (cesium-137, strontium-90, iodine-129, technetium-99, tritium, and uranium), nitrate, and carbon tetrachloride have historically been detected in groundwater wells associated with the 216-U-1&2 Cribs (see Appendix D).

- **216-U-5 and 216-U-6 Trenches, and 216-U-17 Crib:** The 216-U-5 and 216-U-6 Trenches received 0.6 and 1.7 pore volumes, respectively, of unirradiated uranium waste. The 216-U-17 Crib received neutralized process condensate from the 224-U Building. Based on pore volume estimates, these sites could exhibit full thickness vadose zone contamination. However, no historical groundwater contamination is apparent, indicating partial vadose zone contamination.

Low- to Moderate-Volume Process Waste Cribs and Trenches

Two waste sites near the U Plant received low-to-moderate volumes of process waste and are included in the intermediate vadose zone depth grouping based on pore volume estimates (between 0.001 and 0.1 pore volume). Site 216-U-13 received wastewater from equipment decontamination, and Site 216-U-15 received solid and liquid waste from the 388-U Tank in the 276-U Solvent Building. Based on pore volume estimates and no apparent historical groundwater contamination, these sites could exhibit partial thickness vadose zone contamination.

Retention Basins

Site 207-U is the retention basin for historical cooling water, steam condensate, and chemical sewer waste discharges from the U Plant facilities. The retention basin was later used as a storm water evaporation basin. This site is included in the intermediate vadose zone depth grouping based on the unknown volume of liquid waste discharged to the basin and lack of apparent groundwater contamination. The site could exhibit partial thickness vadose zone contamination if a release occurred.

Underground Storage Tanks

Two USTs are present near the U Plant. These sites are considered intermediate sites based on tank liquid volumes, potential release depth below 4.6 m (15 ft) bgs (tank bottom depth), and lack of apparent groundwater contamination.

- The 270-W Tank is an underground process waste neutralization tank that was charged with natural calcium carbonate limestone. The process condensate stream from 221-U and 224-U/UA flowed through the tank, neutralizing the waste stream. The tank was removed from neutralization service (i.e., limestone was no longer added) but remained in place as part of the waste conveyance pipeline following removal of the 216-U-8 Crib from service. The contents of the tank are not specified, and the tank (if intact) may contain a heel of several thousand liters of acidic process condensate. It is believed that the bottom of this tank (at 6 m [20 ft] bgs) may have corroded, and the underlying vadose zone may be contaminated.

- The 241-U-361 Settling Tank received process waste from the 274-U Solvent Recovery Building. This tank contains residual solids and has been sampled for characterization (D&D-36428, *Characterization Report for the 214-U-361 Settling Tank in the 200-UW-1 Operable Unit*).

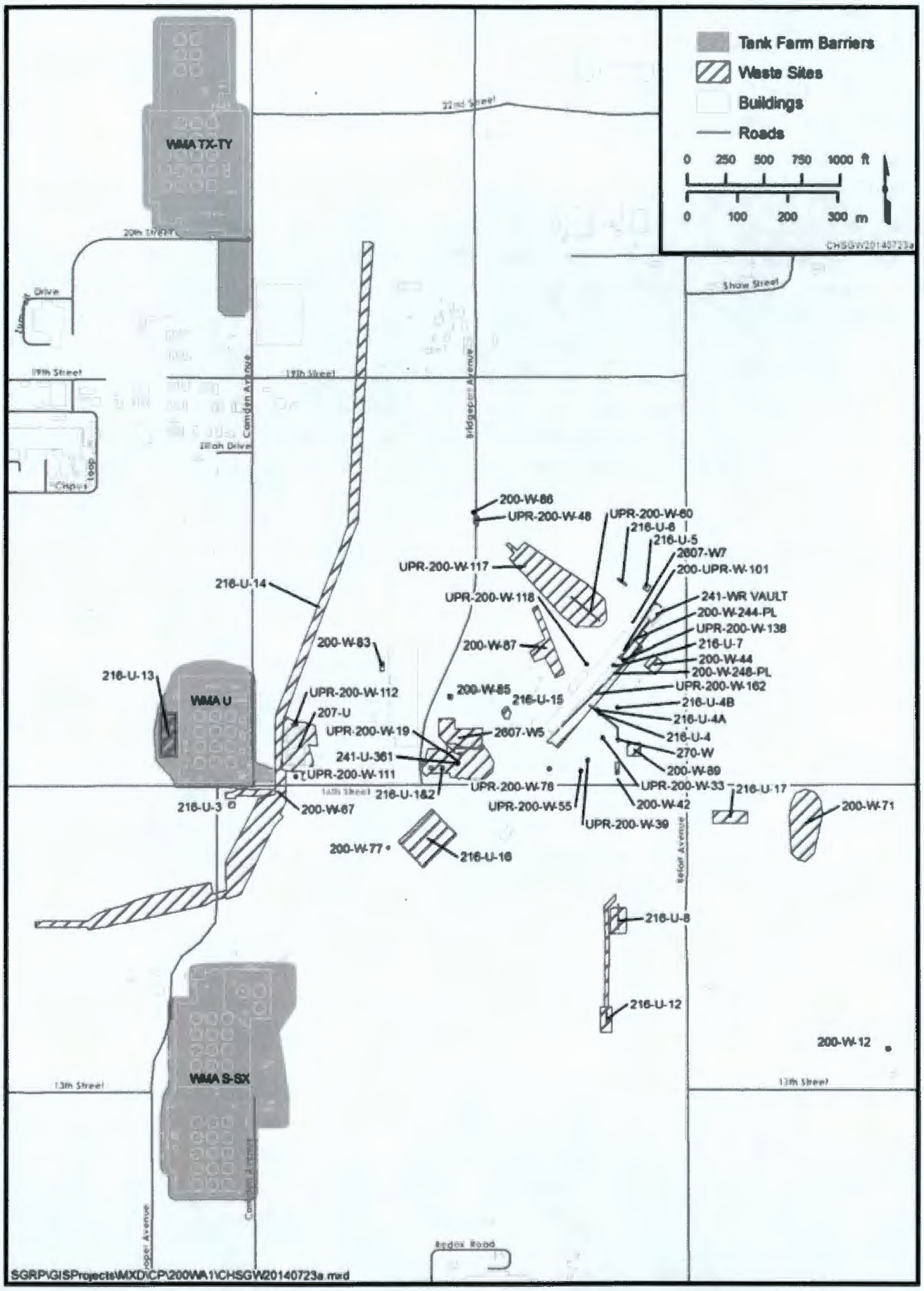


Figure 3-4. 200-WA-1 OU Waste Sites near the U Plant

High-Volume Cooling Water/Steam Condensate/Chemical Sewer Cribs and Ditches

The 216-U-14 Ditch and 216-U-16 Crib are associated with high-volume discharge of cooling water, steam condensate, and chemical sewer (i.e., nonradiological chemical waste discharge) discharges from the U Plant facilities. These sites are included in the deep vadose zone depth grouping based on pore volume estimates between 4 and 14. Based on pore volume estimates and historical groundwater data indicating discharges to these cribs affected groundwater during facility operations, these waste sites could exhibit full thickness vadose zone contamination.

- The 216-U-14 Ditch is an unlined, open surface ditch that received process wastewater and chemical sewer discharges from the 221-U, 271-U, 224-U, and UA Buildings. The ditch also received wastewater discharges from the 284-W Powerhouse (a coal-fired steam plant) and 2723-W and 2724-W Laundry Facilities, and steam condensate and cooling water from the 242-S Evaporator. The ditch discharged to the 216-U-10 Pond. Wastewater infiltrated the vadose zone under the ditch as well as at the pond. Radionuclides (strontium-90 and uranium), chromium, and carbon tetrachloride have historically been detected in groundwater wells associated with the 216-U-14 Ditch (see Appendix D).

- The 216-U-16 Crib received 224-U steam condensate, 224-U chemical sewer waste, 271-U compressor cooling water, 221-U chemical sewer waste, and 224-U process condensate. Radionuclides (cesium-137, strontium-90, and uranium), nitrate, and carbon tetrachloride have historically been detected in groundwater wells associated with the 216-U-16 Crib (see Appendix D).

Septic Systems

Waste Site 2607-W5 consists of a single-compartment tank and two drain fields. Waste Site 2607-W7 accepted waste from a restroom in the 221-U Building. These sites are included in the intermediate vadose zone depth grouping based on length of use (over 40 years) and unknown release volume.

Surface Contamination Sites

Numerous waste sites near the U Plant exhibit surface or near-surface contamination (Table 3-2). These sites are included in the shallow vadose zone depth grouping. Potential sources of contamination range from intentional discarding of contaminated debris to accumulation of contaminated windborne plants and unintentional leaks and spills of contaminated liquids and solids. Most of these sites have been subsequently covered with soil or gravel as an interim stabilization activity. Surface contamination sites primarily pose a potential for direct exposure at or near the ground surface to contamination from the following sources and are not expected to be sources of groundwater contamination:

- Stabilized surface contamination
- Burn pits
- Stabilized contamination on railroad tracks

Sand Filter

The 200-W-44 Sand Filter was used to filter air from the ventilation system of the 221-U Building prior to discharge through the 291-U Stack. The sand filter is a partially belowgrade structure constructed of reinforced concrete with an asphalt-covered concrete slab roof. This waste site is included in the intermediate vadose zone depth grouping. Based on the construction, historical use, and no apparent historical groundwater effects, the waste site could exhibit partial thickness vadose zone contamination of shallow or intermediate depth.

WR Vault

The 241-WR-Vault and two associated pipelines (200-W-244-PL and 200-248-PL, described as follows) are also included in the 200-WA-1 OU. The vault is a belowgrade, reinforced concrete structure containing nine 189,000 L (50,000 gal) tanks. The 241-WR Vault received uranium and thorium slurries (via underground-encased pipelines) from the SSTs and prepared the waste to be fed into the 221-U Facility to extract the uranium and thorium. Chemicals were added to the slurries in the 241-WR Vault tanks to adjust pH and prepare the slurries for extraction before they were transferred to the 221-U Canyon to be processed through the tributyl phosphate (TBP) extraction columns.

The 241-WR Vault (Tank WR-001) also received neutralized waste from the 221-U extraction process and stored it until it was transferred back to the tank farms. Tank leaks within the vault were noted in the 1960s. Tanks WR-001, WR-002, WR-004, and WR-005 are suspected to have leaked. Additional details are provided in Appendix D. The 241-WR Vault is included in the intermediate vadose zone depth grouping. Based on construction, historical use, and no apparent historical groundwater effects, this waste site could exhibit partial thickness vadose zone contamination of shallow or intermediate depth.

French Drains and Injection Wells

- French drains 216-U-4B and 216-U-7 are included in the intermediate vadose zone depth grouping based on pore volume estimates of 0.2 and 0.05, respectively. Based on pore volume estimates and no apparent historical groundwater impact, these sites could exhibit partial thickness vadose zone contamination.
- French drains 216-U-3 and 216-U-4A and Injection Well 216-U-4 are included in the deep vadose zone depth grouping based on pore volume estimates between 5.4 and 9.8. Well 216-U-4 is configured as an injection well (perforated interval is 15.24 to 22.8 m [50 to 75 ft] bgs). Based on pore volume estimates, these sites could exhibit full thickness vadose zone contamination. However, no historical groundwater effect is apparent, suggesting partial thickness vadose zone effect.

Pipelines

The pipeline waste site type includes one intermediate vadose zone site (200-W-42) and two shallow vadose zone sites (200-W-244-PL and 200-W-248-PL). Based on construction and existing data, these waste sites could exhibit partial thickness vadose zone contamination of shallow or intermediate depth.

- The 200-W-42 Pipeline transported large volumes of effluent from 221-U and 224 U through the 270-W Neutralization Tank, southward to the 216-U-6 and 216-U-8 Cribs. The pipeline is constructed of 0.1 m (0.25 ft) diameter stainless steel upstream of the 270-W Neutralization Tank and transitions to 0.2 m (0.5 ft) vitrified clay pipe (VCP) immediately downstream of the tank. The VCP segment was constructed with bell and spigot joints with an acid resistant sealant. An in-line camera survey identified that some of joints were dislodged (BHI-00033, *Surface and Near Surface Field Investigation Data Summary Report for the 200-UP-2 Operable Unit*). The VCP segment and contaminated soil was removed to an approximate depth of 4.6 m (15 ft) in 2006 as part of an interim TCRA. The interim TCRA was authorized in DOE/RL-2005-71, *Action Memorandum for the Time-Critical Removal Action for Support Activities to the 200 UW-1 Operable Unit*. Post-removal radiological surveys and multi-increment verification sampling at the bottom of the excavation revealed localized areas of residual contamination at 4.6 m (15 ft) bgs at VCP sections north of the 216-U-8 Crib. Comparison of pre-excavation characterization borehole samples and post-excavation sampling indicated contamination level decrease significantly between the pipeline burial depth of 3 m (10 ft) and the bottom of excavation at 4.6 m (15 ft). An in-line camera survey of another U Plant stainless steel pipeline feeding the 216-U-1 and 216-U-2 Cribs, which is of a similar vintage and construction to 200-W-42, found that stainless steel pipeline to be in virtually the same condition as when it was installed, with no evidence of leakage (BHI-00033). Based on the similarities of these two pipelines in vintage and construction, it can be inferred that the likelihood of release from the stainless steel segments of the 200-W-42 pipeline is low.
- 200-W-244-PL is a grouping of six pipelines in a concrete encasement connecting the 221-U Building to the 241-WR Vault.

- 200-W-248-PL consists of three stainless steel pipelines (lines 4866, 4976, and 4977) buried in a common soil trench from the north side of the 241-UX-154 Diversion Box, entering the 200-W-244-PL concrete encasement near the south wall of the 241-WR Vault.

Table 3-2 summarizes the sites in each site type category near the U Plant. Figure 3-5 illustrates the inferred distribution of contaminants in the vadose zone for the U Plant waste groupings.

Table 3-2. Summary of Waste Site Types near the U Plant

Site Type	Associated Waste Sites[a]	Estimated Number of Pore Volumes[b]	Indicator Parameters Historically Detected in Groundwater?[c]	Conceptual Model of Potential Vadose Zone Contamination
High-Volume Process Waste Cribs and Trenches	216-U-8, 216-U-12, 216-U-1/-U-2	25 to 78	Yes	Full thickness vadose zone impacts based on pore volume >0.5 and historical groundwater detections
	216-U-5, 216-U-6, and 216-U-17	0.6 to 1.7	No	Potential full thickness vadose zone impacts based on pore volume >0.5; uncertainty based on no detections of indicator parameters in groundwater
Low- to Moderate-Volume Process Waste Trenches	216-U-13, 216-U-15	0.001 to 0.08	No	Partial thickness vadose zone impacts based on pore volume <0.5 and no detections of indicator parameters in groundwater
Retention Basin	207-U	Unknown	No	Partial vadose zone impacts; the potential for contamination from historical leaks is uncertain
USTs	270-W[d], 241-U-361	Unknown	No	Residual waste in tanks; partial thickness vadose zone impacts based on possible tank corrosion and estimated release depth >15
High-Volume Cooling Water/Steam Condensate/Chemical Sewer Cribs and Ditches	216-U-16, 216-U-14	4 to 13.9	Yes	Potential full thickness vadose zone impacts based on pore volume >0.5 and historical detections of indicator parameters in groundwater
Septic Systems	2607-W5, 2607-W7	Unknown	No	Partial thickness vadose zone impacts based on unknown volume and length of use

Table 3-2. Summary of Waste Site Types near the U Plant

Site Type	Associated Waste Sites[a]	Estimated Number of Pore Volumes[b]	Indicator Parameters Historically Detected in Groundwater?[c]	Conceptual Model of Potential Vadose Zone Contamination
Surface Contamination Sites (stabilized surface contamination, burn pits, stabilized contamination on railroad tracks, and surface contamination)	200-W-12, 200-W-67, 200-W-71, 200-W-77, 200-W-83, 200-W-85, 200-W-86, 200-W-87, 200-W-89, UPR-200-W-33, UPR-200-W-48, UPR-200-W-78, UPR-200-W-101, UPR-200-W-111, UPR-200-W-112, UPR-200-W-118, UPR-200-W-138, UPR-200-W-162, UPR-200-W-19, UPR-200-W-60, UPR-200-W-39, UPR-200-W-117	Unknown	No	Partial thickness vadose zone impacts
Sand Filter	200-W-44	Unknown	No	Partial thickness vadose zone impacts
Vault	241-WR-Vault	Unknown	No	Partial thickness vadose zone impacts
French Drains and Injection Wells	216-U-4B, 216-U-7	0.05 to 0.2	No	Partial thickness vadose zone impacts based on pore volume <0.5 and no detections of indicator parameters in groundwater
	216-U-3, 216-U-4A, 216-U-4	5.4 to 17	No	Full thickness vadose zone impacts based on pore volume >0.5; uncertainty based on no detections of indicator parameters in groundwater
Pipe Leaks and Pipelines	200-W-42, 200-W-244-PL, 200-W-248-PL	Unknown	No	Partial thickness vadose zone impacts

a. DOE intends to redefine and update the WIDS summary sheets to be inclusive of all pipelines located within the waste site boundary and all pipeline segments outside of the boundary up to a distance of 7.6 m (25 ft).

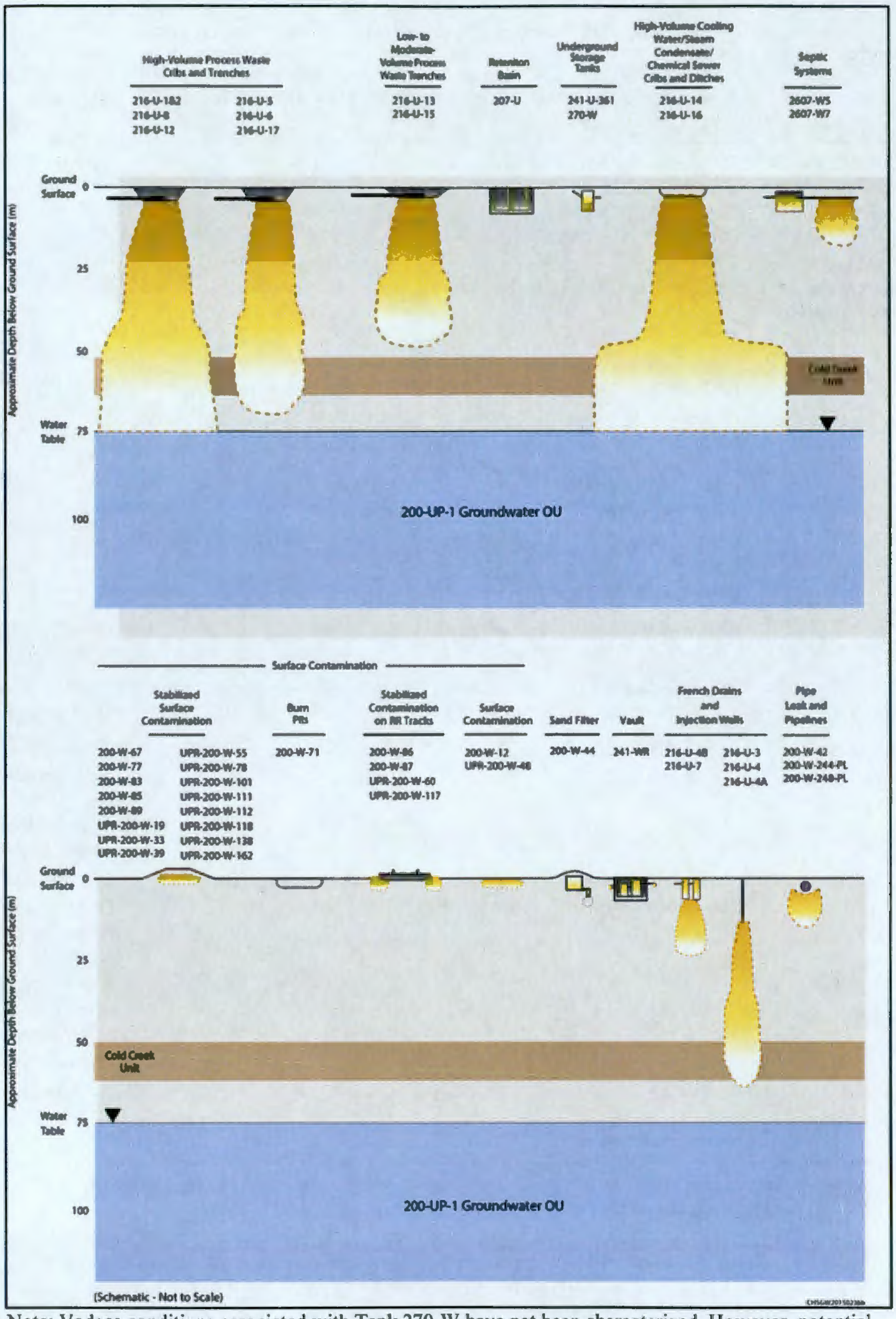
b. One pore volume is the calculated soil pore volume between the structure bottom and groundwater based on an assumed porosity of 30 percent. Estimated Number of Pore Volumes (PV) is the number of times the volume of liquid discharged to the structure could fill one pore volume, and is determined as follows: PV = Liquid discharge volume / [structure bottom area * vadose zone thickness * 0.3].

c. Indicator parameters include cesium-137 and strontium-90 (see Table B-6).

d. Vadose conditions associated with Tank 270-W have not been characterized. However, potential contributions from this tank to observed groundwater contamination have been speculated.

UST = underground storage tank

WIDS = Waste Information Data System



Note: Vadose conditions associated with Tank 270-W have not been characterized. However, potential contributions from this tank to observed groundwater contamination have been speculated.

Figure 3-5. Schematic Representation of Contaminant Distribution at the 200-WA-1 OU Waste Sites near the U Plant

3.3.1.3 Waste Sites near the S Plant

Figure 3-6 shows waste site locations near the S Plant (REDOX Plant), included in 200-WA-1 OU, and a brief description of the waste sites in each grouping follows:

High-Volume Process Waste Cribs and Trenches

Six high-volume process waste cribs (described as follows) are located near the S Plant (Sites 216-S-1&2, 216-S-7, 216-S-8, 216-S-20, 216-S-23, and 216-S-25). These sites are included in the deep vadose zone depth grouping based on pore volume estimates (between 1 and 44 pore volumes); therefore, all seven could exhibit full thickness vadose zone contamination.

- **216-S-1&2, 216-S-7, 216-S-20, 216-S-23, and 216-S-25 Cribs:** Historical groundwater data indicate discharges to these cribs affected groundwater during facility operations. Therefore, these waste sites are likely to exhibit full thickness vadose zone contamination. Cesium-137 and strontium-90 have historically been detected in groundwater wells associated with these cribs. In addition, tritium, technetium-99, uranium, nitrate, and carbon tetrachloride have historically been detected at several of these cribs (see Appendix D). The 216-S-1&2, 216-S-7, and 216-S-23 Cribs received mixed waste including cell drainage from the D-1 Receiver Tank and process condensate from the D-2 Receiver Tank in the 202-S Building. The 216-S-20 Crib received liquid waste from the acid recovery facility located in the 293-S Building. The 216-S-23 Crib received liquid waste from the acid recovery facility located in the 293-S Building. The 216-S-25 Crib received REDOX process steam condensate, tank farm cooling water, and groundwater P&T effluent.

- **216-S-8 Trench:** The 216-S-8 Trench received an estimated 1 pore volume of unirradiated uranium of cold startup waste from the S Plant. Based on the pore volume estimate, this site could exhibit full thickness vadose zone contamination, although no historical groundwater contamination is apparent. The 216-S-8 Trench lies within the extent of carbon tetrachloride and nitrate plumes.

Retention Basins

Site 207-S is the retention basin for historical cooling water and steam condensate discharges from the REDOX Plant. The basin became contaminated, was removed from service, and was backfilled and stabilized with soil in 1954. Although the retention basin received an undocumented volume of liquid waste, the waste site is included in the intermediate vadose zone depth grouping because it could exhibit partial thickness vadose zone contamination if a release occurred. No historical groundwater data are available.

Low- to Moderate-Volume Cribs, Trenches, and Pipe Leaks

Six waste sites near the S Plant received low to moderate volumes of process waste and are included in the intermediate vadose zone depth grouping based on pore volume estimates (between 0.03 and 0.2 pore volume).

- The 216-S-12 Trench received flush water from the 219-S Stack. The 216-S-14 Trench and 200-W-15 pipe leak are hexone-related waste sites. The 216-S-14 Trench was a single-use liquid disposal trench. Hexone-contaminated soil used to backfill the trench excavated to investigate a pipe leak at Waste Site 200-W-15. The 216-S-18 Trench was used for vehicle decontamination and for disposal of contaminated soil. The 216-SX-2 Crib received air compressor condensate from a tank farm compressor system. The discharge was expected to contain some compressor oil residues. Based on pore volume estimates and no apparent historical groundwater contamination, these sites could exhibit partial thickness vadose zone contamination.

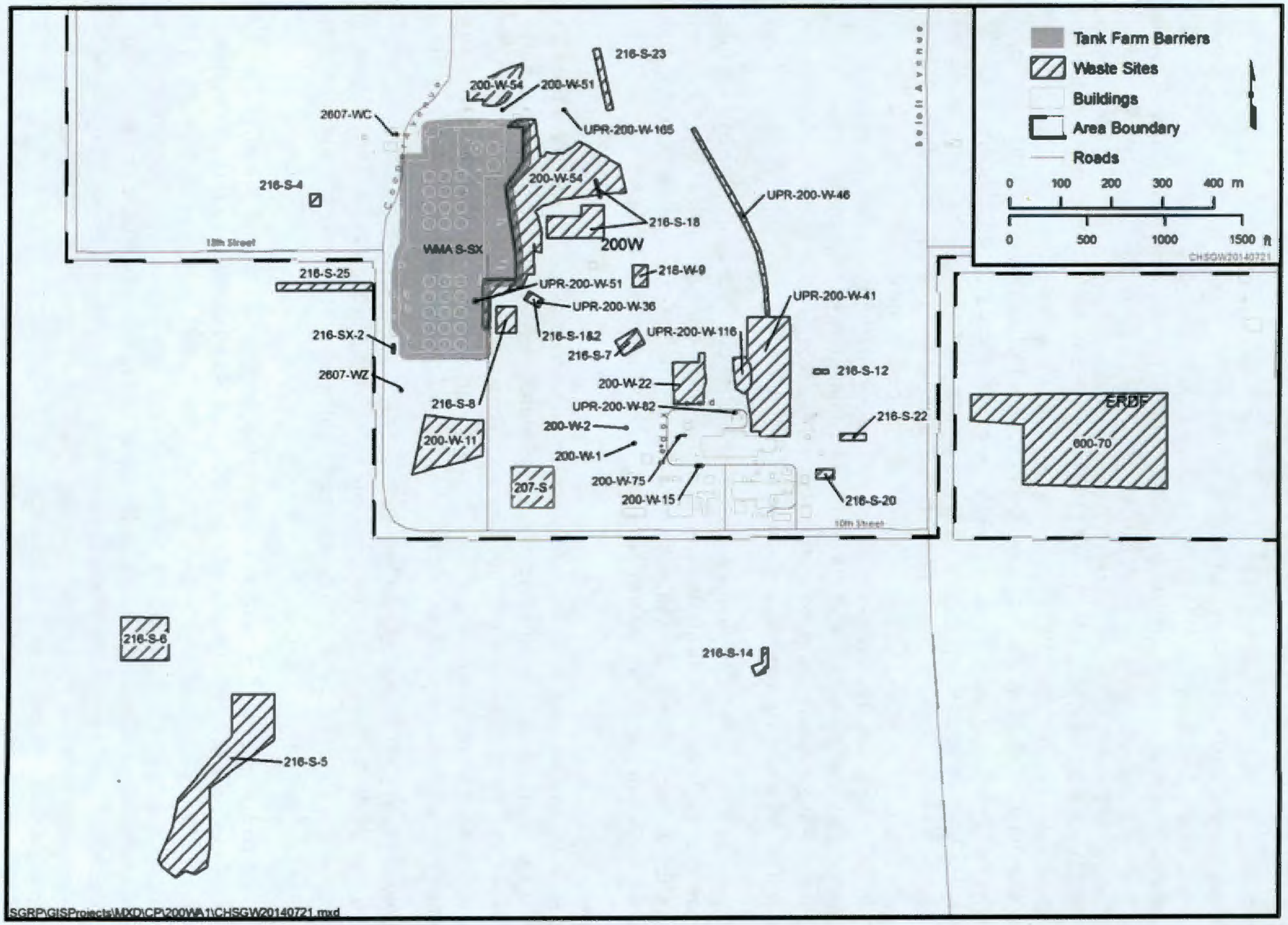


Figure 3-6. 200-WA-1 OU Waste Sites near the S Plant

- The 216-S-22 Crib received an estimated 0.14 pore volumes of process waste from the acid recovery facility located in the 293-S Building. Radionuclides (cesium-137, strontium-90, and uranium) and nitrate have historically been detected in groundwater wells associated with the 216-S-22 Crib (see Appendix D). However, the pore volume estimate suggests a low potential for groundwater contamination from this waste site.

High-Volume Cooling Water/Steam Condensate/Chemical Sewer Cribs

The 216-S-5 Crib and associated overflow trench and the 216-S-6 Crib received high contaminant inventories, which likely caused groundwater contamination during operation. These sites are included in the deep vadose zone depth grouping based on pore volume estimates of 54 and 64, respectively. Both cribs could exhibit full thickness vadose zone contamination. Radionuclides (cesium-137 and strontium-90), hexavalent chromium, and nitrate have historically been detected in groundwater wells associated with these cribs (see Appendix D).

Foundations

Site 200-W-22 is composed of the remaining foundation works for the former 203-S, 204-S, and 205-S Buildings, where uranyl nitrate hexahydrate solutions were managed. Approximately 0.6 ha (1.4 ac) were impacted by releases associated with unloading, transportation, storing, and processing of uranyl nitrate hexahydrate. Release volumes are unknown; therefore, this site is conservatively included in the intermediate vadose zone depth grouping.

Septic Systems

The 200-W-51 Septic Tank was found during construction activities associated with the SY Exhauster and was decommissioned in 1994. Waste Site 2607-WC consists of a septic tank and seepage pit. Waste Site 2607-WZ consists of two 5,678 L (1,500 gal) tanks and a drain field. These sites are included in the intermediate vadose zone depth grouping based on unknown release volume and source.

Surface Contamination Sites

Numerous waste sites near the S Plant are expected to exhibit only surface or near-surface residual vadose zone contamination. These sites, listed in Table 3-3, result from various conditions ranging from surface debris to releases of small volumes of liquid waste and release of contents of waste containers that have resulted in residual contamination at or near the ground surface. Surface contamination sites pose primarily a potential for direct exposure at or near the ground surface to contamination from the following sources:

- Stabilized surface contamination
- Surface piles
- Stabilized contamination on railroad tracks
- Debris

French Drains

The French drains at Site 216-S-4 received a substantial volume of tank farm condensate. The site was subsequently inundated by the 216-U-10 Pond. Vadose zone residual contamination resulting from this site's operation is expected to have been substantially diluted and moved away from the point of discharge by the large volume of water discharged to the pond. Residual vadose contamination at this waste site is expected to be similar to conditions observed in the 216-U-10 Pond. The site is included in the deep vadose zone depth grouping based on an estimated pore volume of 3.9. Based on pore volume estimates, this site could exhibit full thickness vadose zone contamination. No groundwater data specific to this waste site are available.

Injection Wells

Waste Site UPR-200-W-36 was created when effluent from the 216-S-1&2 Cribs discharged to groundwater, potentially through a cracked well casing at Test Well 299-W22-3. This well is located at the east end of the 216-S-1&2 Cribs. Although waste injection was not the intended purpose of this well, the casing rupture apparently allowed process waste to bypass the crib soil column and flow directly into the groundwater. Radionuclides (cesium-137, strontium-90, technetium, and tritium), cyanide, and nitrate have historically been detected in groundwater (see Appendix D).

Silos

Waste site 200-W-75 consists of three in-ground steel cylinders containing soil around sealed radioactive sources. These structures were used to test and calibrate downhole radiation detection devices. These silos were removed from service and have been covered with gravel. The sealed radioactive sources remain within the steel cylinders. This site is included in the shallow vadose zone depth grouping based on a pore volume estimate of 0 (solid waste) and low potential for groundwater impact.

The sites in each site type category near the S Plant are summarized in Table 3-3. Figure 3-7 is a schematic drawing that illustrates the inferred distribution of contaminants in the vadose zone near the S Plant.

Table 3-3. Summary of Waste Site Types near the S Plant

Site Type	Associated Waste Sites[a]	Estimated Number of Pore Volumes[b]	Indicator Parameters Historically Detected in Groundwater?[c]	Conceptual Model of Potential Vadose Zone Contamination
High-Volume Process Waste Cribs and Trenches	216-S-1 and 2, 216-S-7, 216-S-20, 216-S-23, 216-S-25	2 to 44	Yes	Full thickness vadose zone impacts based on pore volume >0.5 and historical groundwater detections
	216-S-8	1	No	Full thickness vadose zone impacts based on pore volume >0.5; uncertainty based on no detections of indicator parameters in groundwater
Retention Basins	207-S	Unknown	No data	Partial vadose zone impacts; the potential for contamination from historical leaks is uncertain.
Low-Volume Cribs, Trenches, and Pipe Leaks	216-S-12, 216-S-14, 216-S-18, 216-SX-2, 200-W-15	0.02 to 0.05	No	Partial thickness vadose zone impacts based on pore volume <0.5 and no detections of indicator parameters in groundwater
	216-S-22	0.14	Yes	Partial thickness vadose zone impacts based on pore volume <0.5; uncertainty based on detections of indicator parameters in groundwater

Table 3-3. Summary of Waste Site Types near the S Plant

Site Type	Associated Waste Sites[a]	Estimated Number of Pore Volumes[b]	Indicator Parameters Historically Detected in Groundwater?[c]	Conceptual Model of Potential Vadose Zone Contamination
High-Volume Cooling Water/ Steam Condensate/ Chemical Sewer Cribs	216-S-5, 216-S-6	58 to 64	Yes	Full thickness vadose zone impacts based on pore volume >0.5 and historical groundwater detections
Foundations	200-W-22	Unknown	No	Partial thickness vadose zone impacts
Septic Systems	200-W-51, 2607-WC, 2607-WZ	Unknown	No	Partial thickness vadose zone impacts based on unknown volume and source
Surface Contamination Sites (stabilized surface contamination, surface piles, stabilized contamination on railroad tracks, and debris)	200-W-1, 200-W-11, 200-W-2, 200-W-54, 218-W-9, 600-70, UPR-200-W-82, UPR-200-W-116, UPR-200-W-41, UPR-200-W-46, UPR-200-W-51 UPR-200-W-165	Unknown	No	Partial thickness vadose zone impacts
French Drains	216-S-4	4	No data	Full thickness vadose zone impacts based on pore volume >0.5; Uncertainty based on no groundwater data
Injection Wells	UPR-200-W-36	Unknown	Yes	Full thickness vadose zone impacts based on historical groundwater detections
Silos	200-W-75	0	No	Radioactive sources in three test calibration cylinder; no vadose impacts identified

a. DOE intends to redefine and update the WIDS summary sheets to be inclusive of all pipelines located within the waste site boundary and all pipeline segments outside of the boundary up to a distance of 7.6 m (25 ft).

b. One pore volume is the calculated soil pore volume between the structure bottom and groundwater based on an assumed porosity of 30 percent. Estimated Number of Pore Volumes (PV) is the number of times the volume of liquid discharged to the structure could fill one pore volume, and is determined as follows: PV = Liquid discharge volume / [structure bottom area * vadose zone thickness * 0.3].

c. Indicator parameters include cesium-137 and strontium-90 (see Table B-6).

UST = underground storage tank

WIDS = Waste Information Data System

1

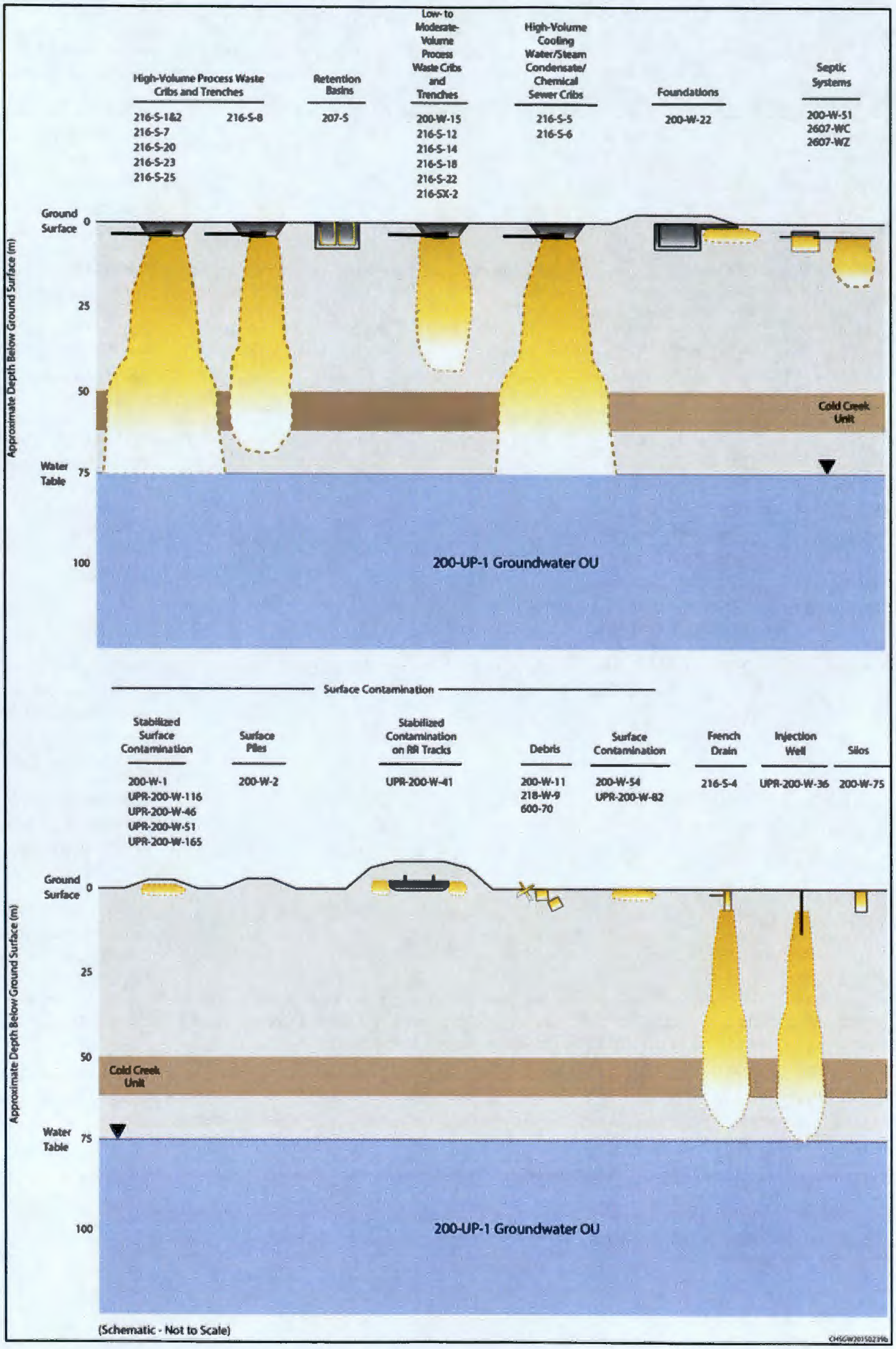


Figure 3-7. Schematic Representation of Contaminant Distribution at the 200-WA-1 OU Waste Sites near the S Plant

3.3.1.4 Waste Sites near the Z Plant

Waste site locations near the Z Plant, included in the 200-WA-1 OU, are shown in Figure 3-8. These sites fall into several general waste site categories, based on waste site configuration, primary waste source, and relative volume of waste received. Site groupings near the Z Plant waste sites are described in the following sections.

High-Volume Process Waste Cribs and Trenches

Three waste sites near the 231-Z Building (216-Z-7, 216-Z-16, and 216-Z-17) are identified as high-volume process waste sites. These sites are known or suspected to have affected groundwater during operation and could exhibit full thickness vadose zone contamination. These sites are included in the deep vadose zone depth grouping based on pore volume estimates (between 9.8 and 30 pore volumes).

- The 216-Z-7 Crib received neutralized evaporation and water vacuum jet discharges during the early plutonium production period at the Hanford Site. The waste discharged to this crib tended to be relatively high in nitrate, sodium, and plutonium, and contained some residual fission products. Later, the crib received liquid laboratory waste generated within the 231-Z Building. Radionuclides (cesium-137, strontium-90, and plutonium-239/240), nitrate, and volatile organic compounds (VOCs) have historically been detected in groundwater wells associated with the 216-Z-7 Crib (see Appendix D).

- The 216-Z-16 Crib entered service during metallurgical research operations at the 231-Z Building. Because the crib received liquid laboratory waste generated within the 231-Z Building, less residual nitrate and lower plutonium and fission product contamination in the vadose zone is expected compared to the 216-Z-7 Crib. Radionuclides (cesium-137, strontium-90, and tritium), nitrate, and VOCs have historically been detected in groundwater wells associated with the 216-Z-16 Crib (see Appendix D).

- The 216- Z-17 Trench and 216-Z-16 Crib are similar because both sites received liquid laboratory waste generated within the 231-Z Building. No groundwater monitoring wells are associated with the 216-Z-17 Trench.

Retention Basins

The 207-Z Retention Basin is an open-topped, in-ground concrete structure that provided temporary storage of steam condensate and cooling water generated in the 234-5Z Building. The retention basin was removed from service and ultimately filled with controlled density fill. This site is included in the intermediate vadose zone depth grouping because the retention basin received an estimated 0.04 pore volumes of liquid waste. The site could exhibit partial thickness vadose zone contamination if a release occurred. No groundwater monitoring wells are associated with the 207-Z Retention Basin.

Low- to Moderate-Volume Process Waste Cribs and Trenches

The 216-Z-4 and 216-Z-6 Cribs received the same waste stream (evaporation condensate and vacuum water jet effluent), with 216-Z-6 replacing 216-Z-4 after only a short time. These sites are included in the intermediate vadose zone depth grouping because the cribs received an estimated 0.04 to 0.12 pore volumes of liquid waste. Both of these sites are expected to exhibit partial thickness vadose zone contamination based on pore volume. No groundwater monitoring wells are associated with these waste sites.

Underground Storage Tanks/Receiving Vault

The Site 231-W-151 concrete receiving vault contains two tanks that were installed to receive drainage from floor drains in the 231-Z Building. This site is conservatively included in the intermediate vadose zone depth grouping based on unknown release volume and bottom depth (4 m [13 ft] bgs).

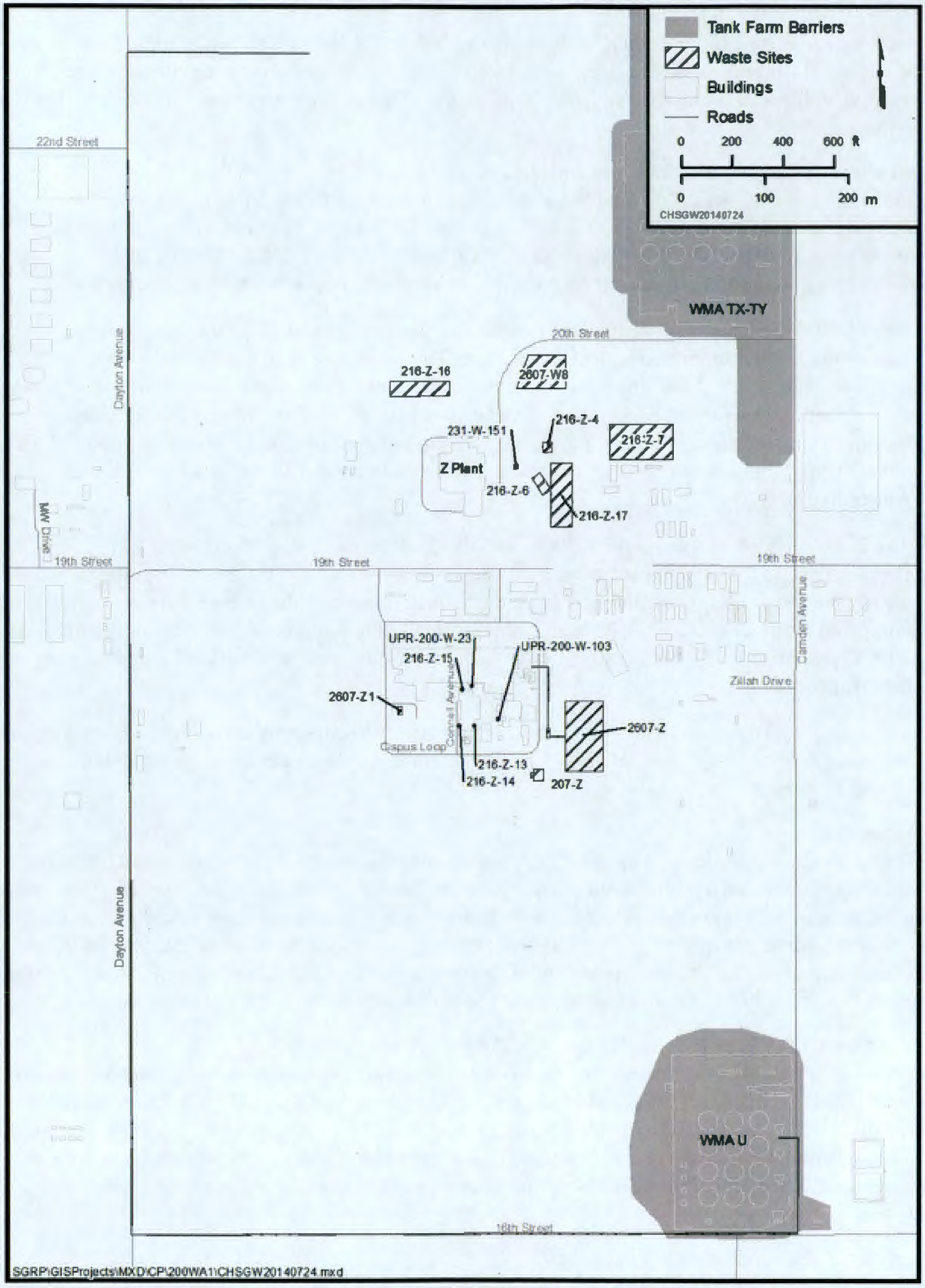


Figure 3-8. 200-WA-1 OU Waste Sites near the Z Plant

Septic Systems

The Waste Site 2607-W8 septic system accepted waste from the 231-Z Building. Waste Site 2607-Z accepted waste from the 234-5Z, 2704-Z, 2701-Z, 236-Z, 292-Z, 2701-Z, 2701-ZA, and 2701-ZB Buildings. Waste Site 2607-Z1 accepted waste from the 234-5Z Building Annex and the 232-Z and 2736-ZB Buildings. These sites are included in the intermediate vadose zone depth grouping based on length of use (over 40 years) and unknown release volume.

Pipe Leaks

UPR-200-W-103 is a historical pipeline leak from the pipeline running between the 236-Z Building and the 216-Z-18 Crib. This site is conservatively included in the intermediate vadose zone depth grouping based on unknown release volume. This site is expected to exhibit shallow, partial thickness vadose zone contamination.

The sites in each site type category near the Z Plant are summarized in Table 3-4. Figure 3-9 is a schematic drawing that illustrates the inferred configuration of contamination distribution near Z Plant.

Surface Contamination Site

UPR-200-W-23 is a historical release of contamination to the ground surface resulting from an equipment fire. This waste site is included in the shallow vadose zone depth grouping. The site was subsequently paved as an interim stabilization activity. This site primarily poses a potential for direct exposure at or near the ground surface to contamination from and is not expected to be a source of groundwater contamination.

French Drains

The 216-Z-13 and 216-Z-14 French drains received emergency condensate and steam condensate from exhaust fan turbines and floor drainage. The 216-Z-15 French drain received condensate drainage from the 291-Z Building S-12 Evaporator Cooler. Based on unknown release volume and no apparent historical groundwater impacts, these sites may exhibit partial thickness vadose zone contamination. No groundwater monitoring wells are associated with these waste sites.

Table 3-4. Summary of Waste Site Types near the Z Plant

Site Type	Associated Waste Sites[a]	Estimated Number of Pore Volumes[b]	Indicator Parameters Historically Detected in Groundwater?[c]	Conceptual Model of Potential Vadose Zone Contamination
High-Volume Process Waste Cribs	216-Z-7, 216-Z-16	29 to 30	Yes	Full thickness vadose zone impacts based on pore volume >0.5 and historical groundwater detections
	216-Z-17	9.8	No data	Full thickness vadose zone impacts based on pore volume >0.5; uncertainty based on no available groundwater data
Retention Basins	207-Z	0.04	No data	Partial thickness vadose zone impacts based on pore volume <0.5

Table 3-4. Summary of Waste Site Types near the Z Plant

Site Type	Associated Waste Sites[a]	Estimated Number of Pore Volumes[b]	Indicator Parameters Historically Detected in Groundwater?[c]	Conceptual Model of Potential Vadose Zone Contamination
Low- to Moderate-Volume Process Waste Cribs and Trenches	216-Z-4, 216-Z-6	0.06 to 0.12	No data	Partial thickness vadose zone impacts based on pore volume <0.5
USTs / Receiving Vault	231-W-151	Unknown	No	Partial thickness vadose zone impacts based on unknown pore volume, unknown potential for release, and bottom depth
Septic Systems	2607-W8, 2607-Z, 2607-Z1	Unknown	No	Partial thickness vadose zone impacts based on unknown release volume and length of use
Pipe Leaks	UPR-200-W-103	Unknown	No	Underground pipeline leak; partial thickness vadose zone impacts based on unknown release volume
Surface Contamination Site (stabilized surface contamination)	UPR-200-W-23	Unknown	No	Partial thickness vadose zone impacts
French Drains	216-Z-13, 216-Z-14, 216-Z-15	Unknown	No data	Partial thickness vadose zone impacts

a. DOE intends to redefine and update the WIDS summary sheets to be inclusive of all pipelines located within the waste site boundary and all pipeline segments outside of the boundary up to a distance of 7.6 m (25 ft).

b. One pore volume is the calculated soil pore volume between the structure bottom and groundwater based on an assumed porosity of 30 percent. Estimated Number of Pore Volumes (PV) is the number of times the volume of liquid discharged to the structure could fill one pore volume, and is determined as follows: PV = Liquid discharge volume / [structure bottom area * vadose zone thickness * 0.3].

c. Indicator parameters include cesium-137 and strontium-90 (see Table B-6).

UST = underground storage tank

WIDS = Waste Information Data System

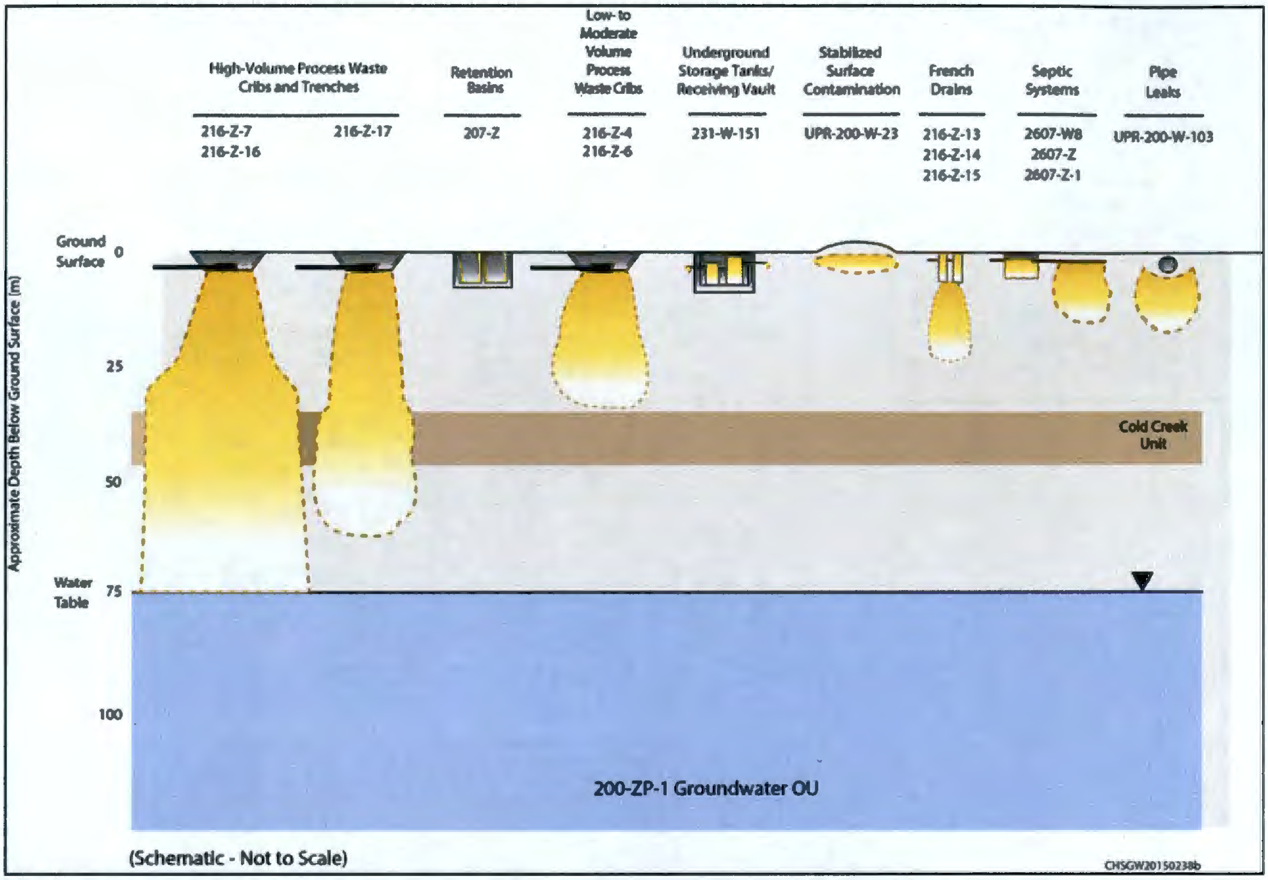


Figure 3-9. Schematic Representation of Contaminant Distribution at the 200-WA-1 OU Waste Sites near the Z Plant

3.3.1.5 Waste Sites near the T Plant

Figure 3-10 shows waste site locations near the T Plant that are included in the 200-WA-1 OU. These waste sites were grouped as follows.

High-Volume Process Waste Cribs

The 216-T-8, 216-T-12, 216-T-27, 216-T-28, 216-T-33, 216-T-34, and 216-T-35 waste sites are all high-volume process waste cribs, having received greater than an estimated 0.5 pore volume of waste effluent (between 0.6 and 18 pore volumes). These cribs received a variety of liquid wastes including tank waste supernatant from the T, TX, and TY Tank Farms; laboratory waste; and radioactive waste generated in the 300 Area and transferred to the cribs by tanker truck or rail tanker car. All of these cribs could exhibit full thickness vadose zone contamination based on pore volume estimates. Four of these cribs (216-T-28, 216-T-33, 216-T-34, and 216-T-35) are known to have affected groundwater during operation based on historical detections of cesium-137 and/or strontium-90. Other detections have included radionuclides (iodine-129, technetium-99, tritium, and uranium), metals (cyanide and chromium), nitrate, and VOCs (carbon tetrachloride and trichloroethene; see Appendix D). No groundwater data are available for Sites 216-T-8, 216-T-12, and 216-T-27.

Retention Basins

Site 207-T is the concrete retention basin for the historical discharge of steam condensate, cooling water, and the chemical sewer from the original bismuth phosphate separation and plutonium concentration processes in the 221-T and 224-T Buildings, respectively. The basin also received cooling water and steam condensate from tank farm evaporator operations. Waste streams passing through the basin were discharged to the 216-T-4-1D Ditch and allowed to infiltrate. The basin exhibits surface contamination and has been backfilled. This site is included in the intermediate vadose zone depth grouping. No historical groundwater contamination is apparent, but the site could exhibit partial thickness vadose zone contamination if a release occurred.

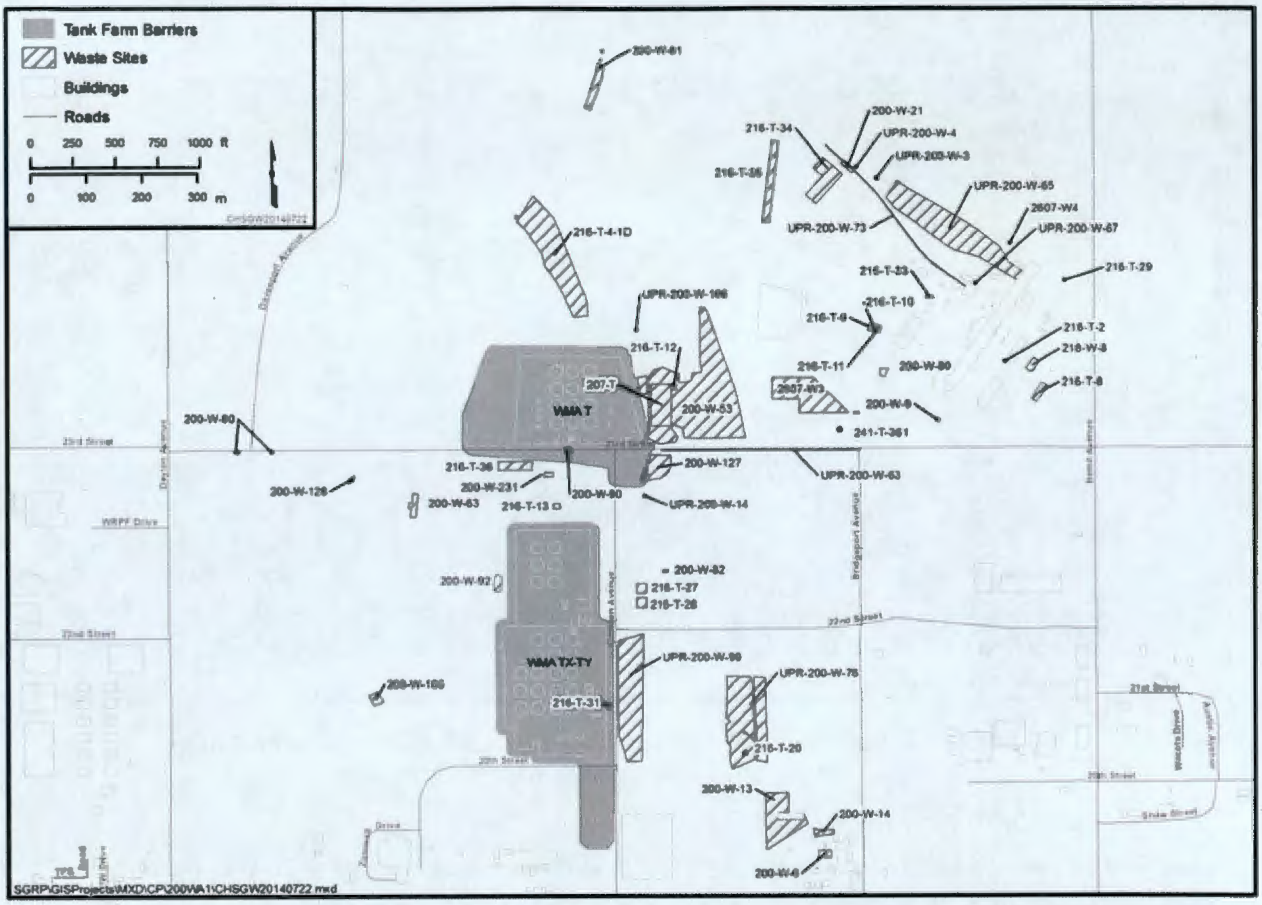


Figure 3-10. 200-WA-1 OU Waste Sites near the T Plant

Low- to Moderate-Volume Process Waste Cribs and Trenches

Sites 216-T-9, 216-T-10, 216-T-11, 216-T-13, 216-T-20, and 216-T-36 received primarily vehicle and equipment decontamination waste. These sites are included in the intermediate vadose zone depth grouping based on estimated pore volumes (up to 0.2). These waste sites may exhibit partial thickness vadose zone contamination based on pore volume estimates combined with no, or inclusive evidence of, groundwater contamination.

Burial Vaults

Site 218-W-8 consists of three subsurface containers configured to allow for deposits of miscellaneous radioactive wastes (e.g., packaged solids, small containers of liquids) generated in the 222-T Process Control Laboratory. This site is included in the intermediate vadose zone depth grouping because the site could exhibit partial thickness vadose zone contamination if a release occurred.

Underground Storage Tank

Site 241-T-361 is a concrete, in-ground settling tank that was used to separate solids from liquid wastes discharged to the tank from the bismuth phosphate separation process in the 221-T Building. The solids tended to be high in uranium and exhibited alkaline pH. This site is included in the intermediate vadose zone depth grouping because the site could exhibit partial thickness vadose zone contamination if a release occurred. No groundwater wells are associated with this site.

High-Volume Cooling Water/Steam Condensate/Chemical Sewer Ditch

Site 216-T-4-1D received a large volume of combined wastewater generated primarily from bismuth phosphate reprocessing at the 221-T Building; plutonium concentration at the 224-T Building; and waste management operations at T, TX, and TY Tank Farms. The site is included in the deep vadose zone depth grouping based on an estimated pore volume of 3.2 and historical detections of cesium-137. Other detections have included chromium, nitrate, and VOCs (see Appendix D). Discharges to this ditch resulted in the development of an extensive groundwater mound under the northern portion of the Inner Area during operation. This site is expected to exhibit full vadose zone contamination but at a low concentration.

Septic Systems

The septic tank system (Site 200-W-231) reportedly supported a temporary construction facility and an X-ray nondestructive examination laboratory. Its association with the film development laboratory suggests that nonsanitary wastes may have been received into the system. This site is included in the intermediate vadose zone depth grouping because the release volume is unknown, and the site could exhibit partial thickness vadose zone contamination if a release occurred.

Waste Site 2607-W3 consists of a septic tank and drain field that was expanded in the 1950s. Waste Site 2607-W4 consists of a single-compartment tank and drain field. These site are included in the intermediate vadose zone depth grouping based on length of use (over 40 years) and unknown release volume.

Surface Contamination Sites

Numerous waste sites near the T Plant exhibit surface or near-surface residual vadose zone contamination. These sites, listed in Table 3-5, resulted from various conditions ranging from surface debris to windblown contamination at or near the ground surface. Surface contamination sites pose primarily a potential for direct exposure at or near the ground surface to contamination from the following sources and are not expected to be sources of groundwater contamination:

- Stabilized surface contamination
- Stabilized contamination on railroad tracks
- Debris

Table 3-5. Summary of Waste Site Types near the T Plant

Site Type	Associated Waste Sites[a]	Estimated Number of Pore Volumes[b]	Indicator Parameters Historically Detected in Groundwater?[c]	Conceptual Model of Potential Vadose Zone Contamination
High-Volume Process Waste Cribs	216-T-28, 216-T-33, 216-T-34, 216-T-35	0.6 to 26	Yes	Full thickness vadose zone impacts based on pore volume >0.5 and historical groundwater detections
	216-T-8, 216-T-12, 216-T-27	0.5 to 18	No data	Full thickness vadose zone impacts based on pore volume >0.5; uncertainty based on no available groundwater data

Table 3-5. Summary of Waste Site Types near the T Plant

Site Type	Associated Waste Sites[a]	Estimated Number of Pore Volumes[b]	Indicator Parameters Historically Detected in Groundwater?[c]	Conceptual Model of Potential Vadose Zone Contamination
Retention Basin	207-T	Unknown	No	Partial thickness vadose zone impacts based on unknown pore volume and unknown potential for release
Low- to Moderate-Volume Process Waste Cribs and Trenches	216-T-9, 216-T-10, 216-T-11 216-T-13, 216-T-20, 216-T-36	Unknown 0.1 to 0.2	No data No	Partial thickness vadose zone impacts based on pore volume <0.5 and no detections of indicator parameters in groundwater
USTs	241-T-361	Unknown	No	Partial thickness vadose zone impacts based on unknown pore volume and unknown potential for release
Burial Vaults	218-W-8	Unknown	No	These vaults represent substantial solid-phase source terms; no vadose impacts identified
High-Volume Cooling Water/ Steam Condensate/ Chemical Sewer Ditch	216-T-4-1D	3	Yes	Full thickness vadose zone impacts expected at low concentration based on pore volume >0.5 and historical groundwater detections
Septic Systems	200-W-231, 2607-W3, 2607-W4	Unknown	No	Partial thickness vadose zone impacts based on unknown history or volume and length of use
Surface Contamination Sites (stabilized surface contamination, surface contamination, stabilized contamination on railroad tracks, and debris)	200-W-106, 200-W-127, 200-W-128, 200-W-53, 200-W-80, 200-W-81, 200-W-90, UPR-200-W-63, 200-W-13, 200-W-14, UPR-200-W-166, UPR-200-W-65, UPR-200-W-67, UPR-200-W-99, 216-T-31, UPR-200-W-3, UPR-200-W-4, UPR-200-W-73, 200-W-92, UPR-200-W-76	Unknown	No	Partial thickness vadose zone impacts

Table 3-5. Summary of Waste Site Types near the T Plant

Site Type	Associated Waste Sites[a]	Estimated Number of Pore Volumes[b]	Indicator Parameters Historically Detected in Groundwater?[c]	Conceptual Model of Potential Vadose Zone Contamination
Foundations	200-W-6, 200-W-21, 200-W-63, 200-W-82	Unknown	No	Contamination expected to be contained to structures. Partial thickness vadose zone impacts
French Drains	216-T-29	0.3	No	Partial thickness vadose zone impacts based on pore volume <0.5 and no detections of indicator parameters in groundwater
	216-T-31	Unknown	No data	Partial thickness vadose zone impacts based on uncertain release volume and history
Injection Wells	216-T-2	175	No data	Full thickness vadose zone impacts based on pore volume >0.5; uncertainty based on no available groundwater data
Pipe Leaks	200-W-9, UPR-200-W-14	Unknown	No	Partial thickness vadose zone impacts

a. DOE intends to redefine and update the WIDS summary sheets to be inclusive of all pipelines located within the waste site boundary and all pipeline segments outside of the boundary up to a distance of 7.6 m (25 ft).

b. One pore volume is the calculated soil pore volume between the structure bottom and groundwater based on an assumed porosity of 30 percent. Estimated Number of Pore Volumes (PV) is the number of times the volume of liquid discharged to the structure could fill one pore volume, and is determined as follows: PV = Liquid discharge volume / [structure bottom area * vadose zone thickness * 0.3].

c. Indicator parameters include cesium-137 and strontium-90 (see Table B-6).

UST = underground storage tank

WIDS = Waste Information Data System

Foundations

Sites 200-W-21, 200-W-63, and 200-W-82 are all radiologically contaminated concrete foundation slabs. Site 200-W-6 is solvent-contaminated soil found beneath section of flooring removed during building modification work in 1993.

French Drains

The 216-T-29 French drain received condensate from the 221-T Building ventilation stack sand filter. This drain received 75,700 L (20,000 gal) of steam condensate and is included in the intermediate vadose zone depth grouping. Based on the estimated pore volume (0.3) and no apparent historical groundwater impacts, this site may exhibit partial thickness vadose zone contamination.

The 216-T-31 French drain was accidentally contaminated by radioactive steam condensate during attempts to unclog a blocked waste line in October 1959. The contaminated culvert, gravel, and soil associated with this site were removed. However, the site is included in the intermediate vadose zone depth grouping because the total volume of contamination released to the drain and site history are uncertain. This site may exhibit partial thickness vadose zone contamination.

Injection Wells

The 216-T-2 Injection Well received over 22.7 million L (6 million gal) of radioactive waste containing fission products and plutonium generated in the 222-T Laboratory and is included in the intermediate vadose zone depth grouping. Based on the estimated pore volumes (175), this site may exhibit full thickness vadose zone contamination. No historical groundwater data are available.

Pipe Leaks

Sites 200-W-9 and UPR-200-W-14 resulted from pipe leaks and are expected to exhibit partial thickness vadose zone contamination.

Table 3-5 summarizes the sites in each site type category near the T Plant. Figure 3-11 is a schematic drawing that illustrates the inferred distribution of contaminants in the vadose zone near the T Plant.

3.3.2 Groundwater Contributions

In addition to evaluating the nature and volume of discharges to the individual waste sites, the apparent historical effects on groundwater were reviewed for this initial evaluation. To support this effort, historical groundwater monitoring results for selected waste constituents were assessed based on process knowledge of waste disposal practices. Some waste constituents (e.g., nitrate and tritium) are highly mobile in the vadose zone and groundwater. The presence of these constituents in groundwater near a particular waste site (with associated concentration increases) can indicate that wastewater has migrated through the vadose zone beneath the waste site and entered groundwater.

Based on past sampling efforts, large nitrate and tritium groundwater plumes are present beneath the Central Plateau, and it can be difficult to determine whether detections of nitrate or tritium originated from a particular waste site. One method used to make this determination was a comparison of the contaminant concentrations observed in upgradient and downgradient wells. When historical HEIS groundwater data for the downgradient well(s) show an increasing or elevated stable concentration relative to the upgradient well, it indicates the waste site is a likely source.

Due to natural subsurface processes, the farther the well is from the source, the more gradual the increase in COPC concentration. This is primarily due to the processes of advection/dispersion as well as other contributing factors (e.g., cation/anion exchange, oxidation/reduction, and precipitation). Other common waste constituents (e.g., cesium-137 and strontium-90) exhibit relatively lower mobility than nitrate and tritium. Groundwater monitoring results for cesium-137 and strontium-90 were evaluated during waste site operations, and the detection of these radionuclides in groundwater was historically used to indicate that a waste site had reached its specific capacity. Therefore, a substantial body of historical groundwater monitoring data exists for these radionuclides. In general, cesium, cobalt, and strontium are not very mobile in alkaline soils. However, when dissolved in acidic solutions and in large volumes, they can migrate through the vadose zone to the underlying groundwater.

For this planning effort, historical groundwater monitoring results for cesium-137 and strontium-90 concentration trends in wells near the 200-WA-1 OU waste sites were evaluated against the historical discharges to the waste sites. These two radionuclides were used as indicators of historical groundwater contamination related to waste sites. These indicator constituents are not highly mobile in the aquifer and, therefore, are not expected to be detected at a substantial distance from their release points. Plate C-2 (Appendix C) is a map of 200-WA-1 and 200-BC-1 OU waste sites where cesium-137 has been detected. Plate C-3 (Appendix C) is a map of 200-WA-1 and 200-BC-1 OU waste sites where strontium-90 has been detected. The 200-WA-1 OU waste sites with cesium-137 or strontium-90 detections are scattered throughout the geographical region, and the majority of identified sites have both contaminants in common. The affected 200-BC-1 waste sites are on the eastern side of the OU.

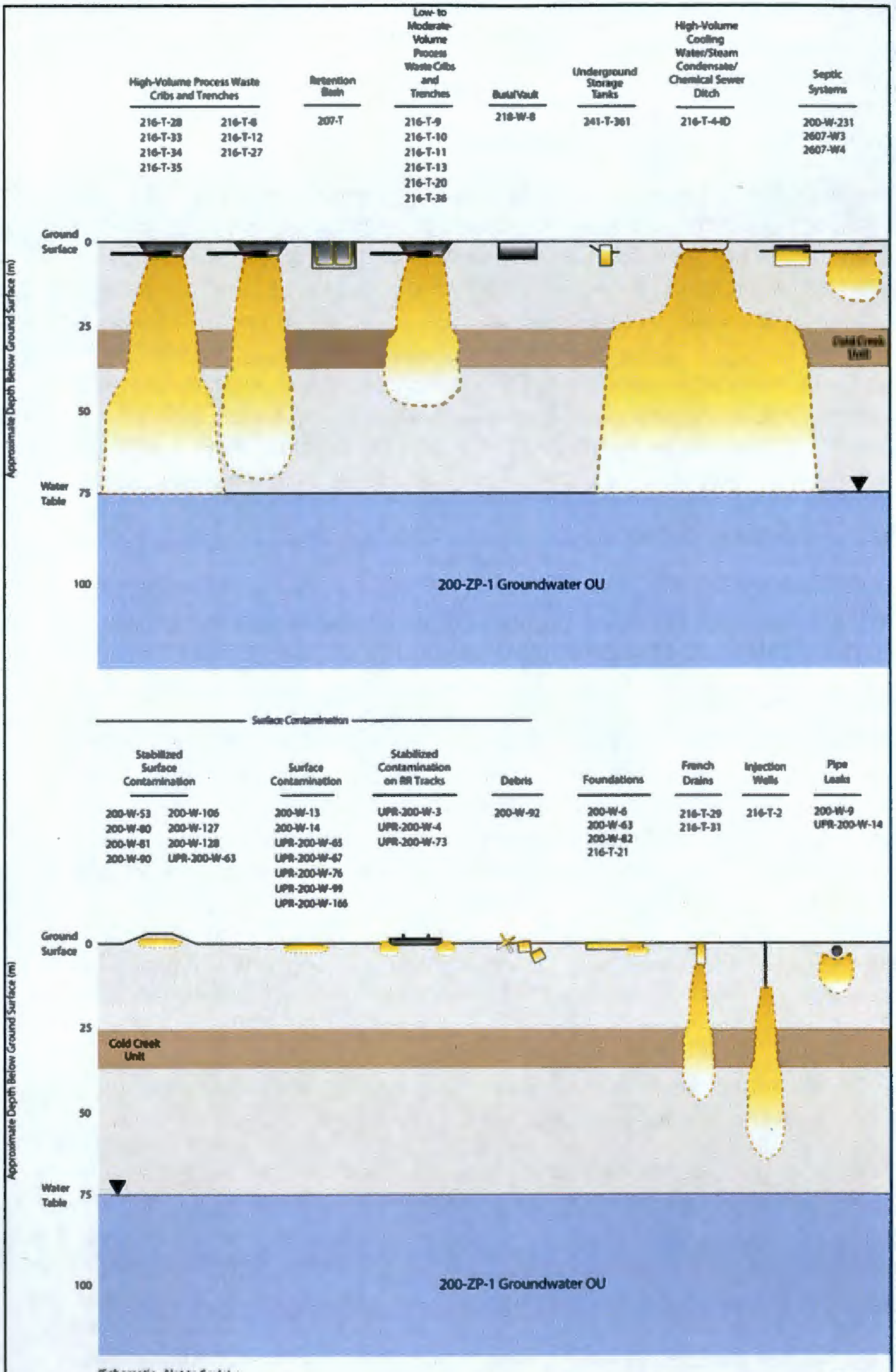


Figure 3-11. Schematic Representation of Contaminant Distribution at the 200-WA-1 OU Waste Sites near the T Plant

Nineteen waste sites in the 200-WA-1 OU exhibited historical groundwater contamination by cesium-137 and strontium-90, consistent with discharges to the waste sites. Nine waste sites in the 200-BC-1 OU exhibited groundwater contamination that may be attributed to the waste sites.

Table B-6 in Appendix B is a summary of waste sites with historical indicators of groundwater radionuclide contamination (based on groundwater monitoring data in HEIS).

3.4 Identification of Target Analyte List

Previous sections describe contaminant waste streams, contaminant sources, and constituents of interest that may be mobile in the environment, and provide an overview of waste site contamination conditions. Tables B-1 through B-4 (Appendix B) identify waste stream source, composition, and receiving waste sites. These tables present generalized contaminant descriptions based on process knowledge of the various operations that occurred in the five geographical plant groupings. These lists, along with the available analytical data for the 200-WA-1 and 200-BC-1 OU waste sites, will be used to develop target analyte lists for each of the five geographical areas for additional site characterization activities that are identified through the data needs assessment (see Chapter 4). Analytical data are available for a subset of the 200-WA-1 and 200-BC-1 OU waste sites (see Appendix D). If an analyte is detected in soil at any of the waste sites within a geographical area, it will be considered for inclusion on that area's target analyte list.

3.5 Land and Groundwater Uses

The 200-WA-1 and 200-BC-1 OUs are located on the Hanford Central Plateau within the Inner Area. Land and groundwater uses are considered for exposure assessment assumptions and risk characterization conclusions (see Section 5.6, Assessment of Risk).

3.5.1 Current Land Use

The current land use activities in the Inner Area are industrial in nature. Several waste management facilities continue to operate in the Central Plateau, including permanent waste disposal facilities such as the Environmental Restoration Disposal Facility (ERDF), low-level radioactive waste burial grounds, and mixed waste trenches permitted by RCRA. Construction of tank waste treatment facilities in the Central Plateau began in 2002. The Integrated Disposal Facility in the Inner Area is the planned disposal location for the vitrified low-activity tank wastes. The U.S. Department of the Navy uses the TSD units on the Central Plateau. In addition, US Ecology, Inc. operates a commercial low-level radioactive waste disposal facility on a 40 ha (100 ac) tract of land. This tract of land is leased to Washington State and is located in the Inner Area.

3.5.2 Reasonably Anticipated Future Land Use

The reasonably anticipated future land use for the portion of the Inner Area where the 200-WA-1 and 200-BC-1 OU waste sites are located is designated as industrial.

DOE worked for several years with cooperating agencies to define land use goals for the Hanford Site. The cooperating agencies and stakeholders included the National Park Service, Tribal Nations, the States of Washington and Oregon, local/county and city governments, economic and business development interests, environmental groups, and agricultural interests. A 1992 report (Drummond, 1992, *The Future for Hanford: Uses and Cleanup, The Final Report of the Hanford Future Site Uses Working Group*) was an early product of the efforts to develop land use assumptions. The report recognized that the Central Plateau would be used for waste management activities for the foreseeable future. Following the report, DOE issued DOE/EIS-0222F, *Final Hanford Comprehensive Land Use Plan Environmental Impact Statement* (HCP EIS), associated ROD (64 FR 61615, "Record of Decision: Hanford Comprehensive

Land Use Plan Environmental Impact Statement (HCP EIS)") in 1999, and a supplemental analysis (DOE/EIS-0222-SA-01, *Supplement Analysis: Hanford Comprehensive Land-Use Plan Environmental Impact Statement*) in 2008.

The HCP EIS (DOE/EIS-0222F) analyzed the potential environmental impacts of alternative land use plans for the Hanford Site and considered the land use implication of ongoing and proposed activities. Under the preferred land use alternative selected in the HCP EIS ROD (64 FR 61615), the Central Plateau was designated for Industrial-Exclusive use, defined as areas "suitable and desirable for management of hazardous, dangerous, radioactive, nonradioactive wastes, and related activities." The 2008 supplemental analysis reconfirmed the land use designations in the HCP EIS (DOE/EIS-0222F) and clarified that the comprehensive land use plan will remain in effect as long as DOE retains legal control of some portion of the Hanford Site, which is expected to be longer than 50 years.

The area designated as the Central Plateau in the Drummond (1992) report and the HCP EIS (DOE/EIS-0222F) is only a portion of the area now commonly known as the Central Plateau. The current 195 km^2 (75 mi^2) area Central Plateau also encompasses a portion of the land known in the previous documents as "all other areas," with a designated land use of conservation (mining). The Inner Area portion of the Central Plateau (described in Section 1.3) is contained within the area designated for Industrial/Industrial-Exclusive land use. At approximately 25 km^2 (10 mi^2), the Inner Area covers about half of the Industrial-Exclusive area and is defined by DOE as the final footprint area of the Hanford Site that will be dedicated to permanent waste management and containment of residual contamination.

3.5.3 Regional Land Use

Communities in the region of the Hanford Site consist of the incorporated cities of Richland, West Richland, Kennewick, and Pasco, and numerous other smaller communities within Benton and Franklin Counties. No residences are located on the Hanford Site. The inhabited residences nearest to the Inner Area 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).

3.5.4 Groundwater Use

The groundwater underlying the Central Plateau is contaminated and is not currently being withdrawn for beneficial uses. Groundwater wells are routinely used on the Central Plateau to measure or monitor groundwater contaminants and groundwater conditions, and to support groundwater P&T systems. Several wells are also available to supply emergency cooling water to facilities, if needed. Groundwater beneath the Central Plateau is not anticipated to become a future source of drinking water until cleanup criteria are met. DOE's goal is to restore Central Plateau groundwater to beneficial use, unless restoration is determined to be technically impracticable.

3.6 Potential Applicable or Relevant and Appropriate Requirements

A preliminary identification of potential ARARs and TBC information in the scoping phase can assist in initially identifying remedial alternatives and is useful for initiating communications with the support agency to facilitate the identification of ARARs. Furthermore, early identification of potential ARARs will allow better planning of field activities. Because of the iterative nature of the RI/FS process, ARAR identification continues throughout the RI/FS as a better understanding is gained of site conditions and remedial action alternatives.

ARARs may be categorized as follows:

- Chemical-specific requirements that may define acceptable exposure levels and, therefore, be used in establishing PRGs

- Location-specific requirements that may set restrictions on activities within specific locations such as floodplains or wetlands
- Action-specific requirements that may set controls or restrictions for particular treatment and disposal activities related to the management of hazardous wastes

EPA/540/G-89/006, *CERCLA Compliance with Other Laws Manual Interim Final*, contains detailed information on identifying and complying with ARARs. Appendix F provides a table of potential ARARs and TBC material for the 200-WA-1 and 200-BC-1 OUs.

3.7 Conceptual Exposure Models for Fate and Transport Evaluation

This section presents a qualitative understanding of contaminant fate and transport and risk to receptors for 200-WA-1 and 200-BC-1 OU waste sites and includes a discussion of exposure areas.

3.7.1 Exposure Pathways and Routes

The exposure pathways, exposure routes, exposure assumptions, and toxicity values that will be used for the human health exposure scenarios are described in Section 3.9.1. Human health risks will be assessed using an outdoor worker exposure scenario for the standard POC (0 to 4.6 m [15 ft] bgs). For radiological contamination below 4.6 m (15 ft) bgs, direct contact risks for human health will be evaluated using a construction worker exposure scenario.

Ecological risks will be assessed for terrestrial receptors on the Central Plateau as described in Section 3.9.2. The ecological receptors, exposure pathways, exposure parameters, and toxicity reference values that will be used to conduct the assessment are also described in Section 3.9.2.

A conditional POC may be proposed for soil depth to evaluate direct contact for human and ecological receptors. This conditional POC would represent the biologically active zone and would be evaluated as an alternative in the FS.

The methods and parameters outlined in Sections 3.9.1 and 3.9.2 support the Central Plateau Inner Area Cleanup Principles and are based on guidance from EPA and the regulations promulgated by Ecology. They also are consistent with BRAs previously conducted at the Hanford Site that have been reviewed and approved by EPA and Ecology.

3.7.2 Contaminant Fate and Transport

The groundwater protection modeling approach will be based on the process defined in DOE/RL-2011-50. The modeling approach is detailed in Section 3.9.3.

3.8 Conceptual Site Model Development

The CSM is a schematic diagram based on historical data that provides the following information:

- Identifies the primary source of contamination in the environment
- Shows how chemicals at the original point of release might move in the environment
- Identifies the different types of human populations or ecological receptors that might come into contact with contaminated media
- Lists the potential exposure pathways that may occur for each population

The CSM is used to plan the risk assessment and evaluation of impact to groundwater and the associated data collection activities. It will be revised as data become available at a site and as the BRA evolves.

The format for CSMs in the 200-WA-1 and 200-BC-1 OU RI/FS report is two 11-by-17-in. sheets presenting an information summary on one side of the page and the CSM on the reverse side. Figures 3-12 and 3-13 provide example CSMs for Waste Sites 216-S-6 and 216-U-7, respectively.

The waste site-specific information to be included in the information summary is as follows:

- **History.** This section provides site-specific information behind the process waste stream, the type of waste, and waste site use. Other site associations and consolidations are described. Interim actions are summarized to indicate timeframe, basis for action, and action taken/completed. Post-action results including remaining impacts and current waste site configuration are defined. Site posting information is also described, if applicable.
- **Description of Construction.** If the waste site is an engineered structure, dimensions and types of materials used to construct the site are discussed. For nonengineered structures, land surface features (e.g., natural depression and natural pit) are described.
- **Waste Quantity.** The total quantity of waste managed or stored within the waste site over the life of the site is summarized.
- **Duration.** The number of years of operation or the occurrence report date (for UPRs) is reported in this section. If a waste site had a significant nonoperating period and was then reactivated, this information is indicated.
- **Contaminant Inventories.** Radioactive contaminants followed by nonradioactive contaminants are described. Contaminant volumes and mobility are presented.
- **Knowledge Basis.** Four check boxes representing history/process knowledge, geophysics, geologic logs, and analytical data are available for selection to represent the sources of information used to support the development of the Information Summary.
- **Characterization.** Summary of investigation and actions are included in this section. Example information may include site walk survey results, surface and/or downhole geophysics, soil vapor surveys, geologic log results, and high-level sampling and analysis.
- **Uncertainty.** Waste site uncertainties are identified in this section.
- **Nature and Extent.** The current nature and extent of contamination is identified based on existing information. If cleanup activities have been performed at the site, only post-cleanup characterization results are included. Where limited characterization information for potential migration to groundwater is available for the waste site, vadose zone pore volume will be estimated, based on discharge volumes. For sites where additional characterization is proposed, the CSM will be updated after the new data are collected.
- **Summary Statements.** This section identifies whether the available information suggests that the site poses a threat to HHE through a direct exposure pathway or is a potential threat to groundwater.
- **Aerial View Figure.** This image shows the waste site in relation to waste sites and sampling locations within the immediate vicinity and may be represented by a map or photograph.
- **Cross Section Figure.** This image depicts the cross section of the site, groundwater level, and geological formation in relation to the sampling depths and waste site location.

This page intentionally left blank.

Figure 3-12. Example CSM for the 216-S-6 Crib (sheet 1 of 2)

Crib

216-S-6 Conceptual Site Model

200-SC-1

HISTORY

The 216-S-6 Crib is located southwest of the 202-S Building and northwest of the 216-S-5 Crib. 216-S-5 and S-6 Cribs were constructed in 1954 to replace 216-S-17 Pond. The crib received contaminated cooling water condensate from the 202-S Building until June 1967, when the 202-S Building was put on standby. In September 1955, the crib was intentionally breached to allow overflow to the ground surface south of the crib in the general vicinity of 216-S-17 Pond. From July 1967 to July 1972, the crib received condensate from waste concentrators in the 202-S Building. The waste was low-salt, neutral to basic, and contained nitrates and varying concentrations of mixed fission products. The crib was surface stabilized in September 1990 and designation changed to Underground Radioactive Material (URM) Area.

Construction

The crib has bottom dimensions of 64 m (210 ft) by 64 m (210 ft), and is 4.5 m (15 ft) deep with a side slope of 1.5:1. It contains approximately 42,400 cubic m of gravel fill and 12,000 cubic m of backfill soil. A perforated corrugated metal pipe runs down the center of the crib, and six 0.3 m (12 in) pipes branch off perpendicular to the main pipe to distribute liquid waste 2 m (7 ft) below grade. Each pipe is 33 m (100 ft) long with a riser at each end located 0.6 m (2 ft) below the surface. The surface is sand and gravel with minimal vegetation.

Waste Quantity 4.47 E+9 Liters

Duration November 1954 through July 1972

Contaminant Inventories

Constituent	Amount	Mobility
Nitrate	250000kg	High
Nitrite	220000kg	High
Tritium	3.5Ci	High
Strontium-90 + D	5.8Ci	Low
Yttrium-90	5.8Ci	No Kd
Cesium-137 + Daughters	11.3Ci	Low
Barium-137m	10.7Ci	No Kd
Samarium-151	0.6Ci	Low
Uranium-234	0.3Ci	Low
Uranium-238 + D	0.3Ci	Low
Plutonium-239	0.2Ci	Low
Plutonium-241 + D	0.3Ci	Low

KNOWLEDGE BASIS

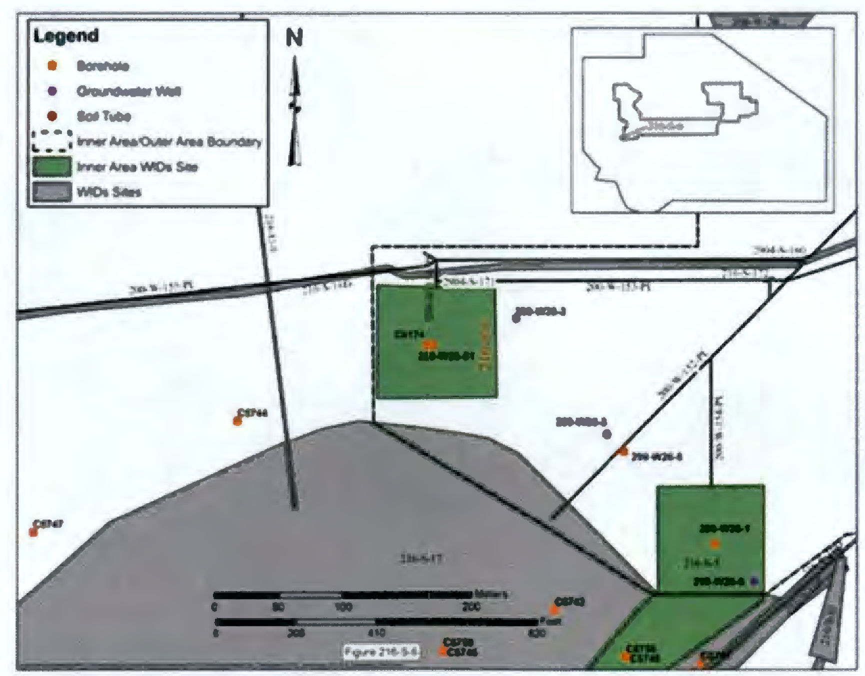
☑ History/Process Knowledge ☑ Geophysics ☑ Geologic Logs ☑ Analytical Data

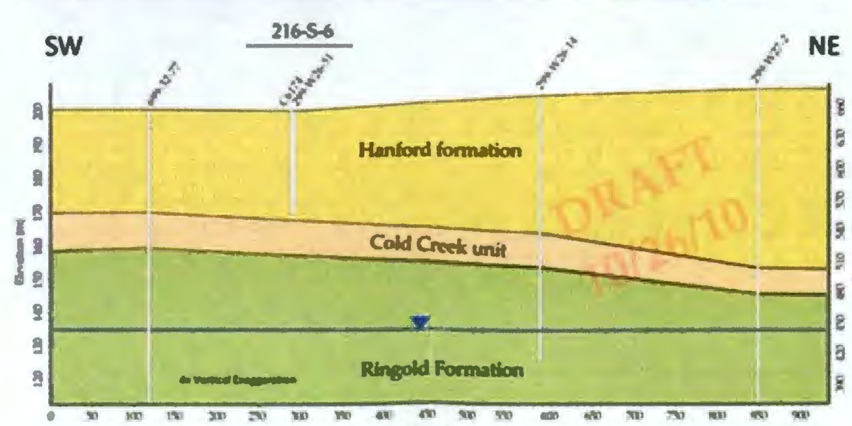
CHARACTERIZATION

The crib is characterized by the following activities:
1. Drilled vadose well 299-26-51 (A8061) to 30 m (100 ft) bgs in 1983 near the center of the crib and conducted gamma logging.
2. Drilled boring C6174 in the center of the crib in 2006 to a depth of 30 m (100ft). Soil samples were collected and analyzed and spectral gamma logging was conducted.
3. Groundwater monitoring of the site was conducted at well 299-W26-2 and well 299-W26-3.
4. Spectral gamma logging of well 299-26-2 was conducted in 1977.

UNCERTAINTY

The actual discharges to the Crib were variable and not well defined at the time of discharge. The potential for groundwater impacts from neighboring waste sites (e.g., 216-S-5 and 215-S-17) may complicate interpretation of impacts from this Crib. Potential co-mingling of contamination from this waste site with previous contamination from 216-S-17 complicates evaluation of near surface contamination. Records reviewed indicated that no flow was observed from the opened side of the Crib, however, aerial photos from 1954 suggested ponded water in the vicinity south of 216-S-6.





NATURE AND EXTENT

Contaminant inventories are based on the process description for 216-S-6 and are estimated values from the Soil Inventory Model (SIM), decayed through 2001. The model results indicate a moderate contaminant inventory at Site 216-S-6.

Radiological contaminants were detected in Borehole A8061 from 3 m (10 ft) bgs to 24 m (80 ft) bgs in 1983. Spectral logging in 2006 detected cesium-137 from 2 m to 19 m (7 to 62 ft) bgs and intermittently from 19.5 m to 27 m (64 to 89 ft). The maximum concentration of cesium-137 was approximately 3,800 pCi/g at 14 m (45 ft) bgs.

Analysis of soil samples collected from borehole C6174 during drilling revealed the following contaminant concentrations in the vadose zone underlying the crib:
-- Chromium from 1.2 to 30 m (4-99 ft) bgs / max of 29 mg/g @ 5 m
-- Nickel from 1.2 to 30 m (4-99 ft) bgs / max of 21.7 mg/g @ 5 m
-- Barium from 1.2 to 30 m (4-99 ft) bgs / max of 141 mg/g @ 7.3 m
-- Cs-137 from 1.2 to 21 m (4-69 ft) bgs/max of 13,800 pCi/g @ 5 m
-- Pu-238 from 2.4 to 5 m (8-16 ft) bgs/max of 2.0 pCi/g @ 5 m
-- Pu-239/240 from 2.4 to 26 m (8-85 ft) bgs/max of 1000 pCi/g @ 5 m
-- U-233/234 from 1.2 to 30 m (4-99 ft) bgs/max of <5 pCi/g @ 7.3 m
-- U-235 from 1.2 to 30 m (4-99 ft) bgs/max of 1.4 pCi/g @ 7.3 m
-- U-238 from 1.2 to 30 m (4-99 ft) bgs/max of 2.6 pCi/g @ 9.3 m
-- Am-241 from 2.4 to 30 m (8-99 ft) bgs/max of 273 pCi/g @ 5 m
-- Np-237 from 2.4 to 21 m (8-69 ft) bgs/max of 0.58 pCi/g @ 7.3 m
-- Ni-63 from 5 to 7.3 m (16-24 ft) bgs/max of 46 pCi/g @ 7.3 m
-- Radio-Sr from 5 to 21 m (21-69 ft) bgs/max of 6,600 pCi/g @ 7.3 m

The deepest detections of contaminants exceeding background were uranium-235 and uranium-238 at a depth of 26 m (85 ft) bgs beneath the Crib.

Spectral gamma logging of borehole C6174 detected cesium-137 from 0.3 m (1 ft) to 30 m (99 ft) bgs with a maximum of 13,000 pCi/g at 5 m (15 ft) bgs. Neutron moisture data indicated variable residual moisture over the inspected profile. Passive neutron data indicate no evidence of neutron activity.

The 1977 scintillation probe profile for well 299-W26-2 found only background radiation levels outside the crib, indicating minimal horizontal spreading in the vadose zone.

Groundwater monitoring at well 299-W26-2 indicated elevated Sr-90 (960 pCi/L) in 1960. Monitoring well 299-W26-3 exhibited in a tritium concentration of 400,000 pCi/L in 1974 as well as Sr-90 at 960 pCi/L. Cs-137 and Co-60 were also detected at well 299-W26-3.

The following contamination conditions are indicated at 216-S-6 Crib:

-- Vadose zone contamination by variable levels of residual Cs-137 and other contaminants between 0.3 and 30 m (1 to 99 ft) bgs.

-- Although the point of release of the crib was well below ground surface, spectral gamma logging has detected contamination near the ground surface.

-- Historical groundwater monitoring has detected elevated concentrations of radionuclides in groundwater immediately down gradient of the crib. This indicates the likelihood that the site historically exhibited full-thickness vadose zone contamination. Historical discharges to nearby sites (e.g., 216-S-17 Pond and 216-S-5 Crib) may also have contributed to observed contamination.

CHPUBS_CP_0001

Figure 3-12. Example CSM for the 216-S-6 Crib (sheet 2 of 2)

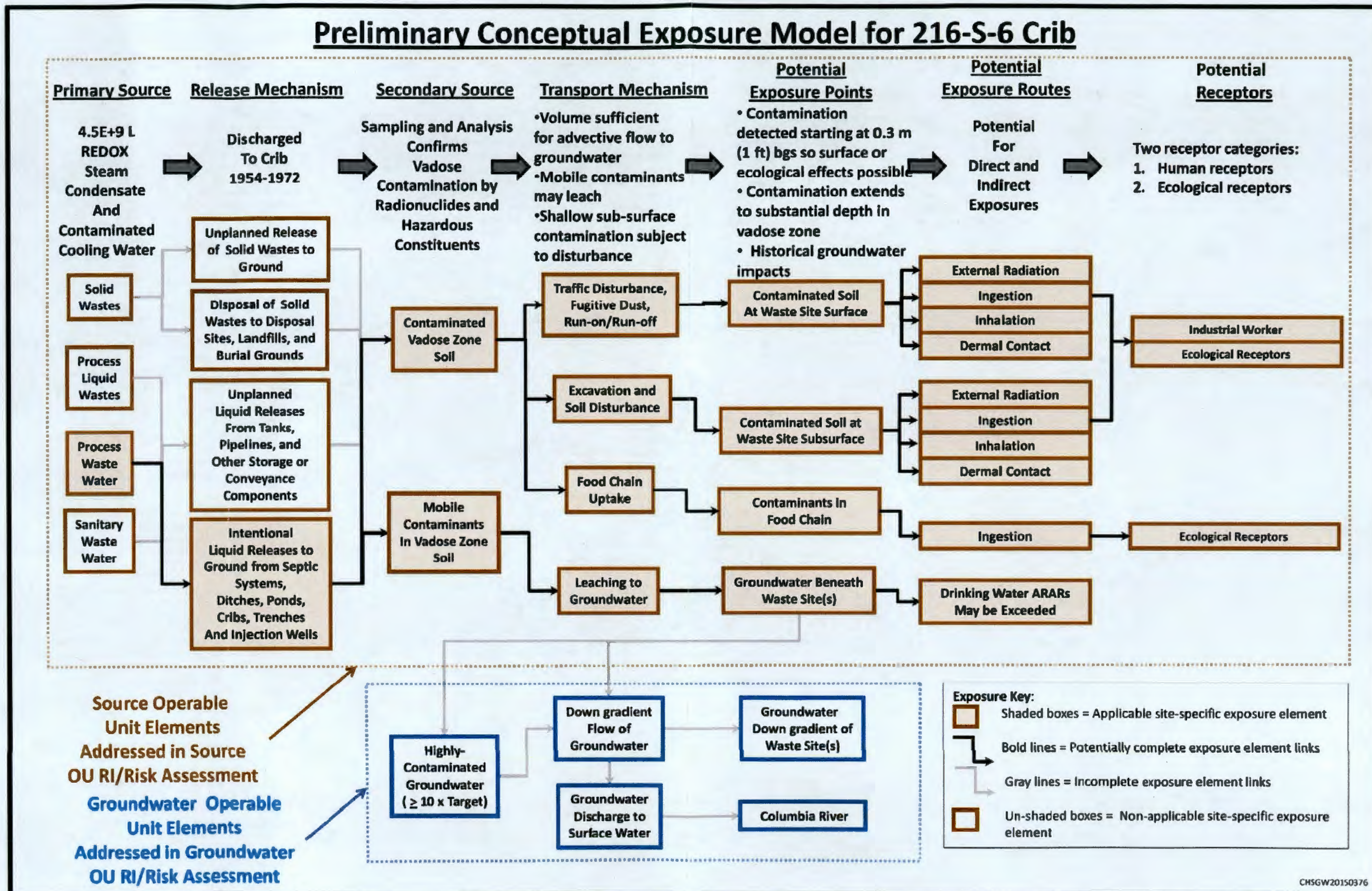


Figure 3-13. Example CSM for the 216-U-7 French Drain (sheet 1 of 2)

French Drain

216-U-7 Conceptual Site Model

200-MG-2

HISTORY

The 216-U-7 French Drain is located on the southeast side of the 221-U Building near Section 6, northwest of the 241-UX-154 Diversion Box. It received episodic release of acidic process condensate from a counting box floor drain during the metal recovery program at the 221-U Building. The volume discharged was not measured and is not specified. The site was retired in June 1957 after the uranium recovery operations in the 221-U Building were shut down. In 1998, the surface contamination areas on the East side of the 221-U building (where this site is located) were surface stabilized with material from the 200 Area Ash Pit and clean gravel. The French Drain is now within a larger area that has been stabilized and posted with Underground Radioactive Material (URM) signs.

Construction

The French Drain is constructed of a 76 cm (30 in) diameter concrete pipe set vertically to a depth of 5.2 m (17 ft) bgs. Gravel fills 1.1 m (3.5 ft) of the pipe. The site has been covered with clean backfill material and 2.5 cm to 7.5 cm (1 in to 3 in) of 2.5 cm (1 in) minus gravel. Detailed drawings indicate that the French Drain is connected to the 221-U counting box. The pipe from the floor drain enters the French drain at a depth of 4 m (13 ft) bgs.

216-U-7 is located close to the southeast side of 221-U Building and is expected to fall within the footprint of the planned engineered barrier to be constructed over 221-U Building.

Waste Quantity Unspecified; assume <10,000 Liters

Duration March 1952 to June 1957

Contaminant Inventories

Constituent	Amount	Mobility
Nitrate	2kg	High
Sulfate	0.5kg	No Kd
Fluoride	0.004kg	No Kd
Chloride	0.005kg	No Kd
Nickel-63	1E-05Ci	Low
Strontium-90 + D	7E-07Ci	Low
Cesium-137 + Daughters	1E-05Ci	Low
Samarium-151	4E-06Ci	Low
Tributyl Phosphate		Low

KNOWLEDGE BASIS

☑ History/Process Knowledge ☐ Geophysics ☐ Geologic Logs ☐ Analytical Data

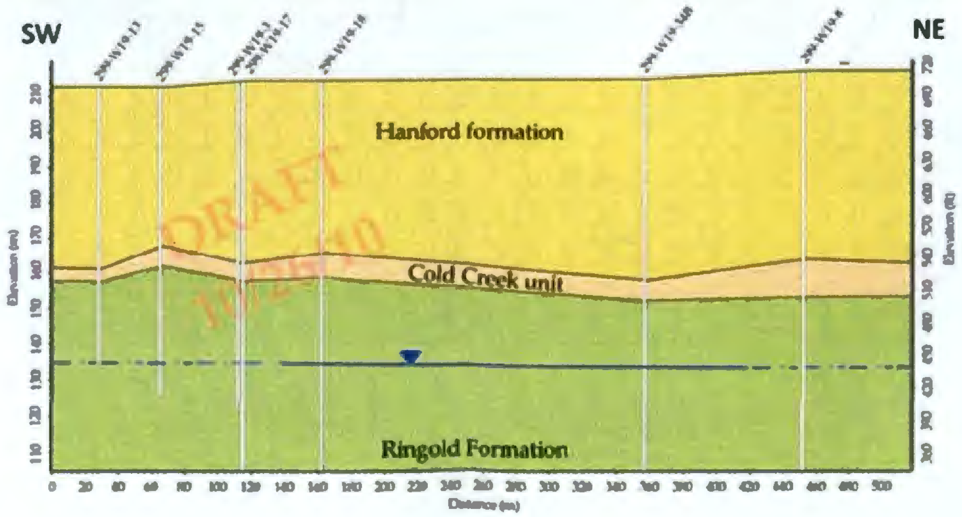
CHARACTERIZATION

No site-specific characterization of this waste site has been performed. This waste site is expected to be functionally similar to the 216-U-4A French drain and the process condensate waste discharged is expected to be the same waste discharged to 216-U-8, 216-U-12 , and 216-B-12 Cribs, without pH adjustment.

UNCERTAINTY

The site-specific horizontal and vertical extent of contamination is undefined by measurements. The quantity of liquid waste discharged to this site, however is expected to be relatively small as the drain would have been used during episodic maintenance and/or repair activities. For planning purposes, it is assumed that the counting box was drained and flushed 2 x per year for 5 years, using 1,000 L per flush (10,000 L total discharge). Actual volume could be as low as near zero. Subsurface contamination conditions can be represented by conditions observed at nearby 216-U-4A French drain.

216-U-7



NATURE AND EXTENT

The site inventory is estimated using the Soil Inventory Model (SIM). The site should have received only a modest volume of waste over the operating period. 216-U-7 French drain has not been characterized, however, the waste stream and operating conditions are similar to two other characterized waste sites (e.g., 216-U-12 and 216-U-4A, respectively) associated with historical U Plant operations.

The nature of the waste can be extrapolated from knowledge of discharges of this waste stream (i.e., acidic process condensate) to other waste sites (e.g., 216-U-8 and 216-U-12). The waste was strongly acidic (i.e., pH about 0.5) and contained nitric acid, uranium, mixed fission products, and some organics (i.e., kerosene-range hydrocarbons and tributyl phosphate). Observations from these cribs indicate that the contaminants in process condensate were relatively mobile in the large volumes discharged to the cribs. Although geochemically similar to to the crib discharges, this French drain is expected to have received orders of magnitude less volume than the cribs.

Understanding of the estimated extent of potential contamination at this waste site may be extrapolated from observations and measurements made in soil boring 299-W19-98 near waste site 216-U-4A French drain, which received acidic laboratory waste from the nearby 222-U Building. Contamination at 216-U-7 would not be expected to have migrated farther into the vadose zone than that observed at 216-U-4A.

Soil contamination apparently related to 216-U-4A was observed to a depth of about 5 m (16 ft) bgs. Contaminants measured in this interval included:
– Am-241 from 1.49 to 7.7 m (5 to 25 ft) bgs/max of 200 pCi/g at 3.7 m (12 ft) bgs
– Cs-137 from 1.49 to 3.73 m (5 to 12 ft) bgs/ max of 420 pCi/g at 1.49 m (5 ft) bgs
– Sr-90 from 1.49 to 4.91 m (5 to 16 ft) bgs/ max of 93 pCi/g at 1.49 (5 ft) bgs

Between 5 m and 11 m (16 ft to 37 ft) bgs, contaminant concentrations interpreted as related to 216-U-4A diminished to, or below, background levels.

The waste stream released to 216-U-7 French drain would have been process condensate, which was routed through the counting box for in-line radiation monitoring on its way to the 241-WR vault. During maintenance activities, pipes within the counting box would have been drained to the box floor and the drainage and flush water routed to the French drain.

Reports of a June 1953 release of uranyl nitrate hexahydrate (UNH) solution that overflowed to the 221-U Building vessel vent blower pit were incorrectly assigned to 216-U-7; this release reportedly went to the vessel vent blower pit, where the floor sump drained to the 241-WR Vault.

The following contamination conditions are indicated at 216-U-7 French drain:

– Contamination by relatively low levels of radionuclides, nitrate, and kerosene-range hydrocarbons and TBP is expected within the upper 4.6 m (15 ft) of the vadose zone, but not at the surface (i.e., the discharge to the French drain occurred at 4 m (13 ft) bgs.

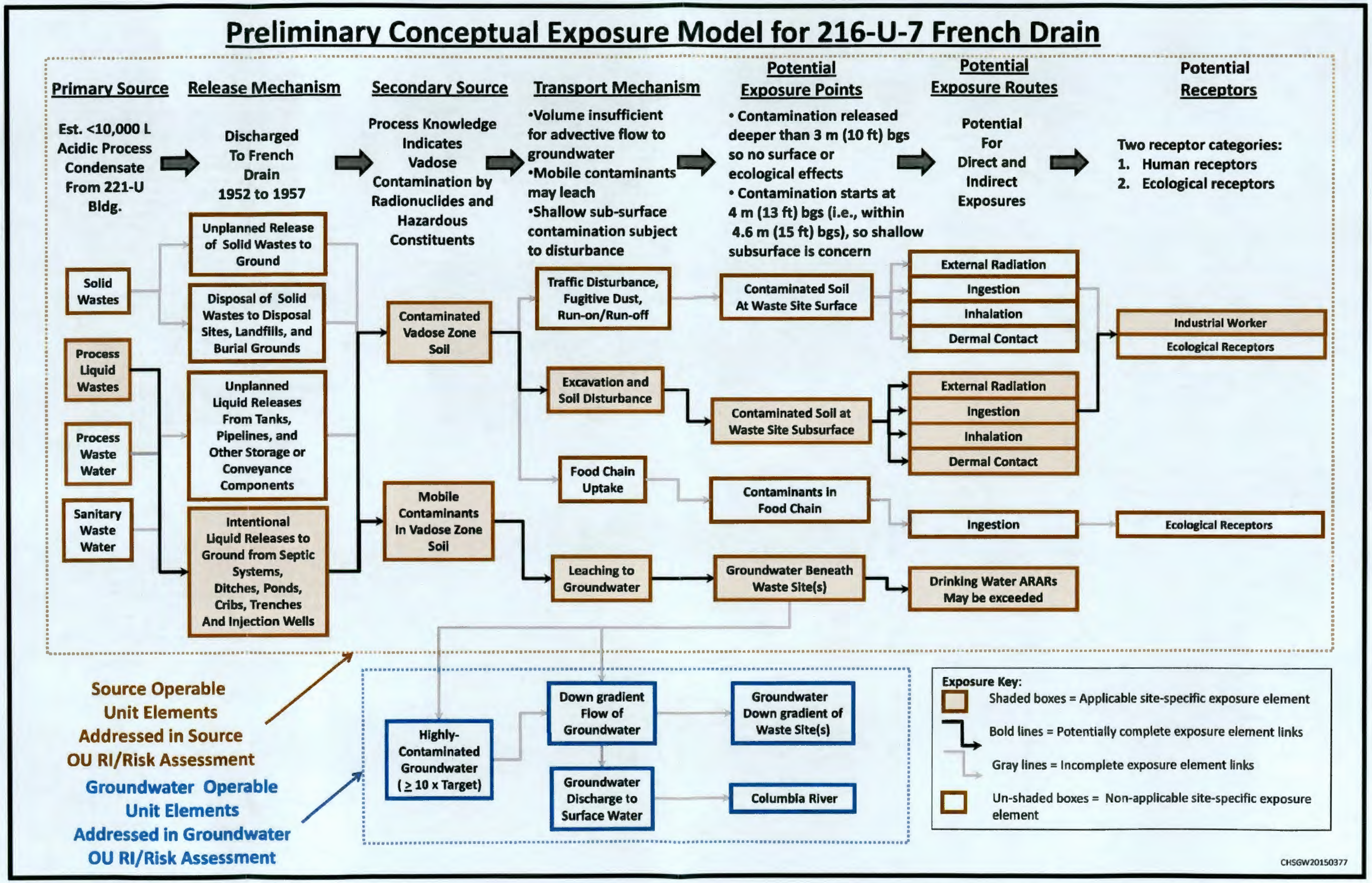
– The point of release is deeper than 3 m (10 ft) bgs and exposure to ecological receptors and food chain effects are not anticipated.

– The relatively small volume of waste discharged to 216-U-7 French drain is not expected to have directly affected groundwater during the operating period.

CHPUBS_CP_0002

1

Figure 3-13. Example CSM for the 216-U-7 French Drain (sheet 2 of 2)



2

3.9 Preliminary Risk Assessment

The purpose of a BRA is to assess potential risks associated with residual contamination at a site under baseline conditions (i.e., no further action), identify key radionuclide and chemical contributors to risk, identify key exposure pathways, and determine if there is a need to take an action to reduce risks. Clarification of the role of the BRA in developing Superfund remedial alternatives and supporting risk management decisions is provided in EPA, 1991, "Role of Baseline Risk Assessment in Superfund Remedy Selection Decisions" (OSWER Directive 9355.0-30). This directive states that the BRA is part of the RI. It further states the following:

> *The baseline risk assessment should "characterize the current and potential threats to human health and the environment that may be posed by contaminants migrating to groundwater or surface water, releasing to air, leaching through soil, remaining in the soil, and bioaccumulating in the food chain" ([NCP] Section 300.430(d)(4)). The primary purpose of the baseline risk assessment is to provide risk managers with an understanding of the actual and potential risks to human health and the environment posed by the site and any uncertainties associated with the assessment. This information may be useful in determining whether a current or potential threat to human health or the environment exists that warrants remedial action.*

The following sections describe the general methodology for conducting the BRA.

3.9.1 Human Health Risk Assessment Approach

Human health risk assessment (HHRA) methods and parameters are drawn from EPA's Risk Assessment Guidance for Superfund (RAGS) (EPA/540/1-89/002, *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A): Interim Final*).

3.9.1.1 Definition of Human Health Exposure Scenario

Human health risks in the Inner Area will be assessed using the outdoor worker exposure scenario for chemicals and radionuclides within the standard point of compliance (0 to 4.6 m [15 ft] bgs). For radiological contamination below 4.6 m (15 ft) bgs, direct contact risks for human health will be evaluated using a construction worker exposure scenario. The basis for the outdoor worker and construction worker scenarios and source of equations used to calculate cancer risks and noncancer hazards will be drawn from EPA, 2015a, *Regional Screening Levels for Chemical Contaminants at Superfund Sites*, and EPA, 2015b, *Preliminary Remediation Goals for Radionuclides*. Key assumptions are as follows:

- Exposure pathways selected for the outdoor worker and construction worker scenarios are based on the assumption that direct contact exposure is potentially complete to contaminants in soil.

Exposure Pathways – Chemicals:	**Exposure Pathways – Radionuclides:**
Incidental Soil Ingestion	Incidental Soil Ingestion
Inhalation of Dust and Volatiles	Inhalation of Dust
Dermal Contact with Soil	Direct (External) Exposure

- Exposure point concentrations (EPCs) for soil will include the standard POC (i.e., 4.6 m [15 ft]) based on the 2007 MTCA (WAC 173-340-740(6)) and may include a conditional POC proposed by DOE in the FS.

The exposure parameters for the outdoor worker scenario for chemicals and radionuclides are defined in Table 3-6. The exposure parameters listed in Table 3-6 reflect the guidance updates published by EPA in 2014.

Although only the outdoor worker scenario exposure parameters are provided in Table 3-6, cleanup levels for direct contact with chemicals in soil, structures (including pipelines), and debris will be developed using the assumptions from the 2007 MTCA (WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties") as described in Section 3.9.1.8.

Table 3-6. Summary of Outdoor Worker Scenario Exposure Parameters

Exposure Parameter	Symbol	Units	Radiological		Chemicals	
			Value	Source	Value	Source
Excess lifetime cancer risk	Risk	Unitless	Isotope-specific	Calculated	Analyte-specific	Calculated
Hazard quotient	HQ	Unitless	Not applicable	Not applicable	Analyte-specific	Calculated
Chronic daily intake	CDI	mg/kg-day, pCi, mg/m^3, or µg/m^3	Isotope-specific	Calculated	Analyte-specific	Calculated
Soil concentration	Cs	mg/kg or pCi/g	Isotope-specific	Measured value	Analyte-specific	Measured value
Averaging time – carcinogens	ATc	days	Not applicable	--	25,550	Default; EPA/540/1-89/002
Averaging time – noncarcinogens	ATnc	days	Not applicable	--	9,125	Default; EPA/540/1-89/002
Body weight – adult	BW_a	kg	N/A		80	EPA/600/ R-090/052F (Table 8-3)
Exposure frequency	EF_{OW}	days/year	225	OSWER Publication 9355.4-24 (Exhibit 1-2)	225	OSWER Publication 9355.4-24 (Exhibit 1-2)
Exposure duration	ED_{OW}	year	25	OSWER Directive 9285.6-03 (Page 15)	25	OSWER Directive 9285.6-03 (Page 15)
Exposure time	ET_{OW}	hr/day	8	OSWER Directive 9200.1-120, Attachment 1	8	OSWER Directive 9200.1-120, Attachment 1
Soil ingestion rate	IRS_{OW}	mg/day	100	OSWER Directive 9285.6-03 (Page 15)	100	OSWER Directive 9285.6-03 (Page 15)
Unit correction factor 1	CF1	g/mg	0.001	Calculated	Not applicable	Not applicable
Unit correction factor 2	CF2	kg/mg	Not applicable	Not applicable	0.000001	Calculated

Table 3-6. Summary of Outdoor Worker Scenario Exposure Parameters

Exposure Parameter	Symbol	Units	Radiological		Chemicals	
			Value	Source	Value	Source
Unit correction factor 3	CF3	year/day	0.00274	Calculated	Not applicable	Not applicable
Unit correction factor 4	CF4	g/kg	1,000	Calculated	Not applicable	Not applicable
Unit correction factor 5	CF5	day/hour	0.0417	Calculated	0.0417	Calculated
Unit correction factor	CF6	µg/mg	Not applicable	Not applicable	1,000	Calculated
Area correction factor	ACF	Unitless	Isotope-specific	Eckerman, 2007	Not applicable	Not applicable
Gamma shielding factor	GSF	Unitless	1	EPA/540-R-00-007	Not applicable	Not applicable
Dermal absorption fraction	ABSd	Unitless	Not applicable	Not applicable	Analyte-specific	EPA/540/R/ 99/005
Skin surface area	SAow	cm[2]	Not applicable	Not applicable	3,527	Attachment 1 of OSWER Directive 9200.1-120
Soil adherence factor	AFow	mg/cm[2]-day	Not applicable	Not applicable	0.12	Attachment 1 of OSWER Directive 9200.1-120
Gastrointestinal absorption factor	ABSGI	Unitless	Not applicable	Not applicable	Analyte-specific	EPA/540/R/ 99/005
Inhalation rate – adult	INHa	m[3]/day	20	OSWER Directive 9285.6-03	Not applicable	Not applicable
Particulate emission factor	PEF	m[3]/kg	7.30E+10	OSWER 9355.4-24	7.30E+10	OSWER 9355.4-24
Volatilization factor	VF	m[3]/kg	Not applicable	Not applicable	Analyte-specific	EPA[c]
Carcinogenic slope factor for soil ingestion	SFsi	Risk/pCi	Isotope-specific	EPA[a]	Not applicable	Not applicable
Carcinogenic slope factor for external exposure	SFx	Risk/year per pCi	Isotope-specific	EPA[a]	Not applicable	Not applicable
Carcinogenic slope factor for inhalation	SFinh	Risk/pCi	Isotope-specific	EPA[a]	Not applicable	Not applicable
Oral carcinogenic slope factor	SFo	(mg/kg-day)[-1]	Not applicable	Not applicable	Analyte-specific	EPA[a]

Table 3-6. Summary of Outdoor Worker Scenario Exposure Parameters

Exposure Parameter	Symbol	Units	Radiological		Chemicals	
			Value	Source	Value	Source
Oral reference dose	RfDo	(mg/kg-day)	Not applicable	Not applicable	Analyte-specific	EPA[a]
Unit risk factor	IUR	$(\mu g/m^3)^{-1}$	Not applicable	Not applicable	Analyte-specific	EPA[a]
Reference concentration	RfC	mg/m^3	Not applicable	Not applicable	Analyte-specific	EPA[a]
Decay constant	λ	Unitless	0.693	EPA/540-R-00-007	Not applicable	Not applicable
Time	t	years	25	OSWER Directive 9285.6-03	Not applicable	Not applicable

Sources:

Eckerman, 2007, *Ratios of Dose Rates for Contaminated Slabs.*

EPA, 2000, *Soil Screening Guidance for Radionuclides: User's Guide*, EPA/540-R-00-007 (OSWER Directive 9355.4-16A).

EPA, 2002, *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (OSWER 9355.4 24).

EPA/540/1-89/002, *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A): Interim Final.*

EPA/540/R/99/005, *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Assessment): Final.*

EPA/600/R-090/052F, 2011, *Exposure Factors Handbook 2011 Edition (Final).*

OSWER 9355.4-24, *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites.*

OSWER Directive 9200.1-120, *Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors.*

OSWER Directive 9285.6-03, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual Supplemental Guidance, "Standard Default Factors," Interim Final.*

Note: Complete reference citations are provided in Chapter 8.

a. Values will be obtained from the sources described in Section 3.9.1.5, "Toxicity Assessment."

EPA = U.S. Environmental Protection Agency

The exposure parameters for the construction worker scenario for radionuclides are defined in Table 3-7. The exposure parameters listed in Table 3-7 reflect the guidance updates published by EPA in 2014.

Table 3-7. Summary of Construction Worker Scenario Exposure Parameters

Exposure Parameter	Symbol	Units	Value	Source
Excess lifetime cancer risk	Risk	Unitless	Isotope-specific	Calculated
Chronic daily intake	CDI	pCi	Isotope-specific	Calculated
Soil concentration	Cs	pCi/g	Isotope-specific	Measured value
Exposure frequency – construction worker	EFcw	days/year	30	Site-specific assumption (5 days per week for 6 weeks); DOE/RL-2007-27; Rev 0; Section A3.3.1

Table 3-7. Summary of Construction Worker Scenario Exposure Parameters

Exposure Parameter	Symbol	Units	Value	Source
Exposure duration – construction worker	EDcw	year	1	OSWER Publication 9355.4-24, Exhibit 5-1
Exposure time – construction worker	ETow	hr/day	8	Site-specific assumption, 8 hours per 24 hour day
Soil ingestion rate – construction worker	IRScw	mg/day	330	OSWER Publication 9355.4-24 (Exhibit 5-1)
Inhalation rate – construction worker	INHCW	m^3/day	60	EPA/600/P-95/002Fa (page 5-11), based on a rate of 2.5 m^3/hr for 24 hr
Unit correction factor 1	CF1	g/mg	0.001	1 gram = 1,000 mg
Unit correction factor 2	CF2	day/hour	0.0417	1 day = 24 hours
Unit correction factor 3	CF3	g/kg	1,000	1,000 g = 1 kg
Unit correction factor 4	CF4	year/day	0.00274	1 year = 365 days
Area correction factor – soil volume	ACF_{ext-sv}	Unitless	Isotope-specific	ORNL 2014
Gamma shielding factor	GSF	Unitless	1	EPA/540-R-00-007
Subchronic particulate emission factor	PEF_{sc}	m^3/kg	1.28×10^{-6}	OSWER 9355.4-24
Carcinogenic slope factor for soil ingestion	SFsi	Risk/pCi	Isotope-specific	EPA[a]
Carcinogenic slope factor for external exposure	SFx	Risk/year per pCi	Isotope-specific	EPA[a]
Carcinogenic slope factor for inhalation	SFinh	Risk/pCi	Isotope-specific	EPA[a]
Decay constant	λ	Unitless	0.693	EPA/540-R-00-007
Time – construction worker	t_{cw}	years	1	OSWER Publication 9355.4-24, Exhibit 5-1

Sources:

EPA/540-R-00-007, 2000, *Soil Screening Guidance for Radionuclides: User's Guide*, (OSWER Directive 9355.4-16A).

EPA/600/P-95/002Fa, 1997, *Exposure Factors Handbook, Update to Exposure Factors Handbook EPA/600/8-89/043 – May 1989, Volume I – General Factors*

OSWER 9355.4-24, *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*.

ORNL, 2014, Area Correction Factors for Contaminated Soil for Use in Risk and Dose Assessment Models, ORNL/TM-2013/00.

Note: Complete reference citations are provided in Chapter 8.

a. Values will be obtained from the sources described in Section 3.9.1.5, "Toxicity Assessment."

EPA = U.S. Environmental Protection Agency

3.9.1.2 Basis for Action

For protection of human health (direct contact), the CERCLA-defined basis for action for protection of human health for radionuclides is 1 in 10,000 cumulative excess lifetime cancer risk. The basis for action for chemicals is based on the EPA Regional Screening Levels calculation at 1 in 100,000 cancer risk or a hazard index of 1.0 for noncancer hazards. Ecological risk and groundwater protection will also be considered to establish a basis for action.

3.9.1.3 Identification of Contaminants of Potential Concern

For protection of human health (direct contact), a COPC is an analyte suspected of being associated with site-related activities, that represents a potential threat to human health, and for which data are of sufficient quality for use in a quantitative HHRA. A broad list of contaminants (radionuclides and chemicals) will initially be evaluated in a quantitative HHRA. The list of contaminants will be identified through the characterization strategy for each OU. Identification of COPCs will take into consideration existing site characterization data, process knowledge, and inventory estimates.

The risk characterization will discuss elevated soil background concentrations and their contribution to site risks as well as naturally occurring elements that are not CERCLA hazardous substances, pollutants, or contaminants. The contribution from naturally occurring metals and radioisotopes as well as widespread anthropogenic radioisotopes will be evaluated in accordance with EPA 540-R-01-003, *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites.*

The approach used for the evaluation of soil background will be the same as that used in the BRA in the River Corridor OUs. A summary of the 90th percentile and maximum Hanford Site soil background concentrations is provided in Table 3-8.

Table 3-8. Hanford Site Soil Background Concentrations

Analyte Name	Analyte Class	Units	90th Percentile Background Value	Maximum Background Value	Source of Background Value
Anthropogenic and Naturally Occurring Radionuclides					
Cesium-137	RAD	pCi/g	1.1	1.6	DOE/RL-96-12
Cobalt-60	RAD	pCi/g	0.0084	0.039	DOE/RL-96-12
Europium-154	RAD	pCi/g	0.033	0.079	DOE/RL-96-12
Europium-155	RAD	pCi/g	0.054	0.098	DOE/RL-96-12
Gross Beta	RAD	pCi/g	23	25	DOE/RL-96-12
Plutonium-238	RAD	pCi/g	0.0038	0.019	DOE/RL-96-12
Plutonium-239/240	RAD	pCi/g	0.025	0.033	DOE/RL-96-12
Radium-228	RAD	pCi/g	1.8	2.3	DOE/RL-96-12
Strontium-90	RAD	pCi/g	0.18	0.37	DOE/RL-96-12
Thorium-228	RAD	pCi/g	1.4	1.6	DOE/RL-96-12
Total Beta Radiostrontium	RAD	pCi/g	0.18	0.37	DOE/RL-96-12

Table 3-8. Hanford Site Soil Background Concentrations

Analyte Name	Analyte Class	Units	90th Percentile Background Value	Maximum Background Value	Source of Background Value
Naturally Occurring Radionuclides					
Potassium-40	RAD	pCi/g	17	20	DOE/RL-96-12
Radium-226	RAD	pCi/g	0.82	1.2	DOE/RL-96-12
Thorium-232	RAD	pCi/g	1.3	1.6	DOE/RL-96-12
Uranium-233/234	RAD	pCi/g	1.1	1.5	DOE/RL-96-12
Uranium-234	RAD	pCi/g	1.1	1.5	DOE/RL-96-12
Uranium-235	RAD	pCi/g	0.11	0.39	DOE/RL-96-12
Uranium-238	RAD	pCi/g	1.1	1.2	DOE/RL-96-12
Metals					
Aluminum	METAL	mg/kg	11,800	28,800	DOE/RL-92-24, Vol. 1
Antimony	METAL	mg/kg	0.13	0.385	ECF-HANFORD-11-0038
Arsenic	METAL	mg/kg	6.47	27.7	DOE/RL-92-24, Vol. 1
Barium	METAL	mg/kg	132	480	DOE/RL-92-24, Vol. 1
Beryllium	METAL	mg/kg	1.51	10	DOE/RL-92-24, Vol. 1
Boron	METAL	mg/kg	3.89	5.86	ECF-HANFORD-11-0038
Cadmium	METAL	mg/kg	0.563	2.98	ECF-HANFORD-11-0038
Calcium	METAL	mg/kg	17,200	105,000	DOE/RL-92-24, Vol. 1
Chromium	METAL	mg/kg	18.5	320	DOE/RL-92-24, Vol. 1
Cobalt	METAL	mg/kg	15.7	110	DOE/RL-92-24, Vol. 1
Copper	METAL	mg/kg	22	61	DOE/RL-92-24, Vol. 1
Iron	METAL	mg/kg	32,600	68,100	DOE/RL-92-24, Vol. 1
Lead	METAL	mg/kg	10.2	74.1	DOE/RL-92-24, Vol. 1
Lithium	METAL	mg/kg	13.3	19.2	ECF-HANFORD-11-0038
Magnesium	METAL	mg/kg	7,060	32,300	DOE/RL-92-24, Vol. 1
Manganese	METAL	mg/kg	512	1,110	DOE/RL-92-24, Vol. 1
Mercury	METAL	mg/kg	0.013	0.029	ECF-HANFORD-11-0038
Molybdenum	METAL	mg/kg	0.47	3.17	ECF-HANFORD-11-0038
Nickel	METAL	mg/kg	19.1	200	DOE/RL-92-24, Vol. 1
Potassium	METAL	mg/kg	2,150	7,900	DOE/RL-92-24, Vol. 1

Table 3-8. Hanford Site Soil Background Concentrations

Analyte Name	Analyte Class	Units	90th Percentile Background Value	Maximum Background Value	Source of Background Value
Selenium	METAL	mg/kg	0.78	0.84	ECF-HANFORD-11-0038
Silver	METAL	mg/kg	0.167	0.273	ECF-HANFORD-11-0038
Sodium	METAL	mg/kg	690	6.06E+03	DOE/RL-92-24, Vol. 1
Thallium	METAL	mg/kg	0.185	0.523	ECF-HANFORD-11-0038
Uranium	METAL	mg/kg	3.21	4.04	Isotopic Activity Conversion based on DOE/RL-96-12 values
Vanadium	METAL	mg/kg	85.1	140	DOE/RL-92-24, Vol. 1
Zinc	METAL	mg/kg	67.8	366	DOE/RL-92-24, Vol. 1
Ammonia	ANIONS	mg/kg	9.23	26.4	DOE/RL-92-24, Vol. 1
Chloride	ANIONS	mg/kg	100	1,480	DOE/RL-92-24, Vol. 1
Fluoride	ANIONS	mg/kg	2.81	73.3	DOE/RL-92-24, Vol. 1
Nitrate	ANIONS	mg/kg	52	906	DOE/RL-92-24, Vol. 1
Phosphate	ANIONS	mg/kg	0.785	225	DOE/RL-92-24, Vol. 1
Sulfate	ANIONS	mg/kg	237	12,600	DOE/RL-92-24, Vol. 1

Notes: Complete reference citations are provided in Chapter 8.

The background values listed are only for shallow soils (less than 4.6 m [15 ft] bgs). A background value of zero applies to soil concentrations collected from deeper soils.

Certain analytes are known to be unrelated to Hanford Site wastes or will not contribute significantly to human health risks. These analytes will not be carried into a quantitative risk assessment:

- Radionuclides with a half-life less than 3 years
- Essential trace elements
- Soil physical property measurements
- Background (naturally occurring) radionuclides (potassium-40, thorium-232 and daughters; radium-226 and daughters)

This approach is the same as used in the River Corridor OUs. If applicable, quantitative risks will not be assessed for analytes without appropriate toxicity values. Analytes without toxicity values will be discussed qualitatively as part of the risk characterization.

3.9.1.4 Exposure Assessment

The exposure assessment will address methods for developing EPCs in soil, methods for calculating concentrations in air from EPCs in soil using EPA's screening models, and methods for developing EPCs in groundwater.

Development of Exposure Point Concentrations in Soil

Spatial exposure areas will be defined, and sampling and analytical data will be grouped for calculating EPCs, taking into consideration factors such as the nature and extent of contamination and process knowledge. Depths in soil will be identified for grouping samples based on the characterization strategy. In general, soil samples collected from small waste sites will be grouped into a single exposure area, whereas soil samples from large waste sites (e.g., ponds) may be separated into more than one exposure area.

Where sufficient data are available, EPA's ProUCL software will be used to calculate EPCs, which will be the 95 percent upper confidence limit (UCL) of the average. As described in EPA's ProUCL guidance (EPA/600/R-07/041, 2013, *ProUCL Version 5.0.00 User Guide*), if all recommended methods to calculate the UCL provide a value that exceeds the maximum concentration, the maximum concentration in an exposure area will be used as the EPC. The flowchart developed for deriving EPCs in the BRAs for River Corridor OUs will be incorporated into the Central Plateau risk assessment to provide added details. Additional discussion will be provided in the uncertainty assessment when ProUCL calculates a 95 percent UCL that is greater than the maximum detected concentration, and the maximum detected value is used.

Development of Exposure Point Concentrations in Air from Soil

Particulate emission factors for windblown dust and volatilization factors for VOCs (when appropriate) will be calculated in accordance with OSWER 9355.4-24, *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites.*

Development of Exposure Point Concentrations for Other Media

Characterization approaches proposed in the SAP (Appendix E) include collection of data for physical features present at a subset of the waste sites (USTs, pipelines, building slabs, concrete basins, and vaults). These are features for which soil data are not considered representative for characterization or risk evaluation purposes. Soil data are considered representative for characterization of other features (timber cribbing, drainfield distribution lines, railroad tracks) that are more "soil-like" (that is, more integrated with the soil and thus the waste discharged or released to it).

Chips and core samples will be collected for nonsoil features. Analytical measurements from these samples will be used for risk characterization from these features. The risk characterization approach will use the 2-D method, which is developed to evaluate risks from exposure to structures with surface radioactive contamination. In this method, the outdoor worker is exposed to radioactively contaminated dust settled on finite slabs. The only pathway considered is external exposure to ionizing radiation (Surfaces Preliminary Remediation Goals for Radionuclides, available at: http://epa-sprg.ornl.gov/).

3.9.1.5 Toxicity Assessment

The toxicity criteria used for the human health cancer risk and noncancer hazard calculations will be obtained from the sources described in the following sections.

Toxicity Values for Nonradionuclides

For nonradionuclides, the analyte-specific toxicity values are determined using the recommended reference hierarchy as described in OSWER Directive 9285.7-53, *Human Health Toxicity Values in Superfund Risk Assessments*. The hierarchy is the same as used in the BRAs for the River Corridor OUs, and is summarized as follows.

- Tier 1 – The EPA Integrated Risk Information System (IRIS) (EPA, 2015c)
- Tier 2 – The EPA Provisional Peer-Reviewed Toxicity Values (PPRTVs)
- Tier 3 – Other Toxicity Values

Tier 1 – IRIS

The preferred source of toxicity data is the EPA IRIS database (EPA, 2015c). Expert toxicologists at EPA have derived the values in this database, and the values have undergone a thorough review and validation both within and outside EPA. If a toxicity value is available in IRIS, that value is used in preference to values published in Tier 2 and Tier 3 sources.

Tier 2 – Provisional Peer-Reviewed Toxicity Value

If a toxicity value is not available in IRIS, the next source is the EPA PPRTVs. This source includes toxicity values that have been developed by the Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center. This database is available to the public (available at: http://hhpprtv.ornl.gov) and is also accessible to EPA risk assessors via the EPA intranet. These values are also published at the EPA Regional Screening Levels website (EPA, 2015a). Tier 2 values are used in preference to Tier 3 values.

Tier 3 – Other Toxicity Values

Tier 3 includes additional EPA and non-EPA sources of toxicity information, including the following:

- The California EPA Toxicity Criteria Database (available at: http://oehha.ca.gov/tcdb/index.asp) provides toxicity values that are peer reviewed and address both carcinogenic and noncarcinogenic effects.
- The Agency for Toxic Substances and Disease Registry Minimal Risk Levels for Hazard Substances are peer-reviewed estimates of the daily human exposure to hazardous substances that is likely to be without appreciable risk of adverse noncarcinogenic health effects over a specified duration of exposure.
- EPA 540-R-97-036, *Health Effects Assessment Summary Tables: FY 1997 Update* (HEAST) toxicity values.

When Tier 1, Tier 2, or Tier 3 toxicity values are not available for an analyte, the toxicity values from the National Center for Environmental Assessment (NCEA) are used. The NCEA toxicity values can be included because the Tier 3 values can include additional EPA and non-EPA sources of toxicity information. The NCEA values can be found in ORNL, 2015, Risk Assessment Information System.

Toxicity Values for Radionuclides

The cancer slope factors for radionuclides will be obtained from HEAST (EPA 540-97-036), 2001, ("April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity-Slope Factors,"). These values are the same as used in the BRA in the River Corridor OUs.

3.9.1.6 Risk Characterization

Risk estimates will be presented by exposure area and depth in soil. The BRA will also discuss risk estimates relative to Hanford Site background levels. The risk characterization section will identify the COPCs that are risk drivers.

3.9.1.7 Discussion of Uncertainties

Uncertainties in the HHRA calculations or conclusions will be specifically discussed in uncertainty sections in the RI/FS (and RFI/CMS, as applicable) document. The discussions will identify whether risks from contaminants in soil are likely overstated or understated.

3.9.1.8 Methods for Calculating Human Health Cleanup Levels

Cleanup levels for direct contact with radionuclides in soil, structures (including pipelines), and debris will be developed using parameters for the industrial worker scenario identified in Section 3.9.1.1, along with toxicity values identified in Section 3.9.1.5. The outdoor worker PRG will be used to represent reasonable maximum exposure for the industrial worker exposure to contaminated soil. For pipelines, structures and debris, the two-dimensional outdoor worker external exposure will be used to represent reasonable maximum exposure. The 2-D method is developed to evaluate risks from exposure to structures with surface radioactive contamination. In this method, the outdoor worker is exposed to radioactively contaminated dust settled on finite slabs. The only pathway considered is external exposure to ionizing radiation (Surfaces Preliminary Remediation Goals for Radionuclides, available at: http://epa-sprg.ornl.gov/). Table 3-6 provides the exposure parameters that will be used. PRGs corresponding to a 10^{-4} acceptable cancer risk level will be used for radionuclides. The methodology used to calculate soil PRGs for radionuclides is consistent with the methodology used for the BRAs for the River Corridor OUs.

Cleanup levels for direct contact with chemicals in soil, structures (including pipelines), and debris will be developed using the assumptions from the 2007 MTCA (WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties") equations 745-1 and 745-2, along with toxicity values identified in Section 3.9.1.5. PRGs will be developed based on a 10^{-5} acceptable cancer risk level or a noncancer hazard quotient of 1. MTCA (WAC 173-340) equations will be used to calculate PRGs based on direct contact (soil ingestion), and where relevant, the PRG value will be based on the inhalation exposure pathway when it is lower than soil ingestion. The cumulative cancer risk threshold for chemicals is also 10^{-5}, so adjustment to cleanup levels based on cumulative risk may be relevant. Adjustments for multiple contaminants having similar mode of action or multiple pathways of exposure will be made where appropriate.

3.9.2 Ecological Risk Assessment Approach

The ecological risk assessment approach will follow EPA guidance and MTCA (WAC 173-340-7490, "Terrestrial Ecological Evaluation Procedures"). The ecological risk assessments will include, as appropriate, explanations of how the methodology conforms to guidance and requirements identified in MTCA (WAC 173-340). The ecological risk assessment approach is the same as that used in the BRAs in the River Corridor OUs.

3.9.2.1 Identification of Contaminants of Potential Concern

These will be identified using the same process developed for the HHRA (Section 3.9.1.3) but will consider ecological pathways and screening levels.

3.9.2.2 Conceptual Ecological Site Exposure Model

The CSM for ecological exposure pathways will include the elements described by EPA 540-R-97-006, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments: Interim Final.* Though not specifically referred to as a CSM, these same elements are also part of WAC 173-340-7492, "Simplified Terrestrial Ecological Evaluation Procedures," and WAC 173-340-7493, "Site-Specific Terrestrial Ecological Evaluation Procedures." Previously developed evaluations will be used, including the conceptual model of ecological exposure pathways and receptors developed for the Tier 1 and Tier 2 ecological PRGs (CHPRC-00784, *Tier 1 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site*; CHPRC-01311, *Tier 2 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site*).

3.9.2.3 Evaluation of Biointrusion

The ecological risk assessment will include a discussion of the depth of soil to which ecological receptors are exposed. This discussion will use the analysis presented in CHPRC-00651, *Evaluation of Biointrusion Depths at the Hanford Site for Protection of Ecological Receptors*. If an alternative POC for soil depth is proposed, both the standard POC and the alternative POC will be presented as remedial action alternatives in the FSs (and corrective measures studies, as applicable).

3.9.2.4 Exposure Assessment

The exposure assessment will use exposure parameters, representative species, and transfer factors found in CHPRC-01311 and CHPRC-00784 that have already been evaluated and used in ecological risk assessments in the River Corridor OUs. Estimation of EPCs in soil will use the same data and parallel the methods as presented for the HHRA.

3.9.2.5 Effects Assessment

The effects assessment will be the same as that employed for the River Corridor OU BRAs. The assessment will use toxicity reference values for wildlife that have been developed in CHPRC-01311 and CHPRC-00784. The same soil thresholds protective of wildlife that were developed from these toxicity reference values will be used for wildlife in the Central Plateau. Effects values for terrestrial plants and invertebrates will be the soil threshold concentrations presented in ECF-HANFORD-11-0158, *Tier 2 Terrestrial Plant and Invertebrate PRGs for Nonradionuclides for Use at the Hanford Site*, and CHPRC-00784.

3.9.2.6 Risk Characterization

Ecological risk characterization will use the following standard methods and approaches already employed along the River Corridor:

- Calculation of ecological hazard quotients
- Evaluation of risk relative to established background levels to aid in identifying risk drivers
- Methods for characterizing risks when a scientific-management decision point (SMDP) is reached

The SMDP is reached when exposures are higher than an ecological hazard quotient of 1.0 (i.e., an EPC is higher than a PRG). The potential for population-level risks to wildlife and community-level risks to plants and invertebrates will be evaluated, and a risk management decision will be made using the SMDP. The approach is the same that was used for the River Corridor OU BRAs. The SMDP will consider the following:

- Spatial characteristics of the remediated waste site (area and depth of the waste site)
- Proximity and size of other waste sites and unaffected habitat
- Extent of site characterization (sample density and characterization of lateral extent of contamination)
- Data quality (presence of qualifiers and adequacy of detection limits)
- Frequency that risk-based thresholds are exceeded and the location(s) of those exceedances
- Chemical-specific properties of each contaminant of concern (COC) (e.g., potential to biomagnify and persistence)
- Ecological receptors specific details

- Feeding guild that is affected (e.g., plants, insects, or omnivorous, herbivorous, insectivorous, or carnivorous wildlife)
- Proportion of receptors affected
- Likelihood of population- or community-level effects
- Home range of the receptors at risk relative to the area exceeding the PRG
- Evaluation of the PRG (level of confidence, basis and relation to other PRGs such as those for human health or groundwater protection)

In the preparation of the ecological risk assessment, risk assessors will evaluate potential risks to populations of mammals, birds, and communities of plants and invertebrates, and will propose conclusions through the SMDP. Risk managers from DOE and regulatory agencies will review and concur or revise the SMDP conclusions.

3.9.2.7 Methods for Calculating Ecological Cleanup Levels

PRGs have been developed for individual feeding guilds (for birds and mammals), and for plants and invertebrates. PRGs for chemicals are based on Lowest Observed Affect Exposure Levels and are found in CHPRC-01311 and CHPRC-00784 (for birds and mammals), and ECF-HANFORD-11-0158 (for plants and invertebrates).

PRGs for radionuclides are developed using the methods presented in DOE's graded approach document (DOE-STD-1153-2002), using as a protective threshold a dose limit of 0.1 rad/day for birds and mammals and 1.0 rad/day for plants and invertebrates.

3.9.3 Contaminant Fate and Transport Modeling

The evaluation of groundwater protection will be based on DOE/RL-2011-50, which will form the basis for all groundwater evaluations on the Central Plateau. The development of soil screening levels (SSLs) and PRGs for groundwater protection will be based on protecting groundwater directly below each waste site. In addition, cumulative impacts from all waste sites and other sources within the Central Plateau will be evaluated.

The graded approach document (DOE/RL-2011-50) establishes the use of Subsurface Transport Over Multiple Phases (STOMP) (PNNL-12030, *STOMP: Subsurface Transport Over Multiple Phases Version 2.0: Theory Guide*) as the fate and transport model to be used for groundwater protection evaluations. To facilitate the modeling approach for the Central Plateau, five hydrogeologic provinces were identified in DOE/RL-2011-50, based on vadose zone hydrogeologic similarity. The characteristics, thickness, and vertical distribution of the vadose zone sediments of the five provinces are provided in DOE/RL-2011-50. Other parameter values used for the groundwater protection evaluation include ranges of distribution coefficient (K_d) values and net infiltration rates.

For evaluation of groundwater protection for waste sites on the Central Plateau (including those within the 200-WA-1 and 200-BC-1OUs), K_d values identified for the River Corridor (DOE/RL-2010-95) will be used. Because DOE/RL-2010-95 did not identify a K_d value for uranium, a K_d value of zero will be used for all waste sites unless site-specific information is available.

Long-term net infiltration rates will be defined as documented in the graded approach document. To summarize, 4 mm (0.16 in.) per year will be used as the long-term infiltration rate for two scenarios, based on two future end states:

- Native Land Cover Scenario: Assumes revegetation with native plants that will mature within about 30 years of remediation and vegetation
- Evapotranspiration Barrier Scenario: Assumes installation of an evapotranspiration barrier at the waste site(s). After the barrier is installed, the effective infiltration rate will be reduced to 0.5 mm (0.02 in.) per year. The barrier will be assumed to have a design life of 500 years. After that, net infiltration rates will return to the natural land cover rate of 4 mm (0.16 in.) per year.

To establish compliance of the groundwater protection evaluation approach with the requirements of WAC 173-340-747(8), "Deriving Soil Concentrations for Groundwater Protection," a single crosswalk for waste sites applicable across the Central Plateau will be developed. This crosswalk will follow the structure documented in the 100-D/H RI/FS report (DOE/RL-2010-95). Following this development, and within each of the OUs, each risk assessment will identify unique application aspects for waste sites and demonstrate how *Washington Administrative Code* requirements are met.

3.9.3.1 Basis for Calculation of Screening Levels and Preliminary Remediation Goals

The approach for evaluation of groundwater protection involves the evaluation of the potential for groundwater contamination from a given waste site (with known or assumed waste geometry) or the calculation of SSLs or PRGs. The SSLs and PRGs are soil and vadose zone concentrations that would not affect groundwater above pre-defined levels. Consistent with DOE/RL-2011-50 (Figure 3-1), the SSLs will be used to identify COPCs, and the PRGs will be used to set cleanup levels.

For the SSL calculation, these soil concentrations would not affect groundwater concentrations above the lowest value from the following calculations:

- Chemicals, concentrations calculated for the EPA Tap Water scenario based on carcinogenic effects calculated at target risk level of 1×10^{-6}, as applicable
- Radionuclides, concentrations calculated for the EPA Tap Water scenario based on carcinogenic effects calculated at target risk level of 1×10^{-5}
- Concentrations calculated for the EPA Tap Water scenario based on noncarcinogenic effects calculated at a hazard quotient value of 0.1, as applicable

The groundwater protection PRGs would be calculated as concentrations that would not affect groundwater concentrations above the lowest value from the following:

- The federal and state maximum contaminant level (MCL) values, where available.
- EPA screening levels for radionuclides for which no MCL is available. The groundwater cleanup level is calculated using the Tap Water scenario at an individual target risk level of 1×10^{-4}.
- MTCA (WAC 173-340) Method B cleanup level for groundwater based on carcinogenic effects calculated at target risk level of 1×10^{-6}, as applicable, with downward adjustment to maintain cumulative risk below 1×10^{-5} for multiple contaminants in accordance with WAC 173-340-708(5) and (6).
- MTCA (WAC 173-340) Method B cleanup level for groundwater based on noncarcinogenic effects calculated at a hazard quotient value of 1, as applicable, with downward adjustment to maintain a total hazard index of 1 for multiple contaminants in accordance with WAC 173-340-708(5) and (6).

3.9.3.2 Evaluation of Cumulative Impacts and Approach for Evaluation of Alternative Point of Compliance

The FS can develop an alternative that considers an alternative POC in groundwater. The detailed evaluation of this alternative will consider the evaluation of cumulative impacts, taking into consideration the upgradient groundwater contamination through the same comprehensive approach as PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*, and the cumulative impact analysis conducted for DOE/EIS-0391. The following considerations will be defined for this evaluation:

- The alternative POC process will define a model domain (in space and time) that covers all the source waste sites within the boundary as well as existing groundwater contamination. An example of this boundary is shown in Figure 3-16. This proposed boundary encompasses all the liquid effluent disposal sites and the existing concentrated groundwater contamination areas within the Central Plateau. The actual boundary will be determined through the RI/FS process (and RFI/CMS, as applicable) for source OUs. The evaluation will be conducted for 1,000 years.
- Inventory estimates for waste sites will include measurements for surface soils and the vadose zone as well as the following sources:
  - Liquid disposal sites: Hanford Site SIM mean values (PNNL-16940, *Hanford Soil Inventory Model (SIM), Revision 2, Software Documentation – Requirements, Design, and Limitations*) will be used for the base case. Ranges of effluent volumes and associated contaminant concentrations provided by SIM will be used to evaluate the uncertainties.
  - Solid waste disposal sites: Inventory estimates will be developed based on available information and available characterization measurements.
  - Tank farm sources: Data will be obtained from the most recent leak assessment reports and tank waste and ancillary equipment inventory estimates.
- A range of end-state conditions for waste sites and groundwater will be evaluated using the same approach documented in PNNL-14027, *An Initial Assessment of Hanford Impact Performed with the System Assessment Capability*, updated to reflect the current decisions and already-implemented response actions for the groundwater contamination on the Central Plateau, including perched water removal.

Cumulative impacts from waste sites, tank farms, and other sources within the Central Plateau will be assessed and documented in a single primary document under the TPA (Ecology et al., 1989a). This document will be prepared following the approval of the first work plan and prior to completion of the first RI/FS (and RFI/CMS, as applicable) for the source OUs within the Hanford Site Central Plateau. Following the issuance of this document, each RI report for source OUs will reference this application document, evaluate any necessary updates based on new information or updated elements of the CSMs, and evaluate how the conclusions can change. Similarly, the Composite Analysis (required under DOE O 435.1, *Radioactive Waste Management*) will reference the same application document, evaluate any necessary changes, and demonstrate the performance metrics required under this DOE Order.

Figure 3-16. Boundary Proposed for the Evaluation of Alternative POC for Groundwater Protection

3.10 Preliminary Remedial Action Objectives

The NCP (40 CFR 300.430(e)(2)(i) "Remedial Investigation/Feasibility Study and Selection of Remedy") specifies that remedial action objectives (RAOs) be developed that specify contaminants and media of concern, potential exposure pathways, and remediation goals. For the purpose of assessing data adequacy, this section includes an initial identification of RAOs. The RAOs will be refined as needed, based on the BRA, and used during the detailed analysis of alternatives conducted in the FS. The RAOs will be finalized and documented in the ROD.

The following RAOs are preliminary descriptions of what the remedial action is expected to accomplish. The RAOs are also used to support the evaluation of the various remedial alternatives in terms of the threshold and balancing CERCLA criteria.

- **RAO 1:** Prevent or mitigate unacceptable risk to human health and ecological receptors associated with radiological exposure to waste or soil contaminated above risk-based criteria.
- **RAO 2:** Prevent or mitigate unacceptable risk to human and ecological receptors associated with chemical exposure to waste or soil contaminated at or above risk-based criteria for human health or soil contaminant levels on a population or community level for ecological receptors.

- **RAO 3:** Control the sources of potential groundwater contamination to support the Central Plateau groundwater goal of restoring and protecting the beneficial uses of groundwater.

3.11 Preliminary Remediation Goals

For human health direct contact, the PRGs will be developed as described in Section 3.9.1.8. Ecological PRGs are described in Section 3.9.2.7. For groundwater protection, development of PRGs will be based on the process defined in DOE's graded approach document (DOE/RL-2011-50). Section 3.9.3 provides the implementation details for this approach.

This page intentionally left blank.

4 Work Plan Approach and Rationale

This chapter presents the approach and rationale for conducting the RI/FS for the 200-WA-1 and 200-BC-1 OUs. The data collected during the RI will be used to characterize the waste sites, conduct a BRA, and support the development and evaluation of remedial action alternatives. Characterization activities are based on identified data gaps that will be filled to support the RI/FS. The SAP (Appendix E) describes the types of analyses to be performed; the samples to be analyzed; and the precision, accuracy, representativeness, completeness, and comparability parameters to obtain a sufficient representation of conditions at the site.

4.1 Strategy for Defining Data Needs

Data gathering occurs at various stages in the RI/FS, remedial design, and remedial action process.

4.1.1 Pre-decision Stage

Data are collected during the RI to support the following actions:

- Identify contaminant sources
- Evaluate the nature and extent of contaminants in environmental media
- Characterize potential risks to HHE
- Evaluate potential impacts to groundwater
- Determine the need for action through the BRA
- Support the development and evaluation of remedial action alternatives to mitigate unacceptable risks

4.1.2 Remedial Design Stage

Additional field data may be collected to support remedial design. For example, sampling may be conducted to determine the precise boundaries of a barrier or excavation and to verify waste characterization information for disposal purposes.

4.1.3 Remedy Implementation Stage

Additional confirmation or verification data to support remedy implementation and evaluate remedial action progress may be obtained using an observational or performance sampling approach.

4.1.4 Remedy Completion Stage

During this stage, data are collected to verify that the remedy has been effective and mitigated the identified risk for the waste sites, and that the remedial action is complete.

This work plan presents an evaluation of data for the pre-decision stage. Information concerning the nature and extent of contamination at waste sites was assessed to determine whether sufficient data exist to characterize risks and impacts to groundwater to support remedial action decision making.

4.2 Data Needs Assessment Process

This section presents a summary of the process that was used to meet waste site-specific or waste site group-specific objectives. The goal of the data needs assessment was to identify waste sites or waste site groups that require additional data to assess nature and extent, to characterize risks, to evaluate impacts to groundwater, or to support remedial action alternative evaluation. Data needs are identified by reviewing uncertainties associated with the nature and extent of contamination, contaminant migration pathways, potential threats to groundwater, assessment of risk to HHE, screening of remedial technologies, and development and evaluation of remedial action alternatives.

The following are site-specific objectives of the data needs assessment:

- Evaluate the available data on the nature and extent of known and potential environmental contamination at each waste site
- Determine whether the data are sufficient to characterize risk to HHE
- Determine if the data are adequate to support remedial technology screening and the development and evaluation of remedial action alternatives
- Where data are determined to be insufficient, develop sampling and analysis to fill the data gap

Information gathered to evaluate the nature and extent of contamination (Appendix D), as well as other relevant information, was used to state the problem to be resolved clearly and concisely:

> *The waste sites in the 200-WA-1 and 200-BC-1 OUs have either received liquid waste streams or have been contaminated to some degree from Hanford Site chemical and radiological processes. Residual radiological and chemical constituents associated with these activities have potentially contaminated shallow/deep soil and may pose a threat to groundwater quality. Concentrations of contaminants in amounts posing an unacceptable risk to human health or the environment, or which present a current or future source of unacceptable groundwater contamination, will be identified and characterized to determine a proper remedial action.*

The information (data) input needed to resolve the problem statement is specified for each 200-WA-1 and 200-BC-1 OU waste site in Appendix D.

4.2.1 Waste Site-Specific Assessment Process

Information on the nature and extent of contamination at waste sites was assessed to determine whether sufficient data exist to evaluate HHE risks, evaluate impact to groundwater, and support remedial action decisions. Data needs were evaluated for each 200-WA-1 and 200-BC-1 OU waste site during process execution. The results of this process are included in Appendix D.

The following categories are evaluated for outstanding data:

- Site Location Confirmed?
- Contamination Present?
  (Process-related constituents greater than background concentration; radioactive/nonradioactive/organic/inorganic)
- Release History Defined?
  (Solid waste, process liquid waste, process wastewater, sanitary wastewater, nonaqueous-phase liquid [NAPL], VOCs, contaminants in soil, and surface contamination)
- Soil Concentration Range Defined?
  (Apparent minimum and maximum)
- Distribution in Affected Media Described?
  (Extent of lateral and vertical contaminant distribution; estimated volume of affected media)
- Unique Geochemical Characteristics Identified?
  (Presence of NAPL, extreme pH conditions, and mobility enhancing/retarding conditions)

- Intermediate and Deep Vadose[1] Impacts Present?
  (Greater than 4.6 m [15 ft] bgs)

Appendix D provides supporting information used to complete the waste site-specific analysis of data needs. Where appropriate, a similar site approach has been used to streamline the characterization, as outlined in Section 4.2.2.

Due to the number and various types of waste sites included in the 200-WA-1 and 200-BC-1OUs, it is helpful to segregate the discussion of data needs into both geographic areas and to provide additional analysis of the waste sites according to the relative estimated depth of contamination. Section 3.3.1 provides a discussion of the geographic and depth groupings of the 200-BC-1 and 200-WA-1 OU waste site data needs assessment. The breakdown of 200-WA-1 and 200-BC-1 OU waste sites groupings by vadose zone contamination depth is as follows:

- 58 Shallow waste sites
- 75 Intermediate waste sites
- 39 Deep waste sites

4.2.2 Use of Similar Site Approach

DOE/RL-98-28 outlines an approach to streamline waste site characterization using investigation results from a representative waste site. This approach has been used in a number of work plans, including DOE/RL-2007-02. Implementation of this approach is intended to provide efficient use of human and financial resources and to reduce sampling in high-risk areas that have the potential to expose workers to high radiation and/or contamination levels.

Following this strategy, some 200-WA-1 and 200-BC-1 OU waste sites were combined into groups (based on similar location, geology, waste site history, contaminants, etc.). Within each group, one representative waste site was selected for field investigation, including sampling. The findings from investigation of the representative waste site will be applied to the other waste sites in the same group that were not investigated. This approach assumes that waste sites with no field investigation data have a similar contaminant distribution and pose risks similar to the investigated site. This approach is well suited to the 200-WA-1 and 200-BC-1 OU waste sites based on the similarities in waste site characteristics, Central Plateau hydrogeology, and contaminant fate and transport processes. Information from the representative site can be used to support evaluation of HHE risk and remedy analysis of the uncharacterized waste sites, if necessary. Appropriate remedial design characterization, as necessary to support remedial action, will be performed at all waste sites in the group during remedy implementation.

The similar site comparisons require that the following elements be similar to their counterparts:

1. Design: Waste site construction determines the depth and configuration of the discharge area.
2. Primary waste source: Sources are the same or from very similar waste streams. Waste sites that received large radionuclide inventories as a liquid waste pose a different threat than sites receiving solid waste or liquid discharge containing contaminant concentrations near background levels.
3. Waste release scenario and volume: The total discharges and loading rates to the units determine depth and configuration of the discharge area.

[1] This definition of deep vadose is solely for the purpose of the 200-WA-1 and 200-BC-1 OU data needs assessment.

4. Hydrogeologic conditions: The depth to groundwater beneath the point of discharge and the stratigraphic sequence will influence contaminant distribution and probability of contaminants reaching groundwater.

5. Geochemical characteristics: The distances that contaminants travel in the vadose zone depend on how strongly they are partitioned to the soils or whether there is potential for formation of solid phase precipitates. Acids or solvents that keep contaminants in solution may transport contaminants farther from the point of discharge than they would normally travel under neutral pH conditions.

Based on these criteria, an assessment of the 200-WA-1 and 200-BC-1 OU waste sites found 9 groups consisting of 1 representative waste site in each group and up to 15 similar waste sites. The similar site groupings and representative waste sites are presented in Tables 4-1 and 4-2. The rationale for selection of the representative waste sites is as follows:

- 216-B-26 was chosen as the representative waste site for the 15 trenches listed in Table 4-1 because it had previously been identified as a representative site for the BC Trenches, and field investigations were performed to characterize the site as described in DOE/RL-2004-66 and DOE/RL-2009-36, *BC Cribs and Trenches Excavation-Based Treatability Test Report*.

- 216-B-14 was chosen as the representative waste site for the five cribs listed in Table 4-1 because it had previously been identified as a representative site for the BC Cribs, and field investigations were performed to characterize the site as described in DOE/RL-2009-36.

- 216-B-58 was chosen as the representative waste site for the 216-B-53B and 216-B-54 Trenches because it had previously been identified as a representative site for the BC Trenches, and field investigations were performed to characterize the site as described in DOE/RL-2004-66.

- 216-S-6 had a slightly higher pore volume, received waste streams with higher potential for contamination, and received waste streams with a higher total inventory of radionuclides at discharge (RHO-CD-673, *Handbook for 200 Area Waste Sites*) than 216-S-5. Results from geophysical logging in 2006 near the center of the waste sites confirmed higher concentrations of cesium-137 and total gamma in the shallow and deep vadose zone at 216-S-6 compared to 216-S-5. For this reason, 216-S-6 was chosen as the representative waste site for the 216-S-5 Crib despite the higher waste release inventory for some analytes according to the SIM shown in Table 4-2. Due to the overflow trench at 216-S-5, the shapes and sizes of these sites are less similar than the other groups, but the pore volume discharged to the sites is very similar. Data from the 216-S-6 Crib will be used to characterize shallow and deep soil within and beneath the 216-S-5 Crib site. However, additional soil sampling will be performed to evaluate soil contamination in the overflow trench at 216-S-5.

- 216-T-28 was chosen as the representative waste site for the 216-T-27 Crib because it had a much higher pore volume and was in use for a longer period.

- 216-T-34 was chosen as the representative waste site for the 216-T-35 Crib because it had a higher pore volume.

- 216-U-6 was chosen as the representative waste site for the 216-U-5 Trench because it had a higher pore volume. Uncertainty in the dimensions of 216-U-5 warrants further characterization of shallow soil at that site.

Table 4-1. 200-BC-1 OU Similar Site Groupings

	Design, Primary Waste Source, and Geochemical Characteristics			Waste Release Scenario and Volumes			Waste Release Inventory (SIM)							Hydrogeology	
Waste Site Name	Waste Site Type	Discharge Depth (ft)	Waste Source	Dates of Use	Volume Released (mL)	Pore Volume	NO_3 (kg)	Cs-137 (Ci)	Eu-154 (Ci)	I-129 (Ci)	Sr-90 (Ci)	Tc-99 (Ci)	Other Relatively Significant Constituents	Proximity to Representative Site (ft)	Vadose Zone Thickness (ft)
216-B-26 Similar Site Group															
216-B-26	**Process Waste Trench**	**10**	**Scavenged TBP Supernatant from 221-U Building**	**1956 and 1957 – 3 months**	**4.75**	**0.42**	**9.5e5**	**585**	**5.3**	**0.023**	**488**	**18**	**Am-241, Cr, $Fe(CN)_6$, Np-237, Pu, U**	**NA**	**330**
216-B-20	Process Waste Trench	10	Scavenged TBP Supernatant from 221-U Building	1956 – 2 months	4.68	0.34	8.3e5	549	4.8	0.027	307	15	Am-241, Cr, $Fe(CN)_6$, Np-237, Pu, U	850	330
216-B-21	Process Waste Trench	10	Scavenged TBP Supernatant from 221-U Building	1956 – 2 months	4.67	0.34	9.1e5	164	5.1	0.024	123	17	Am-241, Cr, Np-237, Pu, U	800	330
216-B-22	Process Waste Trench	10	Scavenged TBP Supernatant from 221-U Building	1956 – 1 month	4.74	0.34	8.8e5	166	5.0	0.026	122	16	Am-241, Cr, Np-237, Pu, U	750	330
216-B-23	Process Waste Trench	10	Scavenged TBP Supernatant from 221-U Building	1956 – 1 month	4.52	0.32	8.4e5	159	4.8	0.025	116	16	Am-241, Cr, Np-237, Pu, U	300	330
216-B-24	Process Waste Trench	10	Scavenged TBP Supernatant from 221-U Building	1956 – 2 months	4.87	0.34	9.7e5	171	5.5	0.024	130	19	Am-241, Cr, Np-237, Pu, U	200	330
216-B-25	Process Waste Trench	10	Scavenged TBP Supernatant from 221-U Building	1956 – 2 months	4.91	0.27	9.8e5	172	5.5	0.024	131	19	Am-241, Cr, Np-237, Pu, U	100	330
216-B-27	Process Waste Trench	10	Scavenged TBP Supernatant from 221-U Building	1957 – 3 months	4.42	0.31	8.8e5	155	5.0	0.022	118	17	Am-241, Cr, Np-237, Pu, U	100	330
216-B-28	Process Waste Trench	10	Scavenged TBP Supernatant from 221-U Building	1957 – 3 months	5.05	0.36	9.5e5	177	5.4	0.027	130	18	Am-241, Cr, Np-237, Pu, U	200	330
216-B-29	Process Waste Trench	8	Scavenged TBP Supernatant from 221-U Building	1957 – 2 months	4.83	0.34	9.6e5	170	5.4	0.024	249	18	Am-241, Cr, Np-237, Pu, U	1,150	332
216-B-30	Process Waste Trench	8	Scavenged TBP Supernatant from 221-U Building	1957 – 1 month	4.78	0.34	8.3e5	168	4.8	0.028	119	15	Am-241, Cr, Np-237, Pu, U	1,050	332
216-B-31	Process Waste Trench	8	Scavenged TBP Supernatant from 221-U Building	1957 –2 months	4.85	0.33	8.5e5	170	4.9	0.029	121	15	Am-241, Cr, Np-237, Pu, U	950	332
216-B-32	Process Waste Trench	8	Scavenged TBP Supernatant from 221-U Building	1957 – 2 months	4.75	0.34	8.2e5	167	4.7	0.029	151	15	Am-241, Cr, Np-237, Pu, U	875	332
216-B-33	Process Waste Trench	8	Scavenged TBP Supernatant from 221-U Building	1957 – 2 months	4.75	0.33	8.0e5	167	4.6	0.029	170	14	Am-241, Cr, Np-237, Pu, U	800	332
216-B-34	Process Waste Trench	8	Scavenged TBP Supernatant from 221-U Building	1957 – 1 month	4.88	0.35	8.2e5	171	4.7	0.030	165	14	Am-241, Cr, Np-237, Pu, U	725	332
216-B-52	Process Waste Trench	8	Scavenged TBP Supernatant from 221-U Building	1957 and 1958 – 2 months	8.53	0.53	1.5e6	300	8.4	0.052	387	26	Am-241, Cr, Np-237, Pu, U	400	332
216-B-14 Similar Site Group															
216-B-14	**Process Waste Crib**	**13**	**TBP Supernatant from U Plant Uranium Recovery and Scavenged Tank Farm Waste**	**1956 – 2 months**	**8.67**	**2.0**	**1.7e6**	**304**	**9.7**	**0.042**	**595**	**33**	**Am-241, Cr, Np-237, Pu, U**	**NA**	**327**
216-B-15	Process Waste Crib	13	TBP Supernatant from U Plant Uranium Recovery and Scavenged Tank Farm Waste	1956 and 1957– 21 months	6.32	1.4	1.3e6	222	7.1	0.031	168	24	Am-241, Cr, Np-237, Pu, U	150	327
216-B-16	Process Waste Crib	13	TBP Supernatant from U Plant Uranium Recovery and Scavenged Tank Farm Waste	1956 – 5 months	5.60	1.3	1.1e6	197	6.0	0.030	145	20	Am-241, Cr, Np-237, Pu, U	150	327
216-B-17	Process Waste Crib	13	TBP Supernatant from U Plant Uranium Recovery and Scavenged Tank Farm Waste	1956 – 1 month	3.41	0.8	5.6e5	120	3.3	0.022	83	9.8	Am-241, Cr, Np-237, Pu, U	225	327
216-B-18	Process Waste Crib	13	TBP Supernatant from U Plant Uranium Recovery and Scavenged Tank Farm Waste	1956 – 2 months	8.52	1.9	1.7e6	299	10	0.042	227	32	Am-241, Cr, Np-237, Pu, U	325	327
216-B-19	Process Waste Crib	13	TBP Supernatant from U Plant Uranium Recovery and Scavenged Tank Farm Waste	1957 – 9 months	6.35	1.4	1.1e6	223	6.4	0.037	159	20	Am, Cr, Np-237, Pu, U	350	327

Table 4-1. 200-BC-1 OU Similar Site Groupings

Waste Site Name	Design, Primary Waste Source, and Geochemical Characteristics			Waste Release Scenario and Volumes			Waste Release Inventory (SIM)							Hydrogeology	
	Waste Site Type	Discharge Depth (ft)	Waste Source	Dates of Use	Volume Released (mL)	Pore Volume	NO_3 (kg)	Cs-137 (Ci)	Eu-154 (Ci)	I-129 (Ci)	Sr-90 (Ci)	Tc-99 (Ci)	Other Relatively Significant Constituents	Proximity to Representative Site (ft)	Vadose Zone Thickness (ft)
216-B-58 Similar Site Group															
216-B-58	**Process Waste Trench**	**8**	**Accumulated Waste from 304 Building**	**1965 to 1967 – 20 months**	**0.42**	**0.07**	**713**	**4.9**	**6.1e-3**	**0**	**4.2**	**1.4e-3**	**Am-241, Pu, U**	**NA**	**326**
216-B-53B	Process Waste Trench	10	Accumulated Waste from 304 Building	1962 and 1963 – 5 months	0.02	0.18	892	6.1	7.6e-3	0	5.2	1.8e-3	Am-241, Cr, Pu, U	250	324
216-B-54	Process Waste Trench	8	Accumulated Waste from 304 Building	1963 – 8 months	1.00	0.005	892	6.1	7.6e-3	0	5.2	1.8e-3	Am-241, Pu, U	100	326

Note: Other Relatively Significant Constituents are constituents (besides those with inventories shown) with relatively high potential to contribute to risk based on multiple factors. Ratios of source concentrations (from SIM [RPP-26744, *Hanford Soil Inventory Model, Rev. 1*]) to groundwater standards were used to rank potential risks to groundwater from mobile constituents. Source concentrations multiplied by soil partition coefficients and divided by soil PRGs were used to rank potential risks from industrial human health exposure pathways. PRGs were taken from ECF-HANFORD-10-0452, *Calculation of Radiological Preliminary Remediation Goals in Soil for an Industrial Worker Exposure Scenario for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports*, and ECF-HANFORD-10-0453, *Calculation of Standard Method C Direct Contact Soil Cleanup Levels for Industrial Land Use for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports*, for the limited purpose of these ranking metrics. In lieu of transport calculations, rankings factored in attenuation mechanisms such as radioactive decay, adsorption, and dilution to weigh potential for risk to groundwater.

Bold = representative waste site
Discharge Depth = bottom of crib or trench below ground surface based on design drawings
Pore Volume = liquid discharge volume/(structure bottom area [vadose zone thickness] 30% porosity)
Proximity = distance from center of site to center of representative site
Vadose Zone Thickness = bottom of structure elevation (based on RHO-CD-673, *Handbook 200 Areas Waste Sites*, surface elevation and discharge depth) – groundwater elevation (interpolated from DOE/RL-2013-22, *Hanford Site Groundwater Monitoring Report for 2012*)
Am-241 = americium-241
Cr = chromium
Cs-137 = cesium-137
Eu-154 = europium-154
$Fe(CN)_6$ = ferrocyanide
I-129 = iodine-129
NA = not applicable
NO_3 = nitrate
Np-237 = neptumium-137
OU = operable unit
PRG = preliminary remediation goal
Pu = plutonium
SIM = site inventory model
Sr-90 = strontium-90
TBP = tributyl phosphate
Tc-99 = technetium-99
U = uranium

Table 4-2. 200-WA-1 OU Similar Site Groupings

	Design, Primary Waste Source and Geochemical Characteristics			Waste Release Scenario and Volumes			Waste Release Inventory (SIM)								Hydrogeology	
Waste Site Name	Waste Site Type	Discharge Depth (ft)	Waste Source	Dates of Use	Volume Released (mL)	Pore Volume	Cr (kg)	NO_2 (kg)	Cs-137 (Ci)	Pu-239 (Ci)	Sr-90 (Ci)	U, total (kg)	Other Relatively Significant Constituents	Proximity to Representative Site (ft)	Vadose Zone Thickness (ft)
216-S-6 Similar Site Group																
216-S-6	**Condensate Crib**	**15**	**Higher Contamination Liquid from 202 S Building**	**1954 to 1972**	**4,440**	**64**	**0.18**	**2.2e5**	**11**	**0.25**	**5.8**	**853**		**-**	**218**
216-S-5	Condensate Crib	15	Lower Contamination Liquid from 202 S Building	1954 to 1957	4,085	58	3.6	2.0e5	56	0.014	31	1,100		900	218
216-T-28 Similar Site Group																
216-T-28	**Process Waste Crib**	**15**	**Steam Condensate and Process Decontamination Waste from T Plant and 340 Lab Building**	**1960 to 1966**	**42**	**26**	**6.0e3**	**1.6e4**	**146**	**37**	**124**	**473**	**Am-241, Eu-154, NO_3**	**-**	**210**
216-T-27	Process Waste Crib	15	Steam Condensate and Process Decontamination Waste from T Plant and 340 Lab Building	**1965 – 3 months**	7	4.5	1.2e3	3.3e3	4.9	1.5	4.1	31	Am-241, Eu-154, NO_3	80	210
216-T-34 Similar Site Group																
216-T-34	**Process Waste Crib**	**15**	**Liquid Lab Waste from 340 Building**	**1966 to 1967 – 11 months**	**17**	**1.4**	**5,833**	**1.5e4**	**0.31**	**5.2**	**0.17**	**64**	**Am-241, I-129, NO_3**	**-**	**265**
216-T-35	Process Waste Crib	15	Liquid Lab Waste from 340 Building	1967 – 10 months	6	0.6	3.0	0	0.077	0.88	7.1e-3	30	Am-241	375	262
216-U-6 Similar Site Group																
216-U-6	**Process Waste Trench**	**10**	**Unirradiated Uranium Cold Startup Liquid Waste from the 221-U Building**	**March 1952**	**2.25**	**1.4**	**941**	**2.9e4**	**0**	**0**	**0**	**634**	NO_3	**-**	**268**
216-U-5	Process Waste Trench	10	Unirradiated Uranium Cold Startup Liquid Waste from the 221-U Building	March 1952	2.25	0.64	941	2.9e4	0	0	0	634	NO_3	100	268
216-Z-16 Similar Site Group																
216-Z-16	**Process Waste Trench**	**16**	**Plutonium-Contaminated Wastewater**	**1968 to 1977**	**102**	**30**	**13**	**0**	**4.8e-5**	**2.7**	**4.4e-5**	**0.42**	**Am-241, F**	**-**	**217**
216-Z-17	Process Waste Trench	8	Plutonium-Contaminated Wastewater	1967 to 1968 – 12 months	37	9.8	4.6	0	1.7e-5	0.99	1.6e-5	0.15	Am-241, F	800	222
216-Z-6 Similar Site Group																
216-Z-6	**Process Waste Trench**	**8**	**Liquid Lab Waste from 231-Z Building**	**1945 – 1 month**	**0.098**	**0.12**	**1.0e-3**	**1.3**	**0.50**	**1.5**	**0.49**	**0.030**	**Am-241, Butanol, CCl_4, Np-237,TBP**	**-**	**216**
216-Z-4	Process Waste Trench	15	Liquid Lab Waste from 231-Z Building	1945 – 1 month	0.011	0.06	1.1e-4	0.14	0.23	0.66	0.23	0.014	Am-241, Butanol,CCl_4, Np-237,TBP	150	215

Table 4-2. 200-WA-1 OU Similar Site Groupings

Waste Site Name	Design, Primary Waste Source and Geochemical Characteristics			Waste Release Scenario and Volumes			Waste Release Inventory (SIM)							Hydrogeology	
	Waste Site Type	Discharge Depth (ft)	Waste Source	Dates of Use	Volume Released (mL)	Pore Volume	Cr (kg)	NO_3 (kg)	Cs-137 (Ci)	Pu-239 (Ci)	Sr-90 (Ci)	U, total (kg)	Other Relatively Significant Constituents	Proximity to Representative Site (ft)	Vadose Zone Thickness (ft)

Note: Other Relatively Significant Constituents are constituents (besides those with inventories shown) with relatively high potential to contribute to risk based on multiple factors. Ratios of source concentrations (from SIM [RPP-26744, *Hanford Soil Inventory Model, Rev. 1*]) to groundwater standards were used to rank potential risks to groundwater from mobile constituents. Source concentrations multiplied by soil partition coefficients and divided by soil PRGs were used to rank potential risks from industrial human health exposure pathways. PRGs were taken from ECF-HANFORD-10-0452, *Calculation of Radiological Preliminary Remediation Goals in Soil for an Industrial Worker Exposure Scenario for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports*, and ECF-HANFORD-10-0453, *Calculation of Standard Method C Direct Contact Soil Cleanup Levels for Industrial Land Use for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports*, for the limited purpose of these ranking metrics. In lieu of transport calculations, rankings factored in attenuation mechanisms such as radioactive decay, adsorption, and dilution to weigh potential for risk to groundwater.

Bold = representative waste site
Discharge Depth = bottom of crib or trench below ground surface based on design drawings
Pore Volume = liquid discharge volume/(structure bottom area [vadose zone thickness] 30% porosity)
Proximity = distance from center of site to center of representative site
Vadose Zone Thickness = bottom of structure elevation (based on RHO-CD-673, *Handbook 200 Areas Waste Sites*, surface elevation and discharge depth) – groundwater elevation (interpolated from DOE/RL-2013-22, *Hanford Site Groundwater Monitoring Report for 2012*)
Am-241 = americium-241
Cr = chromium
Cs-137 = cesium-137
Eu-154 = europium-154
I-129 = iodine-129
NO_3 = nitrate
Np-237 = neptumium-137
OU = operable unit
PRG = preliminary remediation goal
Pu-239 = plutonium
SIM = site inventory model
Sr-90 = strontium-90
SIM = site inventory model
TBP = tributyl phosphate
U = uranium

- 216-Z-16 was chosen as the representative waste site for the 216-Z-17 Trench because it had a much higher pore volume and was in use for a longer period.
- 216-Z-6 was chosen as the representative waste site for the 216-Z-4 Trench because it had a higher pore volume.

The balance of 200-WA-1 and 200-BC-1 OU waste sites that do not fit the criteria for inclusion in similar site groups will be evaluated individually in the RI/FS, based on existing and proposed characterization data.

4.3 Waste Sites Adequately Characterized

At the end of the initial evaluation, waste sites are divided into those with sufficient data to assess nature and extent, characterize risks, and evaluate remedial alternatives, and those sites that require additional data. The SAP (Appendix E, Table E-10) identifies which waste sites have data needs along with the specific rationale applied to the data needs decision for each waste site.

Based on the analysis of the input information for each site presented in Appendix D, one 200-BC-1 OU waste site and six 200-WA-1 OU waste sites are considered adequately characterized with sufficient data to evaluate risk to HHE and evaluate alternatives, and no additional data will be collected. These sites are listed in Table 4-3 with a brief description of the characterization data available. Detailed summaries of the existing characterization data available and a brief description of the nature and extent of contamination at each waste site are provided in the Waste Site Summaries in Appendix D.

Table 4-3. 200-WA-1 and 200-BC-1 OUs Adequately Characterized Waste Sites

Waste Site(s)	Waste Site Type	Characterization Summary and Data Adequacy Rationale
		BC Cribs and Trenches
216-B-26	Trench	One existing deep vadose zone borehole within the trench footprint to the water table at a depth of 104 m (340 ft) bgs and eight shallow boreholes with soil data to 2.4 to 5.2 m (8 to 17 ft) bgs. Sufficient soil sampling data exist to perform HHE risk assessment and to evaluate groundwater protection, nature and extent of contamination, and remedial alternatives. Groundwater sampling data show contaminant of potential concern concentrations below regulatory levels and, therefore, current impacts from this site to groundwater are limited.
		U Plant Vicinity
216-U-1&2	Crib	Surface radiological surveys performed at overlying the UPR-200-W-19 site with five focused surface soil samples. Six shallow subsurface borehole samples collected from three separate boreholes between 0 and 4.6 m (15 ft) bgs. One deep vadose zone borehole near the center of the 216-U-1 Crib extends to 54 m (176 ft) bgs with soil analytical data. This borehole did not extend to groundwater but down to low contaminant concentrations indicated at the CCU. Uranium-238 concentrations reach a maximum of 10,800 pCi/g at the base of the crib and rapidly diminish with depth to less than 10 pCi/g, down to the top of the CCU. Uranium-238 concentrations reach a maximum of 32 pCi/g in the CCU but diminish to less than 5 pCi/g at the bottom of the borehole. Two lateral deep vadose zone borings, installed to the CCU, bound the lateral extent. Twelve DPT borings to 15 to 18 m (50 to 60 ft) bgs were installed near the 216-U-1&2 Cribs with geophysical logging of each borehole.

Table 4-3. 200-WA-1 and 200-BC-1 OUs Adequately Characterized Waste Sites

Waste Site(s)	Waste Site Type	Characterization Summary and Data Adequacy Rationale
		Nine auger borings to approximately 15 m (50 ft) bgs also were installed near the 216-U-1&2 Cribs with limited sampling for technetium-99, nitrogen as nitrate/nitrite, mercury, cadmium, uranium (metal), uranium-235, uranium-238, antimony, and arsenic and other inductively coupled plasma/mass spectrometer metals (barium, chromium [total], cobalt, copper, lead, manganese, selenium, silver, strontium, thallium, titanium, vanadium, and zinc). Geophysical logging data are available for three existing wells near the 216-U-1&2 Cribs, as well as at four additional DPTs at 241-U-361 and UPR-200-W-19. Sufficient soil sampling data exist to perform HHE risk assessment and to evaluate groundwater protection, nature and extent of contamination, and remedial alternatives.
241-U-361	Settling tank	This site is adequately characterized by four DPT borings surrounding the tank to assess release potential. The tank contents also have been sampled. Investigation results indicate no significant contaminant release. In August and September 2007, the settling tank was sampled. Two supernatant samples were collected along with a seven-segment core sample of the sludge. It is presently estimated to contain 104,100 L (27,500 gal) of sludge. The presence of sludge and supernate in the tank 40 years after the tank was removed from service indicates that the tank is not likely to have leaked to a significant degree, if at all. Shallow contamination near Tank 241-U-361 is attributed to UPR-200-W-19. Sufficient soil sampling data exist to perform HHE risk assessment and to evaluate groundwater protection, nature and extent of contamination, and remedial alternatives.
216-U-4	Reverse well	This site is adequately characterized by a deep vadose zone boring drilled to 59 m (194 ft) bgs (CCU at 53.6 m [176 ft] bgs). Concentrations of radiological and inorganic contaminants drop to near background or nondetect levels below the 18 m (60 ft) sample. Due to the depth of release of the reverse well, shallow contamination identified in the deep vadose zone borehole is attributed to the 216-U-4A French drain. Sufficient soil sampling data exist to perform HHE risk assessment and to evaluate groundwater protection, nature and extent of contamination, and remedial alternatives.
216-U-4A	French drain	This site is adequately characterized along with the 216-U-4 French drain directly adjacent to 216-U-4 Reverse Well. During borehole installation, soil was excavated to a depth of 3 m (10 ft). No contamination was identified above a depth of 1.2 m (4 ft) bgs. Two samples were collected from the borehole above 4.6 m (15 ft). Sufficient soil sampling data exist to perform HHE risk assessment and to evaluate groundwater protection, nature and extent of contamination, and remedial alternatives.
216-U-3	French drain	One borehole drilled at edge of a French drain structure to a depth of 39.5 m (129.5 ft) bgs. Low levels of contaminants were found throughout the borehole. Only one sample was collected in the top 4.6 m (15 ft) bgs; however, release depth of the French drain is at 3.7 m (12 ft) bgs with very low concentrations of contaminants at that depth. Geophysical logging of Borehole C4559 indicate that the only manmade radionuclide identified is cesium-137 at 1 pCi/g near the ground surface. Sufficient soil sampling data exist to perform HHE risk assessment and to evaluate groundwater protection, nature and extent of contamination, and remedial alternatives.

Table 4-3. 200-WA-1 and 200-BC-1 OUs Adequately Characterized Waste Sites

Waste Site(s)	Waste Site Type	Characterization Summary and Data Adequacy Rationale
Z Plant Vicinity		
216-Z-7	Crib	Existing characterization includes one deep vadose zone borehole to groundwater through the crib footprint and one DPT with soil sampling data and geophysical logs. Sufficient soil sampling data exist to perform HHE risk assessment and to evaluate groundwater protection, nature and extent of contamination, and remedial alternatives.

bgs = below ground surface
CCU = Cold Creek unit
DPT = direct push technology
HHE = human health and the environment
OU = operable unit
PRG = preliminary remediation goal
RAO = removal action objective
TCRA = time-critical removal action
VCP = vitrified clay pipe

4.4 Sites Requiring Additional Data

In the 200-WA-1 and 200-BC-1 OUs, 139 waste sites have been identified as having additional data needs. Specific data needs for each of these sites are outlined in Appendix D. A specific approach for fulfilling these data needs is provided in the SAP (Appendix E). Generally, this approach includes the following:

- Soil sampling and analysis from shallow borings (0 to 4.6 m [15 ft] bgs) will be used to determine whether concentrations within the upper 4.6 m (15 ft) exceed the risk thresholds for protection of human health and/or if concentrations exceed ecological risk thresholds, as well as the horizontal and vertical extent of contamination in shallow soil to support technology screening and remedial action alternative development.
- Soil sampling and analysis from a single deep borehole placed in proximity to the highest suspected contamination will be used to support groundwater protection evaluations to determine whether the chemical and/or radiological contaminants in the intermediate and deep vadose zone exceed protective levels.

However, the sampling plan does not include additional deep borings for collecting data needed for determining the lateral extent of chemical and/or radiological contamination in the deep vadose zone. Lateral extent will be estimated in the RI/FS report by extrapolating data, using professional judgment or vadose zone modeling tools, from sites in the Central Plateau where the deep vadose zone contamination has been adequately characterized (e.g., the tank farms, 216-U-8 and 216-U-12 Cribs, 200-DV-1 sites, and 216-U-1&2 Cribs). Additional data may be collected during the remedial design phase.

4.4.1 Nonsoil Features

In the 200-WA-1 and 200-BC-1 OUs, a subset of waste sites with "nonsoil" features were identified as having separate data needs for the physical structure. These include vessels (and any waste contained therein) and other physical structures for which soil data are considered not adequately representative. These features include pipelines, USTs, building slabs, concrete basins, and vaults, but do not include timber structures within cribs or railroad tracks. Data needs for each of these sites are outlined in Appendix D. A specific approach for fulfilling these data needs is provided in the SAP (Appendix E). Generally, this approach includes the following:

- Sampling of solid and liquid waste contents from vessels (septic tanks, silos, solid waste vaults), if no data are available or existing data are of insufficient quality. Analytical data for these samples will be used to support evaluation of HHE risk and remedial action alternative development.
- Sampling of nonsoil features (pipelines, USTs, building slabs and foundations, basins, vaults) for which separate characterization data are required to support evaluation of HHE risk and remedial action alternative development.

4.5 Summary of Data Needs Assessment

Sections 4.5.1 and 4.5.2 discuss the results of the data needs assessment for the 200-BC-1 OU and 200-WA-1 OU, respectively. Table E-10 (Appendix E) identifies which waste sites have outstanding data needs along with the specific rationale applied to the data needs decision for each site. A more detailed analysis of the specific data needs identified for each of these sites is described in Appendix D.

4.5.1 200-BC-1 OU Data Needs Evaluation Results

Evaluation results indicate that no additional data are needed to complete the evaluation of risk and remedial alternatives for 23 of the 27 waste sites in the 200-BC-1 OU. The results of this assessment fall into three general categories:

- **Adequately Characterized Sites = 1** Sites that have already received vadose zone characterization sufficient to support evaluation of HHE risk and remedy analysis. Within the 200-BC-1 OU, one trench (216-B-26) was identified in this category. This site has sufficient characterization to serve as a representative site for its similar site grouping.
- **Similar Sites = 22** Sites for which characterization data from a representative site can be used. Using a similar site approach requires that the sites be sufficiently similar in design, primary waste source, COCs, waste release scenario and volume, hydrogeologic conditions, and contaminant migration. These similarities allow the characterization of the representative site to provide a comparable analysis or to provide bounding conditions for the uncharacterized site, to support evaluation of HHE risk and remedy analysis. Twenty-five of the twenty-seven 200-BC-1 OU waste sites have been included in three similar site groupings. Three sites with ample vadose zone characterization either currently (216-B-26) or once all data needs are addressed (216-B-14 and 216-B-58) in the 200-BC-1 OU will serve as representative sites for 22 sites that are considered similar.
- **Data Needs Sites = 4** Sites requiring additional data to support selection of a remedy decision. In the 200-BC-1 OU, four waste sites have been identified as having additional data needs. Two of these sites (216-B-14 and 216-B-58) require additional characterization and will serve as representative sites in their respective similar site groupings. The final two sites (200-E-14 and 216-B-53A) will be characterized independently.

4.5.2 200-WA-1 OU Data Needs Evaluation Results

The 145 waste sites in the 200-WA-1 OU are more diverse and are in different stages of investigation, resulting in a higher complexity of data evaluation results than the 27 waste sites in the 200-BC-1 OU. The results of this assessment fall into three general categories:

- **<u>Adequately Characterized Sites = 6</u>** Sites that have already received vadose zone characterization sufficient to support evaluation of HHE risk and remedy analysis. Within the 200-WA-1 OU, six waste sites were identified in this category. Five of the characterized sites are in the U Plant geographical area (216-U-1&2, 216-U-3, 216-U-4, 216-U-4A, and 241-U-361), with one in Z Plant (216-Z-7).
- **<u>Similar Sites = 6</u>** Sites for which characterization data from a representative site can be used. Using a similar site approach requires that the sites be sufficiently similar in design, primary waste source, COCs, waste release scenario and volume, hydrogeologic conditions, and contaminant migration. These similarities allow the characterization of the representative site to provide a comparable analysis or to provide bounding conditions for the uncharacterized site, to support evaluation of HHE risk and remedy analysis. The 200-WA-1 OU has six groups of similar sites. Sites chosen to be representative for each group are 216-S-6, 216-T-28, 216-U-6, 216-T-34, 216-Z-16, and 216-Z-6. Twelve of the 145 sites are included under the 6 groups of similar sites. However, each of the six comparisons is contingent on execution of additional sampling and analysis for each of the six representative sites.
- **<u>Data Needs Sites = 135</u>** Sites requiring additional data to support selection of a remedy decision. In the 200-WA-1 OU, 135 waste sites have been identified as having additional data needs. Although 216-S-6 is a representative site for the 216-S-5 Crib area, additional data are required in the overflow trench connected to 216-S-5. Similarly, 216-U-6 is a representative site for the 216-U-5 Trench, which requires additional shallow data to determine the 216-U-5 location and boundaries. Therefore, Sites 216-S-5 and 216-U-5 are included in both the similar site group and data needs categories.

This page intentionally left blank.

5 Remedial Investigation/Feasibility Study Tasks

This chapter describes the tasks and activities to be performed for the RI/FS. These descriptions incorporate RI site characterization efforts, data evaluation methods, and the formulation and evaluation of remedial alternatives that will culminate with preparation of an RI/FS report and the proposed plan. These descriptions incorporate the RI site characterization field and analytical tasks necessary to fulfill the data needs presented in Chapter 4, data evaluation methods, analysis of remedial alternatives, reporting, and the preliminary determination of tasks to be conducted after completion of the RI/FS. Recommendations for follow-on characterization work during the design phase also will be provided where necessary to support remedy implementation.

5.1 Task 1—Scoping Project Planning

Project planning involves preparing the RI/FS work plan and field investigation planning documents. The work plan describes how the RI/FS will be implemented; how the investigation will support the overall assessment of site conditions; how investigation data will be evaluated, reduced, and presented; and how the essential elements of the RI/FS and proposed plan will be performed. The work plan includes the overall schedule for the investigation, subsequent studies, and document production. The field planning documents consist of the SAP (Appendix E), which includes the QAPjP, field sampling plan (FSP), and health and safety plan. The FSP provides a description of the field sampling activities. Site descriptions and sampling plans for each waste site are provided in Appendix D.

Because of the uncertainty associated with the tank and vault sump contents at the 241-WR Vault (see Appendix D), a separate DQO will be performed to determine if additional data must be obtained for this site, or if process knowledge and historical records can provide sufficient information for risk assessment and remedy evaluation. Additional records searches and staff interviews will be performed in preparation for the DQO process. If additional data needs related to the 241-WR Vault tank and sump contents are identified, a SAP amendment will be prepared.

If the DQO established the need to enter the 241-WR Vault, additional work planning and scoping will be required to facilitate safe entry into the vault structure.. For initial work planning purposes, reconnaissance would include determining the contents and volumes of each of the nine tanks, any materials remaining in vault sumps, the condition of the tanks and structure, and if feasible, collect samples of the contents of the tanks and sumps.

Because of the potential for highly hazardous conditions, specialized sampling teams, sampling equipment and entry procedures would be required. Based on previous Hanford Site experience, the required activities and approvals to gain access to the vault are presented below along with an estimated timeframe for completion.

- Prepare documented safety analysis, review, and revise (approximately 1 year)
- Perform high-risk planning (9 months), including the following:
  - Develop detailed technical approach
  - Prepare as low as reasonably achievable work plan
  - Prepare work package
- Review and approve planning documents (3 months)
- Mobilize and prepare for entry (6 months)

- Perform investigative entries and inspections (6 months)
- Set up, prepare, and sample contents (3 months)

Because of the in-depth need for planning, developing a safe approach, and obtaining the various approvals, a separate scope of work and SAP amendment would be developed and submitted to the regulatory agencies. The timeframe for submittal of the work planning documentation and SAP amendment, if necessary, would be coordinated with U Plant activities to determine if the investigation can be optimized with other ongoing U Plant activities.

5.2 Task 2—Community Relations

A public involvement plan (DOE et al., 2012, *Hanford Federal Facility Agreement and Consent Order Hanford Public Involvement Plan*) and the NCP (40 CFR 300) outline stakeholder and public involvement opportunities. Community involvement during the RI/RFI activities will be consistent with the Hanford Public Involvement Plan (DOE et al., 2012) and will comply with the NCP. The project will use existing public, stakeholder, and Tribal Nations involvement mechanisms and approaches.

Public involvement includes the following: local officials, general public, stakeholders, HAB, state of Oregon, and the Tribal Nations. All interactions with the HAB and the public are through and coordinated by the DOE-RL Public Involvement Manager.

5.2.1 Tribal Nations Involvement

Interactions between the Tribal Nations and DOE are usually facilitated through the DOE-RL Tribal Program Manager or the DOE-RL Cultural Resources Manager. DOE-RL works primarily with the Tribes affected by past or present Hanford Site operations, including the Yakama Nation, the Confederated Tribes of the Umatilla Indian Reservation, the Nez Perce Tribe, and the Wanapum Band of Indians. Tribal consultation is guided by DOE, 2006, *U.S. Department of Energy American Indian and Alaska Native Tribal Government Policy*, and DOE O 144.1, Admin Chg 1, *Department of Energy American Indian Tribal Government Interactions and Policy*. DOE-RL holds quarterly Tribal technical working sessions, a dialogue on policy and technical issues, and monthly cultural resources meetings, where cultural resource issues are discussed. Where possible, DOE-RL and Office of River Protection briefings will be held on groundwater and vadose zone issues for the Tribal Nations. DOE-RL will work with the Tribal Nations to ensure ongoing communication and involvement in the Inner Area decision-making process.

This effort will include timely notice to potentially affected Tribal Nations in the early planning stages of the decision-making process. Further, to the extent allowed by law, consultation will defer to Tribal Nations policies on confidentiality and management of cultural resources.

5.2.2 Stakeholder Involvement

Stakeholders are individuals who are affected by, or have an interest in, Hanford Site issues. Hanford Site stakeholders include the Hanford Natural Resources Trustees; local governments; local and regional businesses; Hanford Site work force; local, regional, and national environmental interest groups; and local and regional public health organizations.

The HAB is a site-specific advisory board chartered under the *Federal Advisory Committee Act of 1972*. The HAB advises the Tri-Parties on cleanup issues. The HAB's River and Plateau Committee addresses River Corridor and Central Plateau issues. The 200-DV-1 OU Project will work with DOE to identify opportunities to inform and involve this committee on significant work plan issues and progress. The River and Plateau Committee meets approximately 10 times each year. On the basis of the timing of the development of significant work plan components, periodic updates will be provided to the River and Plateau Committee.

The River and Plateau Committee provides an ongoing opportunity for informal stakeholder feedback on work plan components and evolving project activities. The committee decides if an issue should be brought to the HAB.

5.2.3 Public Involvement

Public involvement also is governed by the Hanford Public Involvement Plan (DOE et al., 2012). The general public consists of people who are aware of decisions but choose not to be involved in those decisions. At this time, public meetings or comment periods are not conducted for work plans. If an addendum or change to this work plan is developed, consultation with the Tri-Parties, River and Plateau Committee, and the Public Involvement and Communication Committee will determine the need for public involvement.

5.3 Task 3—Field Investigation

The 200-WA-1 and 200-BC-1 OU RI/FS will conduct field investigations using the specific data collection activities described in the SAP (Appendix E). Additional data sets from other investigations will be used as the basis for determining data needs and to support the RI/FS, including the following:

- Environmental measurements and observation data generated during previous site characterization activities at the Hanford Site, including the results of RI, RFI, treatability studies, and other CERCLA and RCRA-related reports prepared for Central Plateau OUs, such as 200-SW-2, 200-IS-1, 200-DV-1, and tank farms, that relate to 200-WA-1 and 200-BC-1 OU waste sites
- Environmental measurements and observation data collected during monitoring activities, as described in Section 3.2, at the 200-WA-1 and 200-BC-1 OU waste sites
- Environmental measurements and observation data collected during structure demolition and remedial actions at relevant locations within the Central Plateau and other parts of the Hanford Site

Appendix E provides the overall scope of field investigation activities identified for the 200-WA-1 and 200-BC-1 OU waste sites and includes the following types of waste site characterization activities:

- Nonintrusive Techniques
  - Surface and downhole geophysics (e.g., surface electrical resistivity surveys and geophysical surveys in existing wells and borings)
  - Collection and analysis of soil samples from the ground surface
  - Collection and analysis of surficial samples from structures.
- Intrusive Techniques
  - Collection and analysis of vadose zone soil samples using direct push technology (DPT) systems:
    - From approximately 275 shallow soil borings (to 4.6 m [15 ft] bgs)
    - From approximately 40 intermediate soil borings (to approximately 18.2 m [60 ft] bgs)

- Collection and analysis of vadose zone soil samples using conventional drill rigs:
  - From approximately 25 to 30 deep soil borings to groundwater
- Collection and analysis of liquid or solid waste samples from vessels
  - From septic tanks, silos, and burial vaults
- Collection and analysis of concrete core samples using hand-held or rig-mounted core drills.
  - From approximately 2.4 m (8 ft) bgs at bottom of retention basins or from near-surface foundation slabs

- Analysis and Measurement Techniques
  - Samples may be analyzed using either field or fixed laboratory methods. Field measurements may include screening-level measurements (i.e., qualitative or semiquantitative measurements) or field quantitative measurements. Quantitative field measurements will be subject to applicable measurement quality standards established for fixed laboratories.

Additional data collection methods may be used depending on site conditions, data needs, and availability of technologies.

The specific data needs assessment and data collection methodology for pipelines, tanks, and vaults will be consistent with the approach for assessing data needs for other similar 200 Area sites. The RI/FS work plan for the 200-IS-1 OU is under development. Once a methodology for a pipeline data needs assessment has been determined for the 200-IS-1 OU, 200-WA-1 OU and 200-BC-1 OU pipeline, tank, and vault sites will be evaluated consistently with that approach. If additional data needs are identified for the 200-WA-1 and 200-BC-1 OU sites, the SAP will be amended to incorporate characterization required to fulfill those data needs.

The sites that may require a SAP amendment to incorporate the 200-IS-1 OU characterization approach are as follows:

- 200-W-42 Pipeline
- 200-W-244-PL Pipeline
- 200-W-248-PL Pipeline
- 200-E-14 Siphon Tank
- 231-W-151 Receiving Vault
- 270-W Neutralization Tank
- 200-W-12 Dumping Area[1]

[1] The 200-W-12 Dumping area consists of a soil mound with pipes protruding from it, along with an electric heat controller and insulated wires. It has been hypothesized that a tank could be buried beneath the soil mound. If field investigation discovers a buried tank, the contents would need to be assessed using the approach developed for the 200-IS-1 OU.

5.4 Task 4—Sample Analysis/Validation

The SAP for the 200-WA-1 and 200-BC-1 OUs (Appendix E) identifies the target analytes, analytical methods, and analytical performance requirements for analysis of collected samples. The data obtained will be reviewed, verified, and validated in accordance with the QAPjP in the SAP.

The criteria for verification include, but are not limited to, review for completeness (i.e., samples were analyzed as requested), use of the correct analytical methods/procedures, transcription errors, correct application of dilution factors, appropriate reporting of dry weight versus wet weight, and correct application of conversion factors. Laboratory personnel may perform data verification.

Data validation will be performed to ensure that the data quality goals established during the RI/FS planning phase have been achieved. Data validation will be based on EPA functional guidelines. The criteria for data validation are based on a graded approach. The primary contractor has defined five levels of validation—Levels A through E. Level A is the lowest level and is the same as verification. Level E is a 100 percent review of all data (e.g., calibration data and calculations of representative samples from the data set). The QAPjP states that Level C validation will be performed on at least 5 percent of the data by matrix and analyte group. Data validation may be performed by the Sample Management and Reporting organization and/or by a party independent of both the data collector and the data user.

The determination of data usability will be conducted and documented in DQA reports. Data validation will be documented in data validation reports, which will be included in the project file.

5.5 Task 5—Data Evaluation

The measurement and observation data collected during the field activities described in the SAP for the 200-WA-1 and 200-BC-1 OUs (Appendix E) will be evaluated, reduced, and presented in tabular and graphic format for subsequent use in the risk assessment, fate and transport evaluation, and FS, and for preparation of the RI/FS report. The results of the measurement data review and validation presented in the DQA report will be used to qualify the data to confirm that only data of known and acceptable quality are used in subsequent data analyses.

The waste site summaries (Appendix D) developed to support preparation of this work plan will be refined and updated through analysis, interpretation, and evaluation of data collected in accordance with the SAP for the 200-WA-1 and 200-BC-1 OUs (Appendix E) and by other projects, as applicable.

5.6 Task 6—Assessment of Risk

The BRA will be conducted as part of the RI process to assess potential risks to human and ecological receptors from direct contact with soil, and potential risks to groundwater from contaminants in the shallow soils and in the vadose zone. The BRA will determine if there is a need to take remedial action to reduce risks to acceptable levels. The BRA methodology is described in Section 3.9 of this report. Cleanup levels (PRGs) will also be developed as part of this task as described in Section 3.10 of this report.

5.7 Task 7—Treatability Studies

Treatability studies may be conducted to provide more detailed information on the performance of specific remedial technologies. Treatability studies can reduce remedial technology costs and performance uncertainties, provide information that enables a technology to be scaled up for alternative development and evaluation purposes, and support remedial design of a selected alternative.

The decision as to whether treatability studies are necessary to support the FS will be made following data evaluation and assessment of risk and impact to groundwater, and as part of planning for remedial alternatives development, screening, and detailed evaluation. If data are needed to support FS alternative evaluations, then a separate treatability test plan will be prepared. If new technologies are identified as candidate technologies for the 200-WA-1 and 200-BC-1 OU waste sites, then treatability testing may be considered. At this time, treatability studies are not anticipated for the 200-WA-1 and 200-BC-1 OU waste sites.

Treatability tests were performed at the BC cribs and will be used to support FS alternative evaluations. An excavation-based treatability test was performed at the 216-B-26 Trench in 2008. Treatability testing performed at the 216-B-26 Trench is documented in DOE/RL-2009-36. A field test using desiccation technology was initiated in 2011 south of the 216-B-17 Crib, and soil moisture is being monitored for 5 years. Treatability study work performed at the 216-B-17 Crib is documented in PNNL-22826, *Deep Vadose Zone Treatability Test for the Hanford Central Plateau: Interim Post-Desiccation Monitoring Results*.

5.8 Task 8—Remedial Investigation Reports

As the field investigations are completed, reports will be prepared to summarize the activities performed and the information collected in the field. Reports may include survey data for borehole locations, the number and types of samples collected, inventory of investigation-derived waste containers, geological logs, field screening results, and GPL results. The field reports support the preparation of the RI/FS.

5.9 Task 9—Remedial Alternatives Development and Screening

Remedial technologies will be identified and screened, and remedial alternatives will be developed.

5.9.1 Identification and Screening of Technologies

Once the RAOs are established and the general response actions (GRAs) are developed, an initial screening of technologies and process options is conducted with the purpose of evaluating each technology against the CERCLA criteria of effectiveness, implementability, and cost as outlined in the RI/FS CERCLA guidance (EPA/540/G-89/004).

Process knowledge of the waste site (e.g., dimensions, point of release, exposure routes, and volume of release), COPCs, and CERCLA criteria will be used as evaluation matrices to tabulate a list of candidate technologies. The screening process will consider the construction, process history, and operational logistics of each waste site but will be focused primarily on waste streams, COPCs, and extent of impact for those sites where historical analytical data are available.

Chapters 3 and 4 present characteristics of the nature and extent of contamination for waste site groupings, based on data derived from the specific waste site or assumed by considering the known attributes of the site (e.g., site history and similarity to a site). The waste site groupings are based on waste site configuration, primary waste source, and relative volume of waste received. The schematic drawings characterize waste sites in relationship to relative depth of contamination, which identifies sites that may affect groundwater or pose risks to human or ecological receptors. Based on the known or assumed nature and extent of contamination, retained remedial technologies will be screened for effectiveness, implementability, and cost to identify technologies that are to be further evaluated for each site.

5.9.2 Development of the Range of Alternatives

A sample matrix that may be used to screen technologies and remedial process options for the Inner Area is presented in Table B-7 (Appendix B). This matrix was developed from candidate remedial technologies for vadose zone remediation of radionuclides, metals, and organic compounds found in the 200-WA-1 and 200-BC-1 OUs.

Technologies that are not retained during the evaluation will be identified, and a thorough explanation will be provided in an appendix to the RI/FS report. The appendix will present a description of the technology, followed by a rationale for why the technology was not retained. The results of the waste site type categorization process will facilitate selection of the appropriate retained technology that is applicable for each waste site.

The list of technologies will be used to identify the initial alternatives and process options. Alternatives will be developed that provide a range of options and sufficient information to compare alternatives. For source control options, the following types of alternatives will be developed to the extent practicable (EPA/540/G-89/004):

- Source removal and disposal.
- Treatment alternatives that will range from eliminating or minimizing, to the extent feasible, the need for long-term management (including monitored natural attenuation [MNA]) to using treatment as an alternative to address unacceptable risks to HHE at the site. Alternatives will typically differ in the type and extent of treatment used and the management requirements of treatment residuals or untreated wastes.
- One or more alternatives that may involve containment of waste with little or no treatment but will protect HHE by preventing potential exposure or reducing the mobility of contaminants.
- No action alternative.

The mix of technologies and process options for each waste site type category will then be organized into various remedial alternatives that can be compared to the CERCLA evaluation criteria.

5.10 Task 10—Detailed Analysis of Alternatives

The selection of the preferred alternative is determined by evaluating each alternative against the CERCLA evaluation criteria identified in the detailed analysis of alternatives. Each alternative must meet the threshold criteria:

- Overall protection of HHE
- Compliance with ARARs

The analysis of alternatives is then based on the balancing criteria:

- Long-term effectiveness and permanence
- Reductions in toxicity, mobility, and volume through treatment
- Short-term effectiveness
- Implementability
- Cost

The following modifying criteria are evaluated, following comments on the proposed plan, and addressed in the ROD:

- State acceptance
- Community acceptance

5.11 Task 11—RI and FS Report

The RI/FS report will present the data and evaluations that characterize waste site conditions, determine the nature and extent of contamination for each waste site, and assess risk to HHE and threat to groundwater from each waste site. The field reports, which will address individual field investigation activities, are summarized within the RI report. The FS report presents the RAOs, the results of the remedial technologies screening process, and the detailed evaluation of remedial alternatives. The results of treatability studies also are presented, if available. The RI report and FS report may be combined into one report.

The RI/FS report will consider information available at the time of report preparation, including activities conducted outside of this work plan. This may include updated findings and conclusions from the 200-ZP-1 or 200-UP-1 Groundwater OUs remedy decisions, canyon barrier decisions, 200-DV-1 OU decision, or RCRA closure/TSD unit decision.

5.12 Task 12—Post-RI/FS Support

The RI/FS report will be subject to EPA review and approval. Following this approval, the proposed plan will be prepared. The proposed plan will be subject to a public comment period. The RI/FS, proposed plan, and other final project deliverables will be publically available in the TPA (Ecology et al., 1989a) Administrative Record. Once the public comment period is complete, the selected remedy will be defined and documented in the ROD. The ROD contains the responsiveness summary reflecting the public comments received and the response. The following subsections present additional information concerning the proposed plan and ROD.

5.12.1 Proposed Plan

The proposed plan is the mechanism by which the Tri-Parties present the 200-WA-1 and 200-BC-1 OU site information and preferred remedy to the public. The proposed plan describes the site background, risks associated with the OUs, and remedial alternatives evaluated in the RI/FS. The proposed plan includes the comparative analyses of the remedial action alternatives and presents the proposed preferred remedial alternative. The proposed plan provides the public with the opportunity to comment on the alternatives and to participate in the selection of the remedial alternative.

5.12.2 Record of Decision

The final CERCLA modifying criteria, state acceptance, and community acceptance are evaluated following public comment and are addressed. Following comments from the public and comments from supporting regulatory agencies, a remedy is selected and documented in a ROD. The ROD documents the remedial action plan for each of the waste sites and serves four basic functions (EPA 540-R-98-031, *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents*):

- A legally enforceable document that certifies the remedy selection process was carried out in accordance with CERCLA and, to the extent practicable, in accordance with the NCP (40 CFR 300)
- A substantive summary of the technical rationale and background information contained in the Administrative Record file
- A technical document that provides information necessary for determining the conceptual engineering components and remedy costs, and outlines the RAOs and cleanup levels for the selected remedy
- A key communication tool for the public that explains the contamination problems the remedy seeks to address and the rationale for its selection

5.12.3 Post-ROD Activities

The selected remedial alternative is implemented when the ROD is approved. This stage involves remedial design and may include design investigation studies to support detailed design and construction. When wastes are left in place, protectiveness of the remedy is evaluated during the 5-year review process.

If new information is generated that could affect the implementation of the selected remedy, the information will be addressed through one of the following means:

- Memorandum to the post-ROD file for an insignificant or minor change
- An explanation of significant differences for a significant change
- ROD amendment for a fundamental change

This page intentionally left blank.

6 Project Schedule

Table 6-1 shows the project schedule for the activities described in this work plan. The schedule will be evaluated to identify efficiencies, will serve as the baseline for the work planning process, and will be used to measure the progress of implementing this work plan.

Table 6-1. Project Schedule for the 200-WA-1 and 200-BC-1 OUs

Activity	Duration
RI/FS work plan approval	--
Initiate and complete field preparation, mobilization, and cultural resources clearance	12 months after NTP
Complete characterization—field effort	30 months
Complete characterization—data receipt, validation, and evaluation	12 months after characterization completion
Complete RI/FS report	12 months
Submit FS report and proposed plan for the 200-WA-1 and 200-BC-1 OUs (200 West Inner Area) to EPA (TPA Milestone M-015-91B)*	66 months after NTP

* TPA (Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*) Milestone M-015-91B will require revision.

EPA = U.S. Environmental Protection Agency

NTP = notice to proceed

OU = operable unit

RI/FS = remedial investigation/feasibility study

TPA = Tri-Party Agreement

The schedule includes TPA (Ecology et al., 1989a) milestones, field activities, and activity durations. Revisions to the project schedule will be made in accordance with Section 11.3 of the TPA (Ecology et al., 1989a).

This page intentionally left blank.

7 Project Management

This chapter discusses the project organization, project coordination, change control, and dispute resolution processes. Change control processes are used to document and achieve approval for changes that arise during execution of the RI/FS. Problems are resolved at the lowest possible level, with higher levels of project oversight engaged to resolve the issues.

7.1 Project Organization

DOE-RL is responsible for the Central Plateau investigation and cleanup. The DOE-RL contractor implements the investigation and cleanup for DOE-RL and is responsible for planning, coordinating, and executing RI/FS activities. The lead regulatory agency (EPA) authorizes the work scope in accordance with the TPA (Ecology et al., 1989a) and oversees the work for regulatory compliance. Figure 7-1 illustrates the project organization structure for investigation and cleanup of the 200-WA-1 and 200-BC-1 OUs.

7.1.1 U.S. Department of Energy, Richland Operations Office Project Organization

DOE-RL is responsible for cleanup on the Central Plateau. The DOE-RL contractor implements the cleanup for DOE-RL and is responsible for planning, coordinating, and executing the RI/FS activities. The lead regulatory agency (EPA) authorizes the work scope in accordance with the Tri-Party Agreement (Ecology et al., 1989a) and oversees the work for regulatory compliance. Figure 7-1 illustrates the project organization structure for cleanup of the 200-WA-1 and 200-BC-1 OUs.

The DOE-RL Soil and Groundwater Division is responsible for remedy implementation of the 200-WA-1 and 200-BC-1 OUs. The federal project director for the Soil and Groundwater Division reports to the assistant manager for the River and Plateau.

The DOE-RL Contracting Officer is responsible for authorizing the Central Plateau remediation contractor to perform the RI/FS tasks for the 200-WA-1 and 200-BC-1 OUs.

The federal project director is responsible for obtaining lead regulatory agency approval of the work plan and SAPs, which authorize the RI/FS activities under the TPA (Ecology et al., 1989a). The federal project director also assigns the 200-WA-1 and 200-BC-1 DOE-RL technical lead who performs the role of the Project Manager identified in Section 4.1 of the TPA. The DOE-RL Technical Lead is responsible for managing the project, day-to-day oversight of contractors performing the RI/FS activities, maintaining regulatory compliance necessary for completion of the milestones, and for providing technical input to DOE-RL federal project directors.

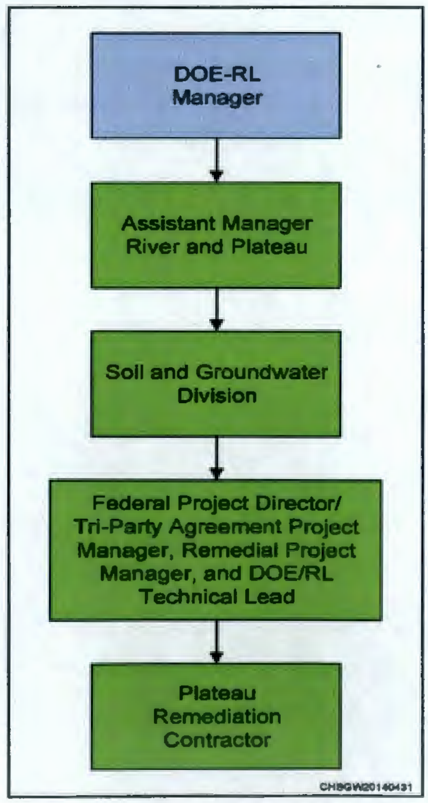


Figure 7-1. Project Organization for the 200 WA-1 and 200-BC-1 OUs

7.1.2 Regulatory Agency Oversight Organization

EPA is the lead regulatory agency for the 200-WA-1 and 200-BC-1 OUs. EPA has assigned a Project Manager who is responsible for overseeing various RI/FS activities. The EPA Project Manager is responsible for working with DOE-RL to resolve issues and approve documents in accordance with Article XIV through Article XVI of the TPA (Ecology et al., 1989a). The EPA Project Manager is responsible for approving the RI/FS work plan and, subsequently, for approving the final remedy, approving completion of construction, and proposing sites for deletion from the NPL (40 CFR 300, Appendix B).

As the nonlead regulatory agency, Ecology's regulatory responsibilities include providing assistance if requested by the lead regulatory agency (EPA), to fulfill mandatory legal obligations (i.e., under a permit), and to consider concurrence for a CERCLA remedial action. Ecology may also contribute and comment on aspects of planning and development of decision documents that may affect other decision documents when Ecology is the lead regulatory agency.

7.1.3 Contractor Organization

RI/FS activities will be integrated and executed by the DOE-RL contractor responsible for the Central Plateau.

7.2 Project Coordination, Decision Making, and Documentation

Coordination among EPA and Ecology, the lead agency (DOE), and the contractors is essential for successful execution of the RI/FS. Consensus from the regulatory agency project managers may be documented in meeting minutes of 200 Area unit managers' meetings.

7.3 Change Control and Dispute Resolution

The work plan represents the Tri-Parties' assessment of the data needs at the end of the systematic planning process. As new information becomes available, changes to the work scope may be required. These changes will be made to the work plan and/or to the SAP (Appendix E), depending on the nature of the change, in accordance with Section 9.3 of the TPA Action Plan (Ecology et al., 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan*).

Dispute resolution is handled in accordance with Article XVI of the TPA (Ecology et al., 1989a).

8 References

40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," *Code of Federal Regulations*. Available at: http://www.access.gpo.gov/nara/cfr/waisidx_10/40cfr300_10.html.

300.430, "Remedial Investigation/Feasibility Study and Selection of Remedy."

40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," Appendix B, "National Priorities List," *Code of Federal Regulations*. Available at: http://www.gpo.gov/fdsys/pkg/CFR-2010-title40-vol27/xml/CFR-2010-title40-vol27-part300-appB.xml.

64 FR 61615, "Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement (HCP EIS)," *Federal Register*, Vol. 64, No. 218, pp. 61615-61625, November 12, 1999. Available at: http://www.gpo.gov/fdsys/granule/FR-1999-11-12/99-29325.

78 FR 240, "Record of Decision for the Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington," Federal Register, Vol. 79, No. 240, pp. 75913-75919, December 13, 2013. Available at: http://www.hanford.gov/files.cfm/TCWM_ROD_FR_pub_12_13_13.pdf.

Agency for Toxic Substances and Disease Registry (ATSDR) database. Available at: http://www.atsdr.cdc.gov/mrls/index.html.

BHI-00033, 1994, *Surface and Near Surface Field Investigation Data Summary Report for the 200-UP-2 Operable Unit*, Rev. 00, Bechtel Hanford, Inc., Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196059635.

C-09-07, 2010, *Federal Facility Agreement and Consent Order Change Control Form: Revise Tri-Party Agreement Appendix C to Align Operable Unit Assignments with Proposed Central Plateau Decisions*, dated September 8, U.S. Department of Energy, Richland Operations Office; U.S. Environmental Protection Agency; and Washington State Department of Ecology. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1011021005.

C-11-05, 2011, *Federal Facility Agreement and Consent Order Change Control Form: Reassignment of 216-S-14 Waste Site from 200-DV-1 Operable Unit to 200-WA-1 Operable Unit*, dated August 2, U.S. Department of Energy, Richland Operations Office; U.S. Environmental Protection Agency; and Washington State Department of Ecology. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1108181089.

CHPRC-00651, 2010, *Evaluation of Biointrusion at the Hanford Site for Protection of Ecological Receptors*, Draft B, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0082377H.

CHPRC-00784, 2014, *Tier 1 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site*, Rev. 1, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0081638H.

CHPRC-01311, 2013, *Tier 2 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site*, Rev. 1, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0088115.

Clean Air Act of 1990, Pub. L. 101-549, as amended, 42 USC 7401, et seq. Available at: http://www.epa.gov/air/caa/.

Clean Water Act of 1977, 33 USC 1251, et seq. Available at: http://epw.senate.gov/water.pdf.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601, et seq. Pub. L. 107-377, December 31, 2002. Available at: http://epw.senate.gov/cercla.pdf.

Section 120, "Federal Facilities."

CP-22319-DEL, 2004, *Plan for Central Plateau Closure*, Rev. 0, Fluor Hanford, Inc., Richland, Washington.

D&D-36428, 2008, *Characterization Report for the 214-U-361 Settling Tank in the 200-UW-1 Operable Unit*, Rev. 0, Fluor Hanford, Inc. Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0081647H.

DOE-0335, 2007, *An Aerial Radiological Survey of the Hanford Reservation Richland Washington Date of Survey: February 29 to March 21, 1996*, Rev. 0, U.S. Department of Energy, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA06101266.

DOE, 2006, *U.S. Department of Energy American Indian & Alaska Native Tribal Government Policy*, U.S. Department of Energy, Washington, D.C. Available at: http://apps1.eere.energy.gov/tribalenergy/pdfs/doe_indian_policy2006.pdf.

DOE, Ecology, and EPA, 2012, *Hanford Federal Facility Agreement and Consent Order Hanford Public Involvement Plan*, U.S. Department of Energy, Richland Operations Office; Washington State Department of Ecology; and U.S. Environmental Protection Agency, Richland, Washington. Available at: http://www.hanford.gov/files.cfm/FacAgreementand-Consent-Order_FINAL.pdf.

DOE/EIS-0222-F, 1999, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*, U.S. Department of Energy, Washington, D.C. Available at:
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D199158842.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D199158843.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D199158844.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D199158845.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D199158846.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D199158847.

DOE/EIS-0222-SA-01, 2008, *Supplement Analysis: Hanford Comprehensive Land-Use Plan Environmental Impact Statement*, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www.hanford.gov/files.cfm/SAwith_signed-R1.pdf.

DOE/EIS-0391, 2012, *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)*, U.S. Department of Energy, Office of River Protection, Richland, Washington. Available at: http://energy.gov/nepa/downloads/eis-0391-final-environmental-impact-statement.

DOE/EH-94007658, 1993, *Remedial Investigation/Feasibility Study (RI/FS) Process, Elements and Techniques*, U.S. Department of Energy, Washington, D.C. Available at: http://www.1hope.org/RIFSGUID.PDF.

DOE O 144.1, 2009, *Department of Energy American Indian Tribal Government Interactions and Policy*, U.S. Department of Energy, Washington, D.C. Available at: https://www.directives.doe.gov/directives/archive-directives/144.1-BOrder/view.

DOE O 435.1 Chg 1, 2001, *Radioactive Waste Management*, U.S. Department of Energy, Washington, D.C. Available at: https://www.directives.doe.gov/directives/current-directives/435.1-BOrder-c1/view.

DOE/RL-91-52, 1992, *U Plant Source Aggregate Area Management Study Report*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196110688.

DOE/RL-91-58, 1992, *Z Plant Source Aggregate Area Management Study Report*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196124396.

DOE/RL-91-60, 1992, *S Plant Aggregate Area Management Study Report*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D195065601.

DOE/RL-91-61, 1992, *T Plant Source Aggregate Area Management Study Report*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196124788.

DOE/RL-92-16, 1993, *200 West Groundwater Aggregate Area Management Study Report*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196125315.

DOE/RL-96-12, 1996, *Hanford Site Background: Part 2, Soil Background for Radionuclides*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D1808987.

DOE/RL-96-32, 2013, *Hanford Site Biological Resources Management Plan*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www.hanford.gov/files.cfm/DOE-RL-96-32-01.pdf.

DOE/RL-96-67, 1996, *200 Areas Soil Remediation Strategy – Environmental Restoration Program*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D197142675.

DOE/RL-98-28, 1999, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D199153696.

DOE/RL-2000-38, 2001, *200-TW-1 Scavenged Waste Group Operable Unit and 200-TW-2 Tank Waste Group Operable Unit RI/FS Work Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D8686208.

DOE/RL-2002-39, 2002, *Standardized Stratigraphic Nomenclature for Post-Ringold-Formation Sediments Within the Central Pasco Basin*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington (also cited as DOE, 2002). Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0081471H.

DOE/RL-2002-42, 2003, *Remedial Investigation Report for the 200-TW-1 and 200-TW-2 Operable Units (Includes the 200-PW-5 Operable Unit)*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2003-23, 2005, *Focused Feasibility Study for the 200-UW-1 Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D7944638. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D7944918. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D7950655.

DOE/RL-2003-24, 2005, *Proposed Plan for the 200-UW-1 Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA007725.

DOE/RL-2004-66, 2005, *Focused Feasibility Study for the BC Cribs and Trenches Area Waste Sites*, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA170624. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA170919. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA171165. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA171467.

DOE/RL-2005-13, 2005, *Action Memorandum for the Plutonium Finishing Plant Above-Grade Structures Non-Time Critical Removal Action*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=DA00914134.

DOE/RL-2005-71, 2005, *Action Memorandum for the Time-Critical Removal Action for Support Activities to the 200-UW-1 Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA01059946.

DOE/RL-2007-02, 2007, *Supplemental Remedial Investigation/Feasibility Study Work Plan for the 200 Areas Central Plateau Operable Units*, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA04659620.

DOE/RL-2007-02, 2007, *Supplemental Remedial Investigation/Feasibility Study Work Plan for the 200 Areas Central Plateau Operable Units: Volume I: Work Plan and Appendices*, Rev. 0, Vol. I, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA06261660.

DOE/RL-2007-02, 2007, *Supplemental Remedial Investigation/Feasibility Study Work Plan for the 200 Areas Central Plateau Operable Units: Volume II: Site-Specific Field-Sampling Plan Addenda*, Rev. 0, Vol. II, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA06294555.

DOE/RL-2008-44, 2009, *Engineering Evaluation/Cost Analysis for the 200-MG-1 Operable Unit Waste Sites*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0096350.

DOE/RL-2008-45, 2009, *Engineering Evaluation/Cost Analysis for the 200-MG-2 Operable Unit Waste Sites*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0096566.

DOE/RL-2009-10, 2010, *Hanford Site Cleanup Completion Framework*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1008190506.

DOE/RL-2009-36, 2010, *BC Cribs and Trenches Excavation-Based Treatability Test Report*, Rev. 1 REISSUE, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084533.

DOE/RL-2009-37, 2009, *Action Memorandum for Non-Time-Critical Removal Action for 200-MG-2 Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0912211267.

DOE/RL-2009-60, 2011, *Sampling and Analysis Plan for Selected 200-MG-1 Operable Unit Waste Sites*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0087632.

DOE/RL-2009-85, 2012, *Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091415.

DOE/RL-2009-86, 2010, *Action Memorandum for Non-Time-Critical Removal Action for 37 Waste Sites in the 200-MG-1 Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084449.

DOE/RL-2009-94, 2010, *216-U-8 Crib and 216-U-12 Crib Vadose Zone Characterization Sampling and Analysis Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084142.

DOE/RL-2009-122, 2012, *Remedial Investigation/Feasibility Study for the 200-UP-1 Groundwater Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0092247.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0092342.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0092341.

DOE/RL-2009-127, 2014, *Remedial Investigation Report for the 200-BP-5 Groundwater Operable Unit*, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2010-95, 2012, *Remedial Investigation/Feasibility Study for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0090581.

DOE/RL-2011-03, 2014, *Removal Action Work Plan for the Deactivation, Decontamination, Decommissioning, and Demolition of the Plutonium Finishing Plan Complex*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084836.

DOE/RL-2011-50, 2012, *Regulatory Basis and Implementation of a Graded Approach to Evaluation of Groundwater Protection*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093361.

DOE/RL-2011-102, 2015, *Remedial Investigation/Feasibility Study and RCRA Facility Investigation/Corrective Measures Study Work Plan for the 200-DV-1 Operable Unit*, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0081657H.

DOE/RL-2011-116, 2012, *Hanford Site Revegetation Manual*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www.hanford.gov/files.cfm/DOE-RL-2011-116_-_Rev_01.pdf.

DOE/RL-2013-22, 2013, *Hanford Site Groundwater Monitoring Report for 2012*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0087974.

DOE/RW-0164, 1988, *Site Characterization Plan: Reference Repository Location, Hanford Site, Washington*, 9 vols., Consultation Draft, U.S. Department of Energy, Washington, D.C. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196007701.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196007769.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196007788.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196007871.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196007870.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196007876.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196007901.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196007935.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196027182.

Drummond, Marshall E., 1992, *The Future for Hanford: Uses and Cleanup: The Final Report of the Hanford Future Site Uses Working Group*, prepared by the Hanford Future Site Uses Working Group for the U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196123428.

ECF-HANFORD-10-0452, 2013, *Calculation of Radiological Preliminary Remediation Goals in Soil for an Industrial Worker Exposure Scenario for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0081644H.

ECF-HANFORD-10-0453, 2013, *Calculation of Standard Method C Direct Contact Soil Cleanup Levels for Industrial Land Use for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports*, Rev. 1, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0081643H.

ECF-HANFORD-11-0038, 2012, *Soil Background for Interim Use at the Hanford Site*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088381.

ECF-HANFORD-11-0158, 2014, *Tier 2 Terrestrial Plant and Invertebrate PRGs for Nonradionuclides for Use at the Hanford Site*, Rev. 1, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0081636H.

Eckerman, K.F., 2007, *Ratios of Dose Rates for Contaminated Slabs*, Environmental Protection Agency, Washington, D.C. Available at: http://epa-prgs.ornl.gov/radionuclides/ContaminatedSlabs.pdf.

Ecology, EPA, and DOE, 1989a, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.hanford.gov/?page=81.

Ecology, EPA, and DOE, 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.hanford.gov/?page=82.

EGG-1183-1661, 1975, *An Aerial Radiological Survey of the U.S. Energy Research and Development Administration's Hanford Reservation (Survey Period: 1973-1974)*, EG&G Energy Measurements, Inc., Las Vegas, Nevada. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=E0014281.

EPA, 1991, *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions* (memorandum to Regions I – X Directors), OSWER Directive 9355.0-30, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C., April 22. Available at: http://www.epa.gov/oswer/riskassessment/pdf/baseline.pdf.

EPA, 2008, *Record of Decision, Hanford 200 Area, 200-ZP-1 Operable Unit Superfund Site, Benton County, Washington*, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=00098825.

EPA, 2015a, *Regional Screening Levels for Chemical Contaminants at Superfund Sites*, U.S. Environmental Protection Agency, Mid-Atlantic Risk Assessment, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/reg3hscd/risk/human/rb-concentration_table/.

EPA, 2015b, *Preliminary Remediation Goals for Radionuclides*, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://epa-prgs.ornl.gov/radionuclides/.

EPA, 2015c, Integrated Risk Information System (IRIS), U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/iris/index.html.

EPA/240/B-01/002, 2001, *EPA Requirements for Quality Management Plans*, EPA QA/R-2, Office of Environmental Information, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/region8/qa/r2-final.pdf.

EPA/240/B-01/003, 2001, *EPA Requirements for Quality Management Plans*, EPA QA/R-5, Office of Environmental Information, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/QUALITY/qs-docs/r5-final.pdf.

EPA/240/B-06/001, 2006, *Guidance on Systematic Planning Using the Data Quality Objectives Process*, EPA QA/G-4, Office of Environmental Information, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/QUALITY/qs-docs/g4-final.pdf.

EPA/540/1-89/002, 1989, *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A): Interim Final*, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://epa.gov/swerrims/riskassessment/ragsa/pdf/rags-vol1-pta_complete.pdf.

EPA/540/G-89/004, 1988, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, Interim Final, OSWER Directive 9355.3-01, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://epa.gov/superfund/policy/remedy/pdfs/540g-89004-s.pdf.

EPA/540/G-89/006, 1988, *CERCLA Compliance with Other Laws Manual: Interim Final*, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/superfund/resources/remedy/pdf/540g-89006-s.pdf.

EPA 540-R-00-002, 2000, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, OSWER 9355.0-75, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://epa.gov/superfund/policy/remedy/sfremedy/rifs/costest.htm.

EPA/540-R-00-007, 2000, *Soil Screening Guidance for Radionuclides: User's Guide*, OSWER 9355.4-16A, Office of Radiation and Indoor Air, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/superfund/health/contaminants/radiation/pdfs/sec_0clean.pdf.

EPA 540-R-01-003, 2002, *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites*, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/oswer/riskassessment/pdf/background.pdf.

EPA 540-R-97-006, 1997, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments: Interim Final*, OSWER 9285.7-25, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/swerrims/riskassessment/ecorisk/ecorisk.htm.

EPA 540-R-97-036, 1997, *Health Effects Assessment Summary Tables: FY 1997 Update*, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=2877.

EPA 540-R-97-036, 2001, *Health Effects Assessment Summary Tables: FY 1997 Update*, April 16, 2001 Update: Radionuclide Toxicity (update of former Table 4), Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=2877.

EPA 540-R-98-031, 1999, *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents*, OSWER 9200.1-23P, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/superfund/policy/remedy/rods/index.htm.

EPA/540/R/99/005, 2004, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment): Final*, OSWER 9285.7-02EP, Office of Superfund Remediation and Technology Innovation, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.semarnat.gob.mx/gestionambiental/Materiales%20y%20Actividades%20Riesgosas/sitioscontaminados/EPA/F-%20RAGS-E-Manual.pdf.

EPA/540/R/99/006, 1999, *Radiation Risk Assessment At CERCLA Sites: Q & A*, Directive 9200.4-31P, Office of Emergency and Remedial Response and Office of Radiation and Indoor Air, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/superfund/health/contaminants/radiation/pdfs/riskqa.pdf.

EPA 542-F-08-002, 2008, *Incorporating Sustainable Practices into Site Remediation*, OSWER 5203P, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.clu-in.org/download/remed/EPA-542-F-08-002.pdf.

EPA 542-R-08-002, 2008, *Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites*, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.cluin.org/download/remed/Green-Remediation-Primer.pdf.

EPA/600/R-090/052F, 2011, *Exposure Factors Handbook 2011 Edition (Final)*, National Center for Environmental Assessment, Office of Research and Development. Washington D.C. Available at: http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252.

EPA/ROD/R10-99/039, 1999, *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington (100 Area Remaining Sites)*, U.S. Environmental Protection Agency, Region 10, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.epa.gov/superfund/sites/rods/fulltext/r1099039.pdf.

EPA, Ecology, and DOE, 2005, *Record of Decision 221-U Facility (Canyon Disposition Initiative) Hanford Site, Washington*, U.S. Environmental Protection Agency, U.S. Department of Energy, and Washington State Department of Ecology, Olympia, Washington. Available at: http://www.epa.gov/superfund/sites/rods/fulltext/r2005100003104.pdf.

EPA, Ecology, and DOE, 2011, *Record of Decision Hanford 200 Area Superfund Site 200-CW-5 and 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Richland Operations Office, Olympia, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093644.

EPA, Ecology, and DOE, 2012, *Record of Decision for Interim Remedial Action Hanford 200 Area Superfund Site 200-UP-1 Operable Unit*, United States Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091413.

Federal Advisory Committee Act of 1972, 5 USC, Pub L. 92-463, Stat. 770. Available at: http://www.gsa.gov/portal/content/100916.

Hall, J.A. (ed.), 1998, *Biodiversity Inventory and Analysis of the Hanford Site: 1997 Annual Report*, The Nature Conservancy of Washington, Seattle, Washington.

HNF-36881, 2008, *Final Frontier at Hanford: Tackling the Central Plateau*, Rev. 0, Fluor Hanford, Inc., Richland, Washington. Available at: http://www.osti.gov/scitech/servlets/purl/924803.

HNF-53759, 2012, *Summer Bat Monitoring Report for Calendar Year 2012*, Mission Support Alliance, Richland, Washington. Available at: http://www.hanford.gov/files.cfm/HNF-53759_-_Rev_00_no_coversheets.pdf

HNF-54666, 2013, *Elk Monitoring Report for Calendar Year 2012*, Rev. 0, Mission Support Alliance, Richland, Washington. Available at: http://www.hanford.gov/files.cfm/HNF-54666_-_Rev_00_without_coversheets.pdf.

Lindsey, K.A., 1996, *The Miocene to Pliocene Ringold Formation and Associated Deposits of the Ancestral Columbia River System, South-central Washington and North-central Oregon*, Open File Report 96-8, Washington Division of Geology and Earth Resources,Washington State Department of Natural Resources, Olympia, Washington. Available at: http://www.dnr.wa.gov/Publications/ger_ofr96-8_ringold_formation.pdf.

M-15-09-02, 2010, *Federal Facility Agreement and Consent Order Change Control Form: Modify Tri-Party Agreement M-15 Series Milestones for Central Plateau Waste Sites and Groundwater*, dated September 14, U.S. Department of Energy, Richland Operations Office; U.S. Environmental Protection Agency; and Washington State Department of Ecology. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1011021007.

National Environmental Policy Act of 1969, 42 USC 4321, et seq. Available at: http://www.fhwa.dot.gov/environment/nepatxt.htm.

NJDEP, 2009, *Derivation of an Ingestion-Based Soil Remediation Criterion for Cr^{+6} Based on the NTP Chronic Bioassay Data for Sodium Dichromate Dihydrate*, Division of Science, Research, and Technology, New Jersey Department of Environmental Protection, Trenton, New Jersey. Available at: http://www.state.nj.us/dep/dsr/publications/pub.htm.

OEHHA, 2014, Office of Environmental Health Hazard Assessment Toxicity Criteria Database, California Environmental Protection Agency, Sacramento, California. Available at: http://oehha.ca.gov/risk/chemicaldb/index.asp.

ORNL, 2014, Risk Assessment Information System, Oak Ridge National Laboratory, Oak Ridge, Tennessee. Available at: http://rais.ornl.gov/.

OSWER 9355.4-24, 2002, *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*, Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/superfund/health/conmedia/soil/pdfs/ssg_main.pdf.

OSWER Directive 9200.1-120, 2014, *Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors*, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/oswer/riskassessment/pdf/superfund-hh-exposure/OSWER-Directive-9200-1-120-ExposureFactors.pdf.

OSWER Directive 9285.6-03, 1991, *Risk Assessment Guidance For Superfund Volume I: Human Health Evaluation Manual Supplemental Guidance "Standard Default Exposure Factors" Interim Final*, Office of Emergency and Remedial Response, Toxics Integration Branch, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/oswer/riskassessment/pdf/OSWERdirective9285.6-03.pdf.

OSWER Directive 9285.7-53, 2003, *Human Health Toxicity Values in Superfund Risk Assessments* (memorandum to Superfund National Policy Managers, Regions 1 – 10), Office of Superfund Remediation and Technology Innovation, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C., December 2003. Available at: http://www.epa.gov/oswer/riskassessment/pdf/hhmemo.pdf.

Pabst, R.J. (ed.), 1995, *Biodiversity Inventory and Analysis of the Hanford Site: 1994 Annual Report*, The Nature Conservancy of Washington, Seattle, Washington.

PNNL and CHPRC, 2009, "Development of a Conceptual Model for Vadose Zone Transport of Tc-99 at Hanford's BC Cribs and the Screening of Remedial Alternatives- 9458," Pacific Northwest National Laboratory and CH2M HILL Plateau Remediation Company, Richland, Washington, in WM2009 Conference in Phoenix, Arizona, March 1-5, 2009. Available at: http://www.wmsym.org/archives/2009/pdfs/9458.pdf.

PNL-6820, 1989, *Hydrogeology of the 200 Areas Low Level Burial Grounds—An Interim Report: Volume 1: Text*, Vol. 1, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D195066506.

PNL-2253, 1977, *Ecology of the 200 Area Plateau Waste Management Environs: A Status Report*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196016615.

PNL-2774, 1979, *Characterization of the Hanford 300 Area Burial Grounds: Task IV – Biological Transport*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://www.osti.gov/scitech/servlets/purl/5699771.

PNNL-6415, 2007, *Hanford Site National Environmental Policy Act (NEPA) Characterization*, Rev. 18, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-6415Rev18.pdf.

PNNL-11800, 1998, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.osti.gov/scitech/servlets/purl/594543.

PNNL-12261, 2000, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington*, Pacific Northwest National Laboratory, Richland, Washington (also cited as Williams et al., 2000). Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196016615.

PNNL-12030, 2000, *STOMP: Subsurface Transport Over Multiple Phases Version 2.0: Theory Guide*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://stomp.pnl.gov/documentation/theory.pdf.

PNNL-13230, 2000, *Hanford Site Environmental Report for Calendar Year 1999*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13230.pdf.

PNNL-13331, 2000, *Population Characteristics and Seasonal Movement Patterns of the Rattlesnake Hills Elk Herd—Status Report 2000*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13331.pdf.

PNNL-13487, 2001, *Hanford Site Environmental Report for Calendar Year 2000*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D8990775. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D8990779. http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D8990790.

PNNL-13688, 2001, *Vascular Plants of the Hanford Site*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/pnnl-13688.pdf.

PNNL-13745, 2002, *Hanford Site Ecological Quality Profile*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13745.pdf.

PNNL-13858, 2002, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-West Area and Vicinity, Hanford Site, Washington*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13858.pdf.

PNNL-14027, 2002, *An Initial Assessment of Hanford Impact Performed with the System Assessment Capability*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14027/PNNL-14027.pdf.

PNNL-14753, 2006, *Groundwater Data Package for Hanford Assessments*, Rev. 1, Pacific Northwest National Laboratory, Richland, Washington (also cited as Thorne et al., 2006). Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14753Rev1.pdf.

PNNL-14907, 2004, *Vadose Zone Contaminant Fate-and-Transport Analysis for the 216-B-26 Trench*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14907.pdf.

PNNL-15443, 2006, *Vadose Zone Transport Field Study: Summary Report*, Pacific Northwest National Laboratory, Richland, Washington. Available at:
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA06876292.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA06876428.

PNNL-16940, 2007, *Hanford Soil Inventory Model (SIM), Revision 2, Software Documentation – Requirements, Design, and Limitations*, Pacific Northwest National Laboratory, Richland, Washington. Available at:
http://www.pnl.gov/main/publications/external/technical_reports/PNNL-16940_final.pdf.

PNNL-17821, 2009, *Electrical Resistivity Correlation to Vadose Zone Sediment and Pore-Water Composition for the BC Cribs and Trenches Area*, Pacific Northwest National Laboratory, Richland, Washington. Available at:
http://www.pnl.gov/main/publications/external/technical_reports/PNNL-17821.pdf.

PNNL-22826, 2013, *Deep Vadose Zone Treatability Test for the Hanford Central Plateau: Interim Post-Desiccation Monitoring Results*, Pacific Northwest National Laboratory, Richland, Washington. Available at:
http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22826.pdf.

RCW 70.105, "Hazardous Waste Management," *Revised Code of Washington*, Olympia, Washington. Available at: http://apps.leg.wa.gov/RCW/default.aspx?cite=70.105.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq. Available at:
http://www.epa.gov/lawsregs/laws/rcra.html.

RHO-BWI-ST-4, 1979, *Geologic Studies of the Columbia Plateau: A Status Report*, Rockwell Hanford Operations, Richland, Washington. Available at:
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196002105.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196000171.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196000172.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196000173.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196000174.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196000175.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196000176.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196000177.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196000178.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196000179.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196000180.

RHO-CD-673, 1979, *Handbook 200 Areas Waste Sites*, 3 vols., Rockwell Hanford Operations, Richland, Washington. Available at:
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196039027.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196039028.
http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196039029.

RHO-RE-ST-12P, 1984, *An Assessment of Aquifer Intercommunication in the B Pond-Gable Mountain Pond Area of the Hanford Site*, Rockwell Hanford Operations, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196002251.

Sample, B.E., J. Lowe, P. Seeley, M. Markin, C. McCarthy, J. Hansen, A. Aly, 2015, "Depth of the Biologically Active Zone in Upland Habitats at the Hanford Site, Washington: Implications for Remediation and Ecological Risk Management," *Integr Environ Assess Manag* 11(1):150-160.

Soll, J.A., J.A. Hall, R. Pabst, and C. Soper (eds.), 1999, *Biodiversity Inventory and Analysis of the Hanford Site Final Report 1994-1999*, The Nature Conservancy of Washington, Seattle, Washington. Available at: http://nerp.pnnl.gov/docs/ecology/biodiversity/biodiversity_1999.pdf.

Soll, J.A. and C. Soper (eds.), 1996, *Biodiversity Inventory and Analysis of the Hanford Site: 1995 Annual Report*, The Nature Conservancy of Washington, Seattle, Washington.

TPA-MP-14, 2011, *Maintenance of the Waste Information Data System (WIDS)*, Rev. 2, U.S. Department of Energy, Richland Operations Office, U.S. Department of Energy, Office of River Protection, U.S. Environmental Protection Agency, and Washington State Department of Ecology, Richland, Washington. Available at: http://www.hanford.gov/files.cfm/TPA-MP14.pdf.

WA7890008967, *Hanford Facility Resource Conservation and Recovery Act Permit*, as amended, Washington State Department of Ecology, Richland, Washington.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303.

WAC 173-340, "Model Toxics Control Act—Cleanup," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340.

340-740, "Unrestricted Land Use Soil Cleanup Standards."

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

340-747, "Deriving Soil Concentrations for Groundwater Protection."

340-7490, "Terrestrial Ecological Evaluation Procedures."

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

340-7493, "Site-Specific Terrestrial Ecological Evaluation Procedures."

WCH-288, 2008, *2008 River Corridor Closure Contractor Revegetation and Mitigation Monitoring Report*, Rev. 0, Washington Closure Hanford, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0086149.

WCH-362, 2009, *2009 River Corridor Closure Contractor Revegetation and Mitigation Monitoring Report*, Rev. 0, Washington Closure Hanford, Richland, Washington. Available at: http://www.easbio.com/docs/2009-reveg.pdf.

WCH-428, 2010, *2010 River Corridor Closure Contractor Revegetation and Mitigation Monitoring Report*, Rev. 0, Washington Closure Hanford, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0086147.

WCH-512, 2011, *2011 River Corridor Closure Contractor Revegetation and Mitigation Monitoring Report*, Rev. 0, Washington Closure Hanford, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0086146.

WCH-554, 2013, *2012 River Corridor Closure Contractor Revegetation and Mitigation Monitoring Report*, Rev. 0, Washington Closure Hanford, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0086145.

WHC-EP-0402, 1992, *Status of Birds at the Hanford Site in Southeastern Washington*, Rev. 1, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196103569.

WHC-MR-0391, 1992, *Field Trip Guide to the Hanford Site*, Westinghouse Hanford Company, Richland, Washington (cited as Reidel et al., 2002). Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196136627.

WHC-SA-2062-FP, 1993, *Accelerated Cleanup of Mixed Waste Units on the Hanford Site, Richland, Washington*, Westinghouse Hanford Company, Richland, Washington. Available at: http://www.osti.gov/scitech/servlets/purl/10189941.

WHC-SD-EN-TI-216, 1994, *Vegetation Communities Associated with the 100-Area and 200-Area Facilities on the Hanford Site*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196108768.

This page intentionally left blank.